SOUTHEASTERN PENNSYLVANIA TRANSPORTATION AUTHORITY



SILVERLINER-VI RAILCAR PROCUREMENT

TECHNICAL SPECIFICATION

SEPTA New Rail Vehicles – September 2025

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SECTION 1
GENERAL TOPICS AND DEFINITIONS

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1.1 Scope

A. This Section includes requirements that apply to every section in the Specifications.

1.2 General Requirements

A. The cars shall be modern commuter rail vehicles designed to be safe, reliable, and maintainable.

B. The Contractor shall have the following responsibilities:

1. Design, manufacture, test, and deliver the products as described by the Technical Specifications ("the Specifications"). Deviations from these requirements are permitted only with specific written Approval of SEPTA, as specified in the Contract Documents.

2. Design and integrate car subsystems such that specified requirements are achieved without conflict or error within or between onboard subsystems and between car subsystems and wayside systems.

3. Flow specified requirements down to all subcontractors and subsuppliers, regardless of their tier, and ensure that designers, subcontractors, suppliers, and subsuppliers are informed of specified requirements, and that appropriate engineering management tools are used to ensure that coordination and communication occurs between the designers of interrelated subsystems.

4. Ensure that SEPTA can communicate directly, in person and electronically, with the suppliers of all car subsystems that interface with SEPTA's wayside infrastructure (such as cab signaling equipment). The Contractor shall be copied on such communication as it applied to the vehicles.

1.3 Specifications

1.3.1 Introduction

A. The Specifications define the functional, performance, and interface design requirements for the cars and Contract-required support systems, as well as processes to be followed during the term of this contract.

1.3.2 Organization

A. The Specifications are divided into sections according to technical discipline and traditional supplier arrangements.

1. The format is for convenience only and does not imply or suggest a preferred subsystem integration approach.

2. Explicit references may appear within sections linking requirements appearing in other sections. Such references shall, in no way, be assumed to limit the

range or applicability of the requirements in this document, whether referenced or not.

1.3.3 Language

A. The Specifications are written in imperative mood and streamlined form:

1. Imperative language is directed to the Contractor, although work may be carried out by a subcontractor or supplier under the Contractor's direction. The words "shall be" are included by inference where a colon (:) is used within sentences or phrases.

2. Examples:

a. "Perform type tests at the manufacturer's facilities unless indicated otherwise in the Specifications," means that Contractor is responsible for type tests being performed, whether by itself or by its subcontractor.

b. "Comply with the following:" means that Contractor shall incorporate the requirements listed after this statement into its design and manufacture of the car.

c. "Stress Analysis Report: Submit minimum 60 days before starting manufacture of carbody structural parts" means that Contractor shall submit the report within the time indicated.

d. "Life expectancy: Minimum 100,000 hours" means that the life expectancy of the component shall be minimum 100,000 hours.

1.3.4 Contract Deliverables

A. Comply with the following:

1. The Specifications require submittal of the following Contract deliverables for review by SEPTA to verify compliance with specified requirements, and for after-delivery support of the cars:

a. Contract Deliverable Requirements List items (CDRLs), which include drawings, documents, analyses, technical data, test procedures and results, manuals, schedules, and similar. These are listed at the end of each section under the heading Contract Deliverable Requirements List.

b. Design review packages.

c. Samples.

d. Mock-ups.

2. Unless otherwise noted in the Contract Documents, each item specified for submittal shall be both reviewed and Approved by SEPTA, whether this is specifically stated or not.

3. SEPTA reserves the right to request additional drawings, documents, analyses, technical data, test procedures and results, or similar information, as required to clarify and amplify the intent of Contract deliverables submitted.

4. SEPTA disposition on items submitted for review or Approval will be one of the following:

    a. Approved: As defined in Section 1.11, Definitions.

    b. Approved As Noted: Approved as defined above, but contains Notes for open questions that cannot be resolved as part of design review and instead must be resolved at a later project stage (e.g., FAI, manuals, etc.)

    c. Conditionally Approved: As defined in Section 1.11.

    d. Disapproved: The Contractor shall revise and resubmit the document, drawing, or data for Approval before beginning that portion of the work.

    e. Insufficient Information: The Contractor shall provide additional details or context and resubmit the document, drawing, or data for Approval before beginning that portion of the work. This resubmittal shall occur within 7 days unless otherwise Approved.

    f. Information Only: The information was submitted to assist in review of a required submittal or to satisfy a request. Specific Approval and comment not required.

1.3.5 Alternate Design Proposals

A. The Specifications include statements allowing alternate designs, products, and standards to be proposed and submitted for Approval.

    1. If the Contractor chooses to propose one of these alternate designs, products, or standards, it shall be submitted to SEPTA for review and Approval, whether this is stated or not, and is subject to Approval before it may be used.

    2. The submittal package shall include a detailed comparison of the features, functions, and performance parameters for the specified design, product, or standard and for the proposed alternate.

1.4 Access to Contractor Facilities

A. SEPTA and its authorized representatives shall have the right to visit facilities of the Contractor and its subcontractors:

    1. Visits are to assess progress, monitor work being performed, conduct QA/QC audits, determine readiness of materials and the subsupplier supply chain, conduct quality inspections, and witness testing.

2. SEPTA and its authorized representatives shall have the right to photograph, at its expense, any or all phases of car or equipment construction, including subcontractor work.

3. SEPTA shall have the right to review documentation at the facilities of the Contractor or subcontractors. This shall include, at a minimum, certifications, inspection records, manufacturing documentation, and software documentation, even when such documentation is proprietary and will be placed in escrow.

1.5 Materials and Equipment

A. Name brands, specific equipment, or specific materials may be referenced in the Specifications:

1. Such equipment has been shown to be successful in previous applications, where correctly applied and integrated with other equipment; however, such references shall not be interpreted as pre-Approval of Contractor designs or applications.

2. The Contractor is responsible for the selection, application, and integration of equipment and materials as necessary to conform to the specified requirements.

B. Equipment provided under this Contract shall be new:

1. Rebuilt or refurbished equipment is prohibited.

2. New equipment damaged during performance of this Contract may be restored to new condition only where Approved in writing by SEPTA on a case-by-case basis, and restorations shall be performed by the original equipment manufacturer.

1.6 Industry Standards and Regulations

A. Comply with the following:

1. Where standards, codes, or reference books are referenced in the Specifications, use the most current version available at NTP, unless otherwise noted.

2. Laws, statutes, and regulations, whether specified in the Specifications or not, shall be enforced. It is the responsibility of the Contractor to deliver cars that comply with all applicable laws, statutes, and regulations enacted as of NTP.

3. References to laws, statutes, or regulations are included in the Specifications to aid the Contractor. Whether referenced or not, applicable federal, state, and local laws, statutes, and regulations shall be included in this Contract.

4. International standards: SEPTA may consider Approval of requests to use an EN (European) or IEC (international) standard instead of a standard referenced in the Specifications, if the Contractor can demonstrate that compliance with such standard would yield equal performance under the conditions encountered in SEPTA's operating environment, as Approved, and is equally stringent to (or more stringent than) the standard referenced in the Specifications. Alternative standards other than EN or IEC will not be considered.

1.7 Americans With Disabilities Act (ADA)

A. The Americans with Disabilities Act (ADA) prohibits discrimination on the basis of disability in the provision of transportation services by public and private entities:

1. The Department of Transportation (DOT) issues legally enforceable regulations to implement the transportation provisions of the ADA, codified in 49 CFR Parts 37 and 38, and compliance with these regulations is mandatory whether referenced in the Specifications or not.

2. Compliance with interpretations by the Federal Transit Administration (FTA) in Administrators Policy Letters is also mandatory.

B. References are furnished to these parts in the Specifications:

1. 49 CFR 38: Technical requirements for cars are primarily found in this part.

2. 36 CFR 1191, Appendix D: Adopted by DOT in 49 CFR 37, Appendix A, by reference with some modifications. In some cases, requirements from this part are applied to cars.

1.8 Secure Equipment Act of 2021

A. Compliance with the recently enacted Secure Equipment Act of 2021 and implementing regulations adopted by the Federal Communications Commission (FCC) is mandatory for all radio frequency telecommunications devices provided for this project. Use of listed communications equipment or services that the FCC determines pose an unacceptable risk to national security or the security and safety of U.S. persons is prohibited.

1.9 System of Units

A. United States customary units are shown with International System of Units (SI) units following in parentheses. This format applies to the Specifications only; requirements for deliverables, on-car displays, PTUs, and all other required items are presented elsewhere in the Specifications.

B. Rounding: If a difference exists between U.S. customary units and SI units due to rounding or conversion error, U.S. customary units shall be primary.

1.10 English Language

A. Communication with SEPTA and its authorized representatives shall be conducted in the English language only, including but not limited to meetings, correspondence, and other documents submitted to SEPTA and all Work Product produced under the Contract.

B. Contract deliverables and design review documentation shall be prepared in coordination with a native-English-speaking technical writer so that the information is presented in U.S. English, clearly and concisely written.

1.11 Definitions

A. The following terms may appear in this document. They are defined as indicated, whether capitalized or not:

A-Car: The odd-numbered car of a married pair that houses the Positive Train Control (PTC) apparatus.

Acceptance: The formal written acceptance by SEPTA that all work, or a specific portion thereof, under the Contract has been satisfactorily completed.

Acceptance, Conditional: Not fully accepted, but with a defined set of conditions identified for achieving acceptance.

Active Cab: The cab in which the control lock is set to Run, providing control of the train, normally the cab at the front of the train.

Adhesion, Percent: During rolling contact, the maximum value of the ratio between the longitudinal tangential force and the normal force at the wheel-rail interface.

Alignment, Horizontal: The horizontal location of a track as described by curves and tangents.

Anchorage: The attachment of the coupler, draft gear, and drawbar to the car underframe.

Approved: Approved in writing by SEPTA for use on the Silverliner VI cars, unless otherwise stated. Approval in no way relieves the Contractor of meeting all requirements of the Specifications. Approval may be qualified as pertaining to a particular stage of the procurement. Note that “Approved”, “Approved by SEPTA”, “SEPTA Approved”, “SEPTA Approval”, and similar constructions, regardless of capitalization, are synonymous terms.

Approval of Contract deliverables that contain deviations from, or violation of the Specifications does not constitute Approval of that deviation or violation. Deviations shall be specifically submitted for Approval.

Approval is intended to mean that SEPTA is aware of the Contractor's intent and there are no objections to the apparent methods, procedures, designs, or

calculations expressed in the submitted drawings or documents. It does not imply that all calculations, dimensions, materials, components, or other details were checked and verified.

Approved Equal or Equivalent: An item, material, or method offered as a substitute for that specified, for which approval in writing has been obtained from SEPTA. The burden of proof that a substitute is, in fact, equal shall rest with the Contractor.

Automatic Train Control: The subsystem for automatically controlling train movement, enforcing train safety, and directing train operations.

Auxiliary Equipment: Any mechanism or structure, other than the carbody, traction motor, or propulsion equipment gearing that performs a function at some time during the operation of the car: e.g., heating and cooling subsystem, pumps, car door mechanism, air compressor or hydraulic power unit, car lighting, etc.

Availability: The probability that a car will be in operable condition and suitable for revenue service. Availability is defined as the ratio of the total number of cars available for revenue service (s) to the total number of cars in the reliability test fleet (f).

$$\text{Availability} = (s/f)$$

B-Car: The even-numbered car of a married pair.

Blending: In braking, a simultaneous application of dynamic and friction brakes with the effort of friction brake supplementing, as required, the electrical braking to achieve the required total brake effort.

Body Roll: The angle in degrees, from the normal to the top-of-rail height plane to the body centerline as the car sways from side to side during normal running at any speed on level tangent track.

Brake Rack: A car set of friction brake equipment including air compressor; brake calipers; air reservoirs; control valves; chokes; correct piping connections and volumes to evaluate dynamic system behavior; and the associated electrical and electronic controls and interfaces, with relevant pressure and force measurement points built in.

Braking, Dynamic: Electrical braking in which the power generated by the traction motors, when driven as generators, is being dissipated by resistor banks on the car and is providing retardation effort.

Braking Effort: Retarding force developed by the propulsion subsystem, braking subsystem, or a combination of both subsystems.

Braking, Electrical: Braking in which the power generated by the traction motors, when driven as generators, is either dynamic or regenerative.

Braking, Emergency: An irretrievable braking effort to fully stop a car at a higher retardation rate than is obtained with a full service brake application.

Braking, Full Service: The normal maximum braking effort employed to stop a car in the absence of an emergency stop signal.

Braking, Regenerative: Electric braking where the power generated by the traction motor, when driven as a generator, is conditioned and returned to the DC bus.

Business Day: Monday through Friday except United States public holidays.

Car: One unit of a train, whose configuration and performance are described by the Specifications, not designed for independent operation but to be semi-permanently coupled to another car to create a married pair.

Catenary: Overhead power supply wire.

Coast: The mode of operation of car or train in which propulsion (positive traction) and braking are inactive.

Component: Any individual assembly, plug-in module, or element that is designed to perform a particular function relating to the operation of a subsystem such as a traction motor, gear box, door control panel, or friction brake control unit. For the purpose of reliability testing, a component or subsystem shall be considered as a component of a larger system which may require costly repairs to ensure functionality of the system or which, if inoperative, will render the car unusable.

Conditionally Approved: Approved, as defined above, with the condition that open comments shall be addressed prior to Final Approval.

Conductor: Crew person responsible for passengers (e.g. ticketing) who also is main operator of doors.

Console: The control panel located in the cab directly in front of the Operator's seat.

Contract: The written agreements executed by SEPTA and the Contractor, covering the performance of the Work and furnishing of labor, materials, equipment, and tools, including work incidental to the procurement.

Contract Deliverable Requirements List (CDRL): A matrix listing data (such as drawings, catalogs, reports, notices, and samples), services, and equipment that the Contract specifies shall be provided by the Contractor. The matrix also indicates when and how often submittals and resubmittals are required.

Contract Specifications: Documents issued by SEPTA that include the Request for Proposals, Proposal Forms, General Provisions, Terms and Conditions, Technical Specifications, and other forms and exhibits.

Contractor: The person or persons, firm, partnership, corporation, or any combination thereof, which, as an independent Contractor, has entered into a Contract with SEPTA.

Converter: A power conversion system that can convert AC voltage to DC voltage, DC voltage to DC voltage, AC voltage to AC voltage, or DC voltage to AC voltage. Some converters are bidirectional (AC to DC and DC to AC) and are sometimes called 4Q (or four quadrant) Converters. The traction line converter is an example of a 4Q converter.

Coupler: A device for mechanically coupling cars together. This term is also applied to connectors, as in "electrical coupler" and "pneumatic coupler."

Days: Unless otherwise designated, the word "days" means Calendar Days.

Deadman Feature: A device that causes a brake application in the event that inattention or disability of a train operator is detected.

Defect: Malfunction or failure in the manufacture or design of any component or subsystem that causes a car to cease operating or operate in a degraded mode.

Delay, Train: An incident causing a revenue train to be offloaded, or a greater than or equal to 6-minute delay to service, or a lost trip.

Design Life: The period of time for which the car is intended to be safely and reliably usable for its original purpose.

Disapproved: The Contractor shall revise and resubmit the document, drawing, or data for Approval before beginning that portion of the work. The Contractor shall consider issues of overall system design, as appropriate, when resubmitting the document, drawing, or data, instead of merely answering the comments in SEPTA's reply.

Draft Gear: The energy-absorbing mechanism that attaches the coupler to the anchorage.

Dwell: The period of time measured from the instant a train stops at a station until the instant it resumes moving.

Engineer: The individual onboard who occupies the active cab and is responsible for train operation. Also referred to as the "Operator".

Existing Car: As used throughout the Specifications, "existing cars" serves to identify the Silverliner V and Silverliner IV cars.

F-End: The end of either an A-car or a B-car at which the cab is located.

Fail-Safe: Equipment configurations that are implemented in hardware where each component has a known set of predictable failure modes that may be individually analyzed for their effect on equipment performance and function. Any failure or set

of failures resulting from a single causative event must cause the equipment to revert to a safe state that is self-annunciating.

Failure: Any malfunction that requires unscheduled equipment maintenance action, repair, or replacement.

Failure, Chargeable: A chargeable failure of an item is a failure that results in a loss of function of that item, which requires maintenance, repair, or replacement of a car component, including:

A fault of an item while operating within its design and environmental specification limits.

Faults caused by improper operation, maintenance, or testing of the item as a result of Contractor-supplied documentation.

Item degradation discovered during the recommended preventive maintenance interval that causes the loss of function or near loss of function of that item (excluding consumable items). Note: Due to the subjective nature of classifying such instances, upon the Contractor's request, the discrepant item(s) shall be retained for review on SEPTA's property for a period not to exceed 14 days.

Consumable items requiring replacement for reasons other than normal car wear/aging.

Loss of function resulting from the required resetting of circuit breakers, or similar re-initialization of subsystems, including the restarting of subsystems incorporating software.

Failures caused by software.

A failure caused by human actions as a result of inadequate or improper Contractor documentation, training, or subsystem indication.

Failure, Non-Chargeable: A failure or condition of an item due to the following:

A failure caused by a specifically identified failure in other equipment.

A failure caused by human error, except where due to inadequate or improper Contractor documentation.

A failure caused by SEPTA personnel not complying with Contractor's documentation that has been accepted and approved by SEPTA.

A failure caused by accidents not associated with the normal operation of the item, such as collision or striking a foreign object on the right-of-way.

A failure caused by operating the item outside of design or environmental specification limits.

Failure of consumable items requiring replacement during specified preventive maintenance, or which should have been replaced during a previously scheduled preventive maintenance interval and were not.

Failures per Million Miles (FPMM): The FPMM of an item is the ratio of the total number of chargeable failures to the total mileage, in millions, of the Test Fleet.

Failure, No Fault Found (NFF): In complex systems, the occurrence of repeated transient failures is evidence of subsystems that are not fully integrated. The operational impact of transient failures is unacceptable to SEPTA. Therefore, multiple occurrences of a transient failure, one where a failure is reported but no fault is found during investigation, will be classified as Chargeable Failures. Multiple occurrences of "no fault found" on the same car and same subsystem shall be tracked. In such a case, only a single failure shall be recorded, where it can be demonstrated by the Contractor that the fault is due to a common cause.

Failure, Primary: A failure that occurs without being related to the failure of associated items.

Failure, Secondary: A failure of a component that is a direct result of a primary failure of an associated component or subsystem, which can be specifically identified as having been the cause of the failure. Where Secondary Failures occur, it shall be the responsibility of the Contractor to prove that protection measures provided integral to the apparatus in which the secondary failure occurred were adequate. In general, it will not be acceptable for Primary Failure in a component or subsystem to lead to failure in other components or subsystems unless those items are provided specifically to prevent more serious or costly damage. Secondary Failures shall be counted as chargeable failures until proven otherwise to the satisfaction of SEPTA.

Failures, Simultaneous: Multiple primary failures that independently prevent satisfactory equipment performance. Each shall be counted as a chargeable failure.

Failure Rate: The frequency of failure.

Firmware: A type of software typically installed onto an embedded component.

Fleet: All cars furnished under the terms of this Contract.

Furnish: To supply and deliver to project site.

Gauge, Track: The distance between the inside face of rails, usually measured 0.625 inch below the top of the heads of running rails and at a right angle thereto.

Hazard: Any real or potential condition that can cause injury, illness, or death to personnel; damage to or loss of a subsystem, equipment, or property; or damage to the environment.

High Voltage: Primary Power, 230 Vac, and others as defined by system hazard and safety analyses.

Indicated: As described in the Specifications, as-built drawings or as required by the other Contract documents.

Install: To place in position for service or use.

Interface: The point at which one subsystem component or subsystem comes into physical or functional contact with another.

Interlock: An arrangement in which the operation of one function or mechanism automatically causes (or prevents) the operation of another.

Inverter: A power converter that converts a DC voltage to an AC voltage. Inverters may also operate in reverse to generate a DC voltage from an AC voltage. Inverters may generate one or more phases of AC voltage.

Irretrievable: In braking, a condition imposed in which a brake cannot be released until a zero-speed indication is attained.

Jerk: The rate of change of acceleration or deceleration, normally measured in miles per hour per second per second.

Lead Cab: See Active Cab.

Lead Car: In the direction of travel, the forward-most car of the train.

Left Hand: Left side of the car when one looks toward the F-end from inside the car.

Line Replaceable Unit (LRU): An assembly or unit that can be removed and replaced by maintenance personnel to make a subsystem on the car serviceable.

Load Weighing: A function that measures car weight to permit control of tractive effort to achieve a constant effort-to-weight ratio.

Low-Voltage Subsystem: The voltage used for auxiliary systems on the car.

Lowest Line Replaceable Unit (LLRU): The lowest unit (component) of a system or subsystem, which is removable and replaceable from an installed position by standard attachments (e.g., by bolts and nuts or quick-disconnects). This definition is dependent upon the location of the equipment relative to where maintenance is being performed.

Married Pair (Two-Car Unit): The combination of an A-car and a B-car, semi-permanently coupled and sharing certain essential apparatus; a married pair is the smallest unit capable of independent operation.

Mileage, Operating: The operating mileage of a car is the total distance traveled by the car during scheduled and non-scheduled movements over established routes as recorded by SEPTA.

Mileage, Test Fleet: The accumulated mileage of all cars accepted for the test fleet. The Test Fleet shall be accumulated on a calendar monthly basis. The Test Fleet's

monthly mileage shall be derived from actual mileage records as recorded by SEPTA for the cars.

Mean Distance Between Delay (MDBD): Defined as the ratio of the total operating miles accumulated (d) to the total number of train delays (D) attributed to the Contractor. All train delays shall be attributed by SEPTA using their normal review process.

MDBD = d/D

Mean Distance Between Failures (MDBF): Defined as the ratio of the total operating miles accumulated (d) to the total number of chargeable failures (f).

MDBF = d/f

Mean Distance Between Failures - ALL (MDBF-ALL): MDBF considering all chargeable failures whether in service, in the yard, or in the shop.

Mean Time to Repair (MTTR): Average time required to bring subsystem from a failed state to an operational state. MTTR shall be calculated considering diagnostic, repair (or replacement), and retest times only. The MTTR shall not include logistics delay time (the MTTR calculation assumes maintenance personnel and spares are available to make repairs).

The MTTR at subsystem level shall be used to verify that the subsystem meets the maintainability requirements. The initial maintainability analysis predictions shall be confirmed during the Maintainability Demonstration.

The calculation of subsystem MTTR shall use a weighted average taking account of the LRU/LLRU failure rates, and the respective average time to repair for those subsystems. The calculation for subsystem is shown below:

$$MTTR = \frac{\sum_{n=1}^{m} (\lambda_n \times T_n)}{\sum_{n=1}^{m} \lambda_n}$$

where:

MTTR is the Mean Time To Repair for the subsystem

m is the number of subsystems or LRU/LLRUs that make up the subsystem

λn is the subsystem or LRU/LLRU failure rate

Tn is the average time required to repair (corrective maintenance) the respective equipment units following a failure, expressed in hours (subsystem or LRU/LLRU)

Normal Service Conditions: Environmental conditions and operating parameters to which the cars will be exposed and under which the cars must operate in conformance with the requirements of the Specifications.

Offload: All passengers are removed from a train, typically as a result of a fault or failure resulting in a car being removed from service.

Operator: The individual onboard who occupies the active cab and is responsible for train operation. Also referred to as the "Engineer".

Overhaul: Disassembly into component parts or subassemblies; replacement of worn and defective parts (with new or reconditioned parts as approved by SEPTA); and reassembly into complete functional assemblies, in accordance with the OEM recommended instructions/procedures.

Pantograph: A carborne device used to transfer electrical power from the overhead wire to the car.

Penalty Brake: A system initiated Full Service brake application to stop the train.

Performance: The measure of output or results obtained by a component, subsystem, person, team, and so forth, as specified.

Phase Break: Insulated (dead) section of catenary which isolates two different power sources.

Pilot Car(s): The first six cars, three married pairs, to be delivered and utilized for qualification testing. The terms Pilot car, cars, or vehicle are to be considered interchangeable.

Primary Failure: See Failure, Primary.

Primary Power: High-voltage dc power supplied to the car via the interface between the current collector and the contact rail.

Provide: To design, furnish, and install, complete and ready for intended use.

Ready-to-run: Same as AW0, no passengers or crews on board.

Redundancy: The existence within a car or subsystem of more than one means of accomplishing a given function.

Relay, vital: A relay whose function is necessary for the safe operation of the train and whose mode of failure results in the safe condition. Such relays must be approved by the AAR Committee E, Mainline Block Signals.

Reliability: The probability of performing a specified function without failure and within design parameters, for the period of operation intended, under actual operating conditions.

Repair: To restore a failed component or subsystem to an operational state.

Requirements: The criteria that must be met in designing the car.

Revenue service: Use of cars to carry fare-paying passengers.

Rework: To reprocess a component or subsystem to as-designed condition.

Right Hand: Right side of the car when one looks toward the F-end from inside the car.

Safe: Free from unreasonable risk of harm, injury, or danger.

Safety: The condition in which persons are free from unreasonable risk of danger, harm, or loss arising from the design, manufacture, assembly, malfunction, or failure of the train, car, or any of its subsystems or components.

SEPTA: Southeastern Pennsylvania Transportation Authority, the party with whom the Contractor has executed the Contract, or the authorized representative of the party with whom the Contractor has executed the Contract.

Service Life: The actual time during which a car serves its intended purpose of safely and reliably transporting passengers. The end of service life occurs when degradation of the structural integrity of the car, or technical obsolescence of its electrical and mechanical subsystems, requires that it be removed from service.

Service Proven: A demonstrated history, subject to Approval, of satisfactory performance and reliability in rapid transit rail service under a duty cycle, operating conditions, track conditions, and speeds similar to those encountered in SEPTA's operations.

Shall: Denotes a mandatory specification or requirement.

Speed:

Balancing Speed: The speed attained by the car when resisting forces exactly equal the maximum available tractive forces.

Base Speed: The speed to which the maximum constant acceleration can be maintained at the nominal line voltage.

Civil Speed: The operating speed limit assigned to each track segment.

Maximum Operating Speed: The maximum speed at which the car will be operated in normal service.

Schedule Speed: The average speed of a car, from terminal to terminal, obtained by dividing the distance between these points by the time taken to make the trip, including time for intermediate station stops.

Car Design Speed: The speed at which the car can operate continuously, safely and without damage to equipment, independent of any speed limits imposed

by car controls, for all passenger load cases, wheel wear states, track conditions, etc. as defined in the Specifications.

Subcontractor: An individual, partnership, firm, or corporation that undertakes integrally on the Project the partial or total design, manufacture, or performance of one or more items of work under the terms of the Contract. As used herein, the terms "subcontractor," "supplier," and "subsupplier" are synonymous.

Subsystem: A subsystem comprises functional elements interconnected within a married pair to perform a specific function.

Superelevation: On a curve, the vertical distance that the outer rail is above the inner rail, measured in inches.

System: Each married pair, in its design and manufacture, should be treated as a single system rather than as an assembly of independently engineered and manufactured elements.

Test Fleet: All cars being monitored by the Reliability Program.

Time, Dead: The time from the occurrence of a step change of the control signal to the beginning of change of the controlled variable.

Time, Reaction: Time from the initiation of a step change of the control signal to the first attainment of the new steady-state value of the controlled variable, within the designed accuracy.

Time, Recovery: The time required for a subsystem or condition to return to its original state (or some stated percentage of its original value) after being disrupted or destabilized.

Tractive Effort: Propelling or braking force developed by the propulsion subsystem.

Trainline: The means of sending a signal to all cars in a train via a continuous electrical circuit connected through appropriate coupling devices.

Unrestricted Operation: Neither the Operator nor the control subsystems shall be required to alter the way in which the train is operated relative to its normal operating characteristics (e.g., reduce speed, longer dwell times, etc.).

Vital: A function or a unit that is critical to overall train or subsystem safety that is required to be implemented in a fail-safe manner.

Weights, Actual: The measured weights of finished cars ready to run.

Weight, Assigned: The loaded car categories assigned as the basis for design, and for subsystem and car testing.

Weight, Ready-to-Run: The weight of a car that is complete in all respects but without passengers or Operator; also known as the AW0 weight.

Wheel Slide: The condition in which the equivalent linear velocity of the wheel is less than the linear velocity of the car.

Wheel Slip: The condition in which the equivalent linear velocity of the wheel is not equal to the linear velocity of the car.

Wheel Spin: The condition in which the equivalent linear velocity of the wheel is greater than the linear velocity of the car.

Work: The furnishing of all the products, materials, equipment, services and the performance of the contractual requirements in the Contract documents, including changes thereto.

Work Week: Monday through Friday.

Zero-Speed: Car velocity of less than 0.5 mph (0.8 km/h) for more than 1 second.

1.12 Acronyms and Abbreviations

A. The following acronyms and abbreviations may appear in this document. They are defined as indicated:

AAR	Association of American Railroads
AC	Alternating Current
ACSES	Advanced Civil Speed Enforcement System
ADA	Americans with Disabilities Act
ABMA	American Bearing Manufacturers' Association
ABS	Automatic Block Signaling
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
ALG	Application Layer Gateway
ANSI	American National Standards Institute
AOQL	Average Outgoing Quality Level
APIS	Automatic Passenger Information Subsystem
APS	Auxiliary Power Supply
APTA	American Public Transportation Association
AQL	Acceptable Quality Level

AREMA	American Railway Engineering and Maintenance-of-Way Association
AR	As Required
A/R	As Required
ARP	Address Resolution Protocol
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASNT	American Society for Nondestructive Testing
ASTM	American Society of Testing and Materials
ATC	Automatic Train Control
ATO	Automatic Train Operation
ATP	Automatic Train Protection
ATS	Automatic Train Supervision
AWG	American Wire Gauge
AWS	American Welding Society
BCP	Brake Cylinder Pressure
BHP	Brake Horsepower
BPVC	Boiler and Pressure Vessel Code
BSS	Boeing Specification Support Standard
BTE	Bench Test Equipment
Btu	British Thermal Unit
CA	Commercially Available
CAGE	Commercial and Government Entity
CASE	Computer-Aided Software Engineering
CAMS	Communications and Monitoring Systems
CB	Circuit Breaker

CBT	Computer Based Training
CBTC	Communications Based Train Control
CCP	Communications Control Panel
CCT	Color Correlated Temperature
CCTV	Closed Circuit Television
CDR	Conceptual Design Review
CDRL	Contract Deliverable Requirements List, also an item on the list
CEM	Crash Energy Management
CFC	Chlorofluorocarbon
CFD	Computational Fluid Dynamics
CFR	Code of Federal Regulations
CGHAZ	Coarse Grain Heat Affected Zone
CGI	Computer-Generated Imagery
CIL	Certifiable Items List
CMMI	Capability Maturity Model Integration
CMV	Charging Magnet Valve
COTS	Commercial off-the-shelf
COT&S	Clean, Oil, Test and Stencil
CPM	Circular Permanent Magnet
CPM	Critical Path Method
CPU	Central Processing Unit
CRC	Cyclic Redundancy Check
CS	Consist Switch
CSI	Cab Signal Interference
CTFD	Cab and Train Functional Description
DB	Dry Bulb

DBDD	Database Design Description
DBS	Decelerometer-Based Speed
DBTT	Ductile-to-Brittle Transition Temperature
DC	Direct Current
DMS	Document Management System
DOT	Department of Transportation
DPRAM	Dual-Ported RAM
DQT	Design Qualification Test
DST	Daily Safety Test
EAV	Emergency Application Valve
ECAIS	Electric Coupler Advance Inhibit Switch
ECCB	Environmental Control Circuit Breaker
ECN	Ethernet Consist Network
ECP	Engineering Change Proposal
ECU	Electronic Control Unit
ED	End Device
EEPROM	Electrically Erasable Programmable Read Only Memory
e.g.	exempli gratia (for example)
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EN	European Standard
EPA	Environmental Protection Agency
EPROM	Electrically Programmable Read Only Memory
ERS	Event Recorder System
ES	End Station
ESD	Electro-Static Discharge

ETB	Ethernet Train Backbone
ETBN	Ethernet Train Backbone Node
E-TCDN	Ethernet Train Communication and Diagnostic Network
E-TCN	Ethernet Train Control Network
ETFE	Ethylene Tetrafluoroethylene
ETN	Ethernet Train Network
ETP	Electrolytic Tough Pitch
EUN	Ethernet Unit Network
FAI	First Article Inspection
FAT	Factory Acceptance Test
FCC	Federal Communications Commission
FFT	Fast Fourier Transform
FD	Functional Description
FDR	Final Design Review
FEA	Finite Element Analysis
FEM	Finite Element Model
FHA	Fire Hazard Analysis
FMECA	Failure Modes Effects and Criticality Analysis
FMI	Field Modification Instructions
FPMM	Failures per Million Miles
FRA	Federal Railroad Administration
FRACAS	Failure Reporting Analysis and Corrective Action
FRP	Fiber-Reinforced Plastic
FST	Flammability, Smoke, and Toxicity
FTA	Federal Transit Administration, United States Department of Transportation
FTA	Fault Tree Analysis

FTP	File Transfer Protocol
GMAW	Gas Metal Arc Welding
GSA	General Services Administration
GW	Gateway
HAZ	Heat Affected Zone
HCFC	Hydrochlorofluorocarbon
HDLC	High-Level Data Link Control
HP	Hostler Panel
HRI	Hazard Risk Index
HSCB	High Speed Circuit Breaker
HSLA	High Strength Low Alloy (steel)
HTL	Hazard Tracking Log
HTTP	Hypertext Transfer Protocol
HVAC	Heating, Ventilation and Air Conditioning
IACS	International Annealed Copper Standard
IC	Integrated Circuit
ICD	Interface Control Document
ICEA	Insulated Cable Engineers Association
ICMP	Internet Control Message Protocol
ID	Identification
ID	Inside Diameter
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IFI	Industrial Fasteners Institute
IGBT	Insulated Gate Bipolar Transistor

IGMP	Internet Group Management Protocol
I/O	Input/Output
IP	Internet Protocol
IPC	Institute of Printed Circuits
ISACA	Information Systems Audit and Control Association
ISO	International Standards Organization
LACP	Link Aggregation Control Protocols
LAN	Local Area Network
LCD	Liquid Crystal Display
LCU	Logical Control Unit
LED	Light Emitting Diode
LLDP	Link Layer Discovery Protocol
LLRU	Lowest Line Replaceable Unit
LRU	Line Replaceable Unit
LRV	Light Rail Vehicle
LTE	Long Term Evolution
LVPS	Low-Voltage Power Supply
MAC	Media Access Control
MAC Panel	Maintenance Access Panel
MC	Master Controller
MDBD	Mean Distance Between Delay
MDBF	Mean Distance Between Failure
MIL	Military Specification (or Standard)
MLCU	Master Logical Control Unit
MP	Married Pair
MPS	Master Program Schedule

MRB	Material Review Board
MS	Margin of Safety
MTC	Manual Train Control
MTTR	Mean Time to Repair
NACE	National Association of Corrosion Engineers
NBS	National Bureau of Standards
NDT	Nil-Ductility Temperature
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NIC	Network Interface Card
NIST	National Institute of Standards and Technology
NOA	Notice of Assignment
NTP	Notice to Proceed
NVR	Network Video Recorder
OCA	Operational Condition Assessment
OD	Outside Diameter
OEM	Original Equipment Manufacturer
OLED	Organic Light Emitting Diode
OPF	Operation Parameter Files
OSCC	Onboard Secure Code Computer
O&SHA	Operating & Support Hazard Analysis
OSHA	Occupational Safety and Health Administration, United States Department of Labor; Occupational Safety and Health Act
OSI	Open System Interconnection
OTS	Operator Training Simulator
PA	Public Address
PCB	Printed Circuit Board

PCS	Passenger Call Station
PDR	Preliminary Design Review
PDST	Programmable Devices Summary Table
PHA	Preliminary Hazards Analysis
PHL	Preliminary Hazard List
PIV	Peak Inverse Voltage
PLD	Programmable Logic Device
PMI	Production Modification Instructions
PMP	Program Management Plan
P/N	Part Number
PPE	Personal Protective Equipment
PQR	Procedure Qualification Records
PROM	Programmable Read Only Memory
PSS	Program Station Stop
PTC	Positive Train Control
PTD	Portable Test Device
PTE	Portable Test Equipment
PTFE	Polytetrafluoroethylene
PTU	Portable Test Unit
QA	Quality Assurance
QC	Quality Control
QoS	Quality of Service
QR	Quick-response (Code)
RAM	Random Access Memory
RAM	Reliability, Availability, Maintainability
RCIL	Reliability Critical Items List

RE	Railway Engineering abbreviation denoting AREMA-type rail
RF	Radio Frequency
RFC	Request for Comments
RFI	Radio Frequency Interference
RFID	Radio Frequency Identification
rms	Root mean square
rpm	Revolutions per minute
RRB	RAM Review Board
RTCP	Real-Time Control Transport Control Protocol
RTM	Resin Transfer Molding
RTP	Real-Time Transport Protocol
RWAS	Roadway Worker Alert System
SAE	Society of Automotive Engineers
SRAM	System Requirements Allocation Matrix
SCAMPI	Standard CMMI Appraisal Method for Process Improvement
SCCP	Software Configuration Control Plan
SCFM	Standard Cubic Feet per Minute
SCI	Software Configuration Item
SCM	Specification Compliance Matrix
SCIST	Software Configuration Item Summary Table
SCP	Safety Certification Plan
SCR	Software Change Request
SCTR	Specification Change Technical Request
SDD	Software Design Description
SEPTA	Southeastern Pennsylvania Transportation Authority
SFD	System Functional Description

SFTP	Secure File Transfer Protocol, or SSH File Transfer Protocol
SHA	System Hazard Analysis
SiC	Silicon Carbide
SIR	Surveillance Inspection Report
SITPM	Systems Integration Testing Plan and Matrix
SMT	Surface-Mounted Technology
S/N	Serial Number
SNMP	Simple Network Management Protocol
SNR	Signal-to-Noise Ratio
S-P	Severity and Probability
SPL	Sound Pressure Level
SPM	Safety Program Manager
SPMP	Software Project Management Plan
SPTSR	Secure Positive Train Stop Release
SQA	Software Quality Assurance
SQAP	Software Quality Assurance Plan
SQC	Statistical Quality Control
SPL	Sound Pressure Level
SRS	Software Requirements Specification
SRTM	Software Requirements Traceability Matrix
SSFD	Subsystem Functional Description
SSH	Secure Shell
SSHA	Subsystem Hazard Analysis
SSL	Secure Socket Layer
SSPC	The Society for Protective Coatings
SSPP	System Safety Program Plan

STI	Speech Transmission Index
STP	Software Test Plan
STPr	Software Test Procedure(s)
STR	Software Test Report(s)
SST	Software Summary Table
SUM	Software User Manual
SVD	Software Version Description
SVVP	Software Verification and Validation Plan
SVVR	Software Verification and Validation Report
TCD	Train Control Display
TCP	Transmission Control Protocol
TCR	Train Composition Recognition
TCRP	Transit Cooperative Research Program
TELNET	Teletype Network
TFE	Tetrafluoroethylene
TFT	Thin Film Transistor
TFTP	Trivial File Transfer Protocol
TL	Trainline
TLS	Transport Layer Security
TOD	Train Operator's Display
TOR	Top of (Running) Rail
TRDP	Train Real Time Data Protocol
TS	Train Switch
TTDP	Train Topology Discovery Protocol
TWC	Train-to-Wayside Communication
TWDT	Train-to-Wayside Data Transfer

UDP	User Datagram Protocol
UHMW-PE	Ultra-High-Molecular-Weight Polyethylene
UIC	Union Internationale des Chemins de fer (International Union of Railways)
UL	Underwriters Laboratories, Inc.
UMTA	Urban Mass Transportation Administration
UNS	Unified Numbering System
URL	Uniform Resource Locator
US	United States
USB	Universal Serial Bus
USP	Universal Service Port
UTC	Coordinated Universal Time
UV	Ultraviolet
VHF	Very High Frequency
VLAN	Virtual Local Area Network
VMDS	Vehicle Monitoring and Diagnostic Subsystem
VOC	Volatile Organic Compound
VPI	Vacuum Pressure Impregnated
VSWR	Voltage Standing Wave Ratio
WAAS	Wide Area Augmentation System
WB	Wet Bulb
WDR	Wide Dynamic Range
WPS	Welding Procedure Specification
WSP	Wheel Slide Protection
WTB	Wire Train Bus

1.13 Abbreviations for Units of Measure

A. The following abbreviations for units of measure may appear in this document. They are defined as indicated:

A	ampere
A/cm²	amperes per square centimeter
A/in²	amperes per square inch
Ah	amp hours
A/V	ampere per volt
bhp	brake horsepower
Btu/h	British thermal units per hour
Btu/h/°F	British thermal units per hour per degree Fahrenheit
Btu/lb	British thermal units per pound
C	degrees Celsius
cd	candela
cd/ft²	candela per square foot
cd/m²	candela per square meter
cfm	cubic feet per minute
cm	centimeter
cm²	square centimeter
cpm	cycles per minute
dB	decibel
dBA	decibel on the ‘A’ weighted scale
dBC	decibel on the ‘C’ weighted scale
F	degrees Fahrenheit
fc	foot-candle
fps	frames per second
ft	foot

ft^2	square foot
ft^3	cubic foot
ft-lbf	foot pounds force
ft-lb/in	foot pounds per inch
ft/min	feet per minute
ft^3/min	cubic feet per minute
ft/s	feet per second
fps	frames per second
G	acceleration due to gravity (9.81 m/s^2)
g	gram
g/m^2	grams per square meter
gpm	gallons per minute
h	hour
H	henry
in	inch
in^2	square inches
in-lb	inch pounds
in/s	inch per second
Hz	hertz
J	joule
J/mm	joules per millimeter
K	kelvin
kg	kilogram
kg/m^2	kilograms per square meter
kg/m^3	kilograms per cubic meter
kHz	kilohertz

km	kilometer
km/h	kilometers per hour
kN	kilonewton
kPa	kilopascal
kWh	kilowatt-hour
kW/m²	kilowatts per square meter
l	liter
l/m	liters per minute
lb	pound(s)
lb/ft²	pounds per square foot
lb/ft³	pounds per cubic foot
lbf	pound force
lbf/in²	pounds force per square inch
lb/in	pound per inch
l/s	liter per second
m	meter
m/s	meters per second
m²/kg	square meters per kilogram
m³	cubic meter
m³/min	cubic meters per minute
mg	milligram
mg/cm²	milligrams per square centimeter
mg/in²	milligrams per square inch
MHz	megahertz
µin	microinch
µm	micrometer

µN/m²	micronewton per square meter
mi	mile
min	minute
ml	milliliter
mm	millimeter
mm²	square millimeters
mm/s	millimeters per second
MN/m	meganewton per meter
MPa	megapascal
mph	miles per hour
mph/s	miles per hour per second
mph/s²	miles per hour per second squared
ms	millisecond
m/s	meters per second
m/s²	meter per second squared
m/s³	meter per second cubed
m³/min	cubic meters per minute
mT	millitesla
µPa	micropascal
µsec	microsecond
mV	millivolt
µV	microvolt
N	newton
N-m	newton-meter
N/mm²	newton per square millimeter
oz	ounce

oz/in²	ounces per square inch
oz/yd²	ounces per square yard
Pa	pascal
ppm	parts per million
psi	pounds force per square inch
psig	pounds per square inch gauge
rpm	revolutions per minute
s	second
scfm	standard cubic feet per minute
V	volt
Vac	volt alternating current
Vdc	volt direct current
V/m	Volts per meter
W	watt
w.g.	water gauge
Wh	watt hour
W/h/°C	watts per hour per degree Celsius
Wh/m²	watt hour per square meter
W/m²	watts per square meter
yd	yard
yd²	square yard

1.14 Contract Deliverable Requirements List (CDRL)

No CDRLs are required for this Section.

1.15 Referenced Standards

The following standards are referenced in this Section:

36 CFR 1191	Americans With Disabilities Act (ADA) Accessibility Guidelines for Buildings and Facilities; Architectural Barriers Act (ABA) Accessibility Guidelines, Appendix D, Technical
49 CFR 37	Transportation Services for Individuals With Disabilities (ADA)
49 CFR 38	Americans With Disabilities Act (ADA) Accessibility Specifications for Transportation Vehicles

SECTION 2
DESIGN AND PERFORMANCE CRITERIA

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2.1 General

2.1.1 Scope

A. This Section describes the operating environment in which the car must perform; and establishes general design criteria and system performance.

2.1.2 Design and Manufacturing Coordination

A. The Contractor shall be responsible for system design of the entire car and all its equipment.

B. The Contractor shall be responsible to SEPTA for proper interrelation, function, and system integration of all phases of all vehicle systems and their interrelation with all other parts of the car and associated support and wayside equipment.

C. The Contractor shall be responsible for the integration and interface of all Contractual requirements.

D. The Contractor shall present its approach to the integration and interface at the kickoff meeting.

E. Vehicle and system designs shall consider the concept of life-cycle cost. Designs that maximize reliability and availability and minimize maintenance costs are preferred.

F. The Contractor shall be responsible for ensuring all requirements, guidelines, and other information relevant to the design, manufacture, and test of the vehicles are passed on to all its subsuppliers and vendors.

G. Interfaces regarding "outside the car envelope" topics shall be coordinated with SEPTA by the Contractor. Subject areas requiring such interfaces include, but are not limited to, the wayside signal system, cab signal system, Control Center radio system, various communication systems, overhead power supply, maintenance facilities, the car's RFI and EMI limits, and clearances. This shall include both the SEPTA and Amtrak wayside.

2.1.3 State and Federal Requirements

A. The cars shall comply in all respects with the latest requirements of the applicable laws and regulations of the United States of America, especially the regulations of the Federal Railroad Administration of the United States Department of Transportation (such as, but not limited to, the Part 200 series of Title 49 of the Code of Federal Regulations), and of the states of Pennsylvania, Delaware, and New Jersey, including their respective Public Utility Commissions, in which the cars will be operated by SEPTA.

B. The Contractor and its suppliers are responsible for obtaining CFR or other mandated standard approval or certification for parts or components that require such.

C. Testing shall be conducted in full compliance with all FRA requirements.

D. It is noted that while specific agency regulations and recommendations are called for in this Technical Specification, they shall not be considered to be to the exclusion of all others.

E. Should there be an inadvertent conflict between Federal or State regulations and this technical specification, the Contractor shall immediately bring these to SEPTA's attention.

2.1.4 ADA Requirements

A. The Contractor and its Industrial Designer shall ensure that the cars comply in all respects with the requirements of the Americans with Disabilities Act of 1990, and the regulations contained in 49 CFR Parts 27, 37 and 38, sub-parts A and E, and 36 CFR Part 1192 which are in effect at the time of contract award.

B. Parking space for two mobility devices shall be provided adjacent to the high level boarding doors. Details to be defined during design review. See also Section 14, Interior and Exterior Appointments.

C. Floor and interior surfaces should have high contrast colors in this regard, and high contrast signage and striping patterns at folding seats, doorway thresholds, step risers, handholds and the like shall be provided, as Approved.

D. Door closing signals shall be provided at the individual door opening to provide an audio guide for passengers with reduced vision acuity.

E. Audio tones disturbing to canine guides shall be avoided.

2.1.5 Human Engineering

A. The car design shall be based on human factors engineering.

B. All switches and controls shall be designed for ease of logical use.

C. The cab shall be spacious, well insulated from sound, and arranged to have the most ergonomic layout possible to avoid repetitive motion injury.

D. Exterior safety appliances shall be designed for maximum ease of use.

E. Any surface exposed to passengers shall not rise above 125 °F (51.7°C).

F. The Operator's cab, train crew controls and passenger area design shall accommodate the 5th percentile female to 95th percentile male of current United States adult general population anthropometric data.

G. Vehicle maintenance locations and other non-passenger areas shall be designed to the 5th percentile female to 95th percentile male, with normal vision and hearing.

H. Specifics may be found in "The Measure of Man and Woman: Human Factors in Design." by Alvin R. Tilley.

2.1.6 Commercial Off The Shelf parts

A. To the most practical extent and unless otherwise requested in this specification, the use of commercial off the shelf (COTS) parts or equipment is required.

2.1.7 Limitation of Technical Specification

A. The design criteria and constraints that are known to SEPTA have been specified.

B. If other factors require definition after Contract award, the Contractor shall be responsible for making those definition requirements known to SEPTA in a timely manner for mutual investigation and satisfactory resolution.

C. The Contractor shall not be relieved of the overall responsibility of providing an adequate design for the SEPTA service conditions.

2.1.8 Energy Efficient Design

A. The design of the vehicles shall permit operation to be as efficient as possible. Several sections of this document contain requirements for equipment efficiency. These shall be regarded as minimum requirements, and efforts shall be made to improve efficiency wherever practicable.

1. The net energy usage per mile shall be no greater than 7.3kWh per mile per married pair. This value shall be the average net energy usage over the complete SEPTA system during a one year test. Refer to Section 15, Test Program, for further details.

2. The average energy consumption of all auxiliary loads per car shall not exceed 45.895kW. This value shall be the average net energy usage over the complete SEPTA system during a one year test. Refer to Section 15, Test Program, for further details.

3. Should the energy usage values obtained during the one year test be different to the specified values, the Contractor may propose alternate energy consumption requirements for approval. Any proposal to amend the energy consumption requirements shall be accompanied by a thorough justification.

4. The values for energy usage per mile, and energy usage for the auxiliary system, are based on those for the SEPTA Silverliner V car. Following the completion of the one year energy consumption test, and should the Contractor so request, SEPTA will make available a married pair of SEPTA Silverliner V cars so that the Contractor may measure and verify the average energy usage of those car.

B. During each design phase, the Contractor shall update and submit the energy consumption simulations and predictions initially provided as part of the proposal package, as detailed in EN 50591.

C. The vehicle, including but not limited to the propulsion equipment (as detailed in Section 10, Propulsion and High Voltage System), shall be equipped with suitable energy measurement equipment.

D. Sufficient and suitable measurement and recording equipment (as detailed in Section 18, Diagnostics) shall be provided to permit a direct comparison between the recorded data and the submitted energy consumption simulations and predictions.

E. During vehicle and equipment qualification testing, the results of actual energy measurements shall be recorded. The energy measurement results shall be analyzed and compared by the Contractor with the submitted simulations.

F. The Contractor shall prepare and submit for Approval a report containing the results of the energy usage comparisons for each identified system. The report shall provide an overall result that identifies the percentage deviation at system level and at vehicle level between the predicted energy consumption and the actual energy consumption. **(CDRL 02-01, Energy Efficiency Report)**

2.1.9 Design Life

A. The vehicle shall be designed and manufactured to perform satisfactorily for a minimum of 40 years.

B. The carbody and all its structural elements, including trucks and running gear, shall have a minimum design life of 40 years of operation at AW2 load.

C. The design and the selection of materials shall prevent corrosion damage, including the effects of winter station and grade crossing ice/snow melting products, carwash solutions, and commonly used cleaning agents (see Section 16, Materials and Workmanship), during the 40-year design life.

D. Identify individual components (e.g. video screens) that are desirable for their technology, but do not meet a minimum design life of 20 years, for possible Approval. These components shall be listed at the kickoff meeting in a dedicated list and updated during the design review phases as needed.

2.1.10 Vehicle Configuration

A. The following vehicle configurations are required:

1. Standard married pair

2. Airport Service married pair (if selected)

a. Interior layout and equipment differences from standard married pair are described in Section 14, Interior and Exterior Appointments

b. All cars shall have all needed provisions (wiring, mounting/attachment points, etc.) to convert a standard car to an airport car, or to convert an airport car to a standard car.

3. Test and Inspection married pair (details are described in Section 28, Test and Inspection Vehicle, if selected).

B. Both cars of each married pair shall have a full-width cab installed at the “F” End.

C. The Operator's console shall be offset to the right side of the car.

D. The cab shall be separated from the passenger compartment by a wall with a hinged lockable door.

1. When the cab is occupied, the door shall separate the entire front end from the passenger compartment.

2. When the cab is not occupied, the door shall lock the operator console and allow passenger or crew access to the end door.

E. The married pair shall be capable of independent operation, and it shall be possible to couple together other married pairs at either end to obtain the desired train consist length (see Section 2.1.11 regarding maximum consist lengths).

F. The cab end of each car of the married pair shall be designated as the "F" end.

G. The opposite end of each car shall be designated as the "A" end.

H. Wheels and door leaves shall be numbered starting from the "F" end, with all odd-numbered components on the same side of the car.

I. Traction motors, gear units, axles and trucks shall be numbered starting from the "F" end.

2.1.11 Car Numbers

A. Car numbers shall be assigned as Approved.

B. Odd numbers shall be assigned to A-cars (the car containing the ATC/PTC unit), with the next higher even number being assigned to the B-car in the married pair.

C. Numbers shall be marked on the cars as specified in Section 14, Interior and Exterior Appointments.

2.1.12 Train Consist Operational Compatibility

A. Silverliner VI cars shall be capable of fully functional operation in dedicated Silverliner VI train consists and shall be capable of operation with other equipment types at a reduced level of functionality. Details are described below:

B. Train consists comprised exclusively of Silverliner VI cars:

1. Normal train consists will not exceed 6 cars.

2. The cars shall be fully compatible for normal operation in trains of up to 12 cars; this will permit one disabled train to couple to another train, and also permit regular shop movements of empty trains.

C. Mixed Silverliner VI and Silverliner V train consists:

1. The cars shall be coupled via the mechanical coupling, inclusive of the integral pneumatic connections of Main Reservoir and Brake Pipe.

2. There is no intention to routinely operate Silverliner VI and Silverliner V cars together in normal revenue service in mixed consists.

3. This capability will be used for emergency rescue of a disabled train with passengers, and for regular shop movements of empty trains.

D. Locomotive-hauled operation:

1. The cars shall be fully compatible for unlimited duration movement when locomotive-hauled or coupled to conventional freight cars as in a freight train.

2. Each married pair shall be provided with one appropriate coupler adapter to connect to an Association of American Railroads knuckle coupler and equipped with a permanently connected brake pipe hose.

E. Hose orientation shall be similar to the arrangement used on the Silverliner V cars and shall use the identical style hose.

2.2 Dimensions, Clearances, and Track Standards

2.2.1 Vehicle Dimensions

A. The maximum exterior dimensions listed below and in the clearance limit drawing in Appendix I shall not be exceeded.

Dimension Description	Dimension (U.S.)	Tolerance (U.S.)	Dimension (Metric)	Tolerance (Metric)
Length of car over couplers	85 ft. 1.5 in.	+0.75 in., -0 in.	25.95 m.	+1.905 cm., -0 cm.

Dimension Description	Dimension (U.S.)	Tolerance (U.S.)	Dimension (Metric)	Tolerance (Metric)
Maximum overall height above rail, new wheels	14 ft. 8 in.	+0 in.	4.47 m.	+0 cm.
Maximum pantograph lock down height	14 ft. 8 in.	+0 in.	4.47 m.	+0 cm.
Width of car body, at floor height	10 ft. 0 in.	±0.125 in.	3.05 m.	±0.3175 cm.
Width of car body, above floor height	10 ft. 6 in.	+0 in.	3.2 m.	+0 cm.
Truck spacing, center-to-center	59 ft. 6 in.	+0 in., -0.25 in.	18.14 m.	+0 cm., -0.635 cm.
Floor height above rail, new wheels	4 ft. 3in.	±0.25 in.	1.3 m.	±0.635 cm.
Minimum interior clear width at widest point	10 ft. 0 in.		3.05 m.	
Minimum clear opening height of side window	2 ft. 0 in.	-0 in.	0.61 m.	-0 cm.
Minimum interior height, low ceiling (if approved)	6 ft. 9 in.		2.06 m.	
Minimum interior height,	7 ft. 3 in.		2.21 m.	
Minimum side doorway opening height (high platform)	6 ft. 6 in.		1.98 m.	
Minimum side doorway opening clear width	2 ft 10 in.		0.86 m.	
Minimum end doorway opening height	6 ft. 8 in.		2.03 m.	
Minimum end doorway opening width	2 ft. 6 in.		0.76 m.	
Coupler centerline height above rail	2 ft. 10.5 in.	+0 n. -0.5 in	0.88 m.	+0 cm, -1.27 cm.
Distance between carbody jacking pads (two sets of pads)	61 ft. 7.88 in. 57 ft. 4.12 in.	±0.25 in. ±0.25 in.	18.79 m. 17.48 m.	±0.635 cm. ±0.635 cm.

Dimension Description	Dimension (U.S.)	Tolerance (U.S.)	Dimension (Metric)	Tolerance (Metric)
Center aisle minimum width, 3+2 seating area	1 ft. 9 in.		0.53 m.	
Center aisle minimum width, 2+2 seating area	2 ft. 8 in.		0.81 m.	
Average annual mileage per car	61,000 mi.		98,170 km.	

2.2.2 Track Standards

A. The SEPTA portion of the Railroad Division is operated in compliance with FRA Track Standard Classes 1 through 4 and maintained according to SEPTA SMW-100 Track Department Manual, and over Amtrak Northeast Corridor and Harrisburg Line track with FRA Track Standard Classes 1 through 6.

B. The car design considerations for maximum track deviations shall be based upon the appropriate FRA class and maximum permissible speed. Refer to the Federal Railroad Administration (USDOT) Track Safety Standards, 49 CFR Part 213 for detailed information on allowable track geometry.

C. No warranty is made by SEPTA that track will be maintained in its present condition. The car shall be designed to operate at an unbalanced curve superelevation of 5.0 inches (12.70 cm) in accordance with 49 CFR Part 213.57 (d).

D. Rail Details

Rail Type:	Rail Weight: 115 RE	80 percent
	Rail Weight: 132 RE	20 percent
Joints:	Welded	90 percent
	Bolted	10 percent
Tie Plate Cant:		1 in 40
Minimum Lateral Radius:	Main Track:	440 feet (134.11 m)
	Yard Track:	220 feet (67.06 m)
Maximum Actual Superelevation:		6 inches (15.24 cm)
Most severe reverse curve conditions (crossovers):	Main Track:	R1: 800 feet (243.84 m) T: 0 feet (0 m) R2: 800 feet (243.84 m)
	Yard Track:	R1: 450 feet (137.17 m) T: 0 feet (0 m) R2: 450 feet (137.16 m)
Minimum frog no. - crossover between tracks on 12-foot centers:		6 1/2
Maximum vertical gradient:		1 in 20

Maximum vertical curve (parabolic):		2000 feet (609.60 m)
Nominal track gauge:		4 feet, 8.5 inches (1.44 m)
Minimum track spacing:		11 feet, 9 inches (3.58 m)

2.2.3 Passenger Stations

A. The SEPTA Railroad Division and the Amtrak Northeast Corridor and Harrisburg Line use both high-level and low-level station platforms.

1. High-Level Platforms

a. Platform Design Height (above top of rail):

4 feet, 0 inch (1.22 m)

b. Platform edge to centerline of track (min. distance):

5 feet, 7 inches (1.70 m)

2. Low-Level Platforms

a. Platform Design height (above top of rail):

8 inches (0.20 m)

b. Platform edge to centerline of track (min. distance):

5 feet, 1 inch (1.55 m)

2.2.4 Catenary Wire

A. The SEPTA Railroad Division and the Amtrak Northeast Corridor and Harrisburg Line use fixed tension catenary systems.

B. All wire heights are measured from the top of the running rail to the bottom of the contact wire.

1. Wire height is for a 11,500 Volt catenary.

a. Minimum wire height: 15 feet, 0 inch (4.57 m)

b. Maximum wire height: 22 feet, 6 inches (6.86 m)

2.2.5 Clearances

A. The complete car under all operating conditions must comply with Amtrak's clearance envelope.

B. The following shall apply with the wheels and suspension system at the dimension which is the worst case for the particular condition:

1. No parts of the car shall exceed the dynamic clearance envelope determined by the dimensional outline shown in the car clearance diagram in Appendix I.

C. When measured at the plane of the top of rail on level tangent track under both normally inflated air suspension conditions (with all leveling valves then locked in the neutral position) and fully deflated air suspension conditions, no part of the car at both AW0 and AW1 load condition shall extend more than 5 feet 8 inches (1.73 m) from track centerline when one rail is then superelevated 6 inches (15.24 cm).

D. Truck components shall clear the running rails by a minimum of 2.75 inches (6.99 cm) with fully worn wheels and AW3 load.

E. Sufficient clear access shall be provided to the axle ends to allow wheel truing without the removal of any parts.

F. The car shall be designed so that the carbody and its underfloor equipment shall clear the running rails in the event of a derailment with the wheels resting on the ties.

2.2.6 Trucks and Underfloor Equipment

A. The carbody and attached equipment shall be designed to provide positive clearance for the trucks under worst case operating conditions, except for any stops attached to the carbody for the purpose of limiting truck movement in case of derailment.

B. Worst case conditions will result from such factors as horizontal and vertical curves, track superelevation, worn wheels, maximum passenger load, sway, derailment, suspension system failures, etc., either singly or in combination.

C. Sufficient clearance shall be provided in the truck areas such that if one axle of the car is lowered 8 inches (0.20 m), as in a derailment, there shall not be contact with any wheel by any part of the car when air springs are deflated.

D. All underfloor mounted equipment, unless otherwise required, shall clear the running rails under normal conditions by a minimum height of 8 inches (0.20 m), to prevent excessive damage during a derailment.

2.2.7 Clearance Diagram

A. As part of the Conceptual Design Review efforts, and continuing thereafter, the Contractor shall prepare a complete set of clearance diagrams for the car. **(CDRL 02-02, Vehicle Clearance Diagrams)**

B. These shall include static and dynamic clearance envelopes relative to the wayside allowances, lean allowance, clearances for all parts of the truck, and identification of the center of gravity and roll center.

C. A diagram shall be included of the car superimposed on the car clearance diagram in Appendix I along with all supporting calculations and all necessary cross sections, which shall show the worst-case clearance to the outline including offset due to curve compensation.

D. All supporting calculations and conditions shall be provided as part of this deliverable.

E. Roll angle shall comply with 49 CFR Part 213.57 (d).

F. Single point suspension failures as well as truck and wheel wear shall be included in the calculations.

2.3 Wayside Signal System

A. The SEPTA Railroad Division and the Amtrak Northeast Corridor and Harrisburg Line signal systems consists of wayside signals and cab signals controlled by 100 Hertz and 250 Hertz double-rail track circuits.

B. US&S Tru-II, GRS Phase Selective and US&S Phase Selective vital track relays are used.

C. Pickup current values vary depending upon the manufacturer, and the Contractor is required to verify these values with the manufacturer during emissions testing.

D. Train detection at highway grade crossings is performed by audio frequency overlay track circuits.

E. The minimum cab signal system in-rail current is 2.0 Amperes at the entering end of a track circuit.

F. Further details for the ATC and PTC systems can be found in Section 20, ATC/PTC.

2.4 Operating Environment

2.4.1 General

A. The Contractor is required to design and construct the cars to be fully suitable for the environmental conditions in the Philadelphia area, such as temperature conditions, relative humidity, precipitation (including rain, snow and freezing rain), wind, fogs, ultraviolet radiation, and atmospheric contaminants that may include, but not be limited to, water vapor, deicing salts, ozone, nitrous oxide, hydrogen sulfide, particulates, nitrogen dioxide, sulfur dioxide, carbon monoxide, acidic rainfall, fuel oil, diesel emissions, cleaning solutions, oil vapor, carbon, silica, iron, and copper.

B. The car shall be capable of being operated at the specified performance levels, stored, and maintained without impairment resulting from the natural or induced environmental conditions, such as car washing and use of calcium chloride or other deicing agents, within which SEPTA will operate the vehicle.

C. The climate factors listed below shall be used as design guidelines and considered operational requirements.

D. Actual localized temperatures and conditions within and under the car will be more severe than the ambient climatic conditions due to conditions such as solar loading, equipment heat emissions, undercar heat trapped under high level station platforms and elevated tunnel temperatures. The Contractor shall be responsible for evaluating these factors and shall ensure that the design of all equipment takes these factors into consideration.

E. The Contractor will be required to ensure that the cars and all components and subassemblies will not be subject to any degradation or damage from exposure to more extreme environmental conditions than those listed below during manufacture, storage, and shipment.

2.4.2 Environmental Conditions

Ambient Temperature:	-15°F to 120°F (-26°C to 49°C)
Relative Humidity:	20% to 100%, including conditions of condensation
Maximum Rainfall (Amount):	10.7 in (272 mm) in 24 hours
Maximum Rainfall (Intensity):	8.9 in/h (226mm/h) for 15 minutes
Maximum Snowfall:	31 in (787 mm) in 24 hours
Maximum Wind Speed (Sustained):	73 mph (117 km/h)
Maximum Wind Speed (3s Gust)	90 mph (145 km/h)
Ice or Freezing Rain:	10 - 12 times per year

2.4.3 Car Wash

SEPTA Yards are equipped with car wash facilities to maintain the exterior cleanliness of the fleet. The cars shall be able to operate through the car wash at restricted speed, with no damage to any components or subsystems, throughout their entire design life.

2.5 Weight

2.5.1 Weight Limitations

A. To minimize operating costs and the loadings on existing wayside structures, the Contractor shall, by making maximum use of its technical expertise and the most weight-efficient designs available, produce a car of minimum weight without compromising vehicle integrity or the specification requirements.

B. The design weight of a car (AW0 Target Weight), empty of passengers and crew but ready to run, shall be conformed at the Technical Specification Review Meeting on the basis of the Contractor's technical proposal and shall not exceed 145,000 pounds (65770.89 kg) for either car of a married pair. Variation in weight between the "A" and "B" cars shall not exceed 7,000 pounds (3175.15 kg).

C. No car in excess of the Rejection Weight of 156,000 pounds (70,760.41 kg), whether measured or calculated, will be permitted onto SEPTA property. The Rejection Weight limit is not to be exceeded under any circumstances.

D. Load conditions of the car:

1. AW0: The assigned weight of an empty car, ready for revenue service, with neither crew nor passengers aboard.

2. AW1: AW0 plus all passenger and Operator seats occupied. Where an ADA parking space is provided, the weight of a passenger with mobility device shall be used.

3. AW2: AW1 plus four passengers per square meter (0.37 passengers per square foot) of standing area. Where flip-up seats are provided, the worst case, seated passengers or standees at such location, shall be used.

4. AW3: AW1 plus six passengers per square meter (0.56 passengers per square foot) of standing area. Where flip-up seats are provided, the worst case, seated passengers or standees at such location, shall be used.

E. Passenger and Operator Weights

1. Passenger weight to be assumed: 175 lb (79 kg).

2. Operator weight (with tools) to be assumed: 300 lb (136 kg).

3. Passengers with mobility aid devices weight to be assumed: 600 lb (272 kg).

2.5.2 Weight Balance Criteria

A. Each car shall be balanced laterally and longitudinally. The calculated lateral unbalance shall not exceed 40,000 inch-pounds (4,518.39 N-m).

B. The truck-to-truck weight difference within a car shall not exceed 2,000 pounds (907.18 kg).

C. The load on each axle of a car with AW0 load in a ready to run condition shall be between 24 and 26 percent of the car weight.

D. The use of additional ballast weight is not allowed to compensate for imbalance conditions.

E. Balance shall be obtained through equipment placement without compromising maintenance access.

2.5.3 Weight Reporting

A. The Contractor shall not permit vehicle performance or structural factors of safety to be degraded by the as-built weight exceeding the weight estimates used during design.

B. The Contractor shall require the full cooperation of its Subcontractors in this effort and shall require weighing of sample components at the earliest possible dates.

C. The Contractor shall create and maintain through the warranty period a car weight report: **(CDRL 02-03, Car Weight Report)**

1. The report shall present:

a. Car weights, including a breakdown of the weights of components that comprise the car, imbalance, and axle loading.

b. Center-of-gravity data.

c. Breakdown of car weight by subsystem.

d. Weights for truck-mounted and carbody- mounted components separately before totaling them.

D. Contractor shall include the report with each monthly project update, as specified in Section 25, Program Management and Commissioning.

E. Where relevant, the report shall note the impact of weight reduction recommendations, as part of this report.

F. Actual weight values shall tabulate and report car weights from pre-shipment inspections.

G. Contractor shall provide final weight estimate accounting for all changes to the cars (e.g., field modifications).

2.6 Noise, Shock, And Vibration

2.6.1 General

A. The noise environment created by each car shall at all times comply with the requirements of 40 CFR Part 201, 49 CFR Part 210, and 49 CFR Part 229.

2.6.2 Interior Noise Levels

A. The sound level in the cab during normal operation shall average less than or equal to 85 dB(A), with an upper 99% confidence limit of 87 dB(A) per 49 CFR 229.121. Noise measurements shall be made using a sound level meter and measurement technique

conforming, as a minimum, to the requirements of Subparagraph (a)(3) of 49 CFR 229.121.

B. With the car stationary on open, ballasted track the sound level with all doors and windows closed, all subsystems systems including the air compressor in operation and the HVAC system operating in normal speed fan mode, the noise level shall not exceed 68 dB(A).

C. The sound level in the passenger seating area at AW0 load shall not exceed 75 dB(A) when the car is operated in open, dry, level tangent ballasted welded rail track meeting FRA Class 4 track characteristics, in any normal mode of acceleration, deceleration or coasting with all subsystems operating, at speeds up to 70 miles/hour (112.65 km/hour).

D. Sound level measurements shall be made in accordance with ANSI S1.4 requirements for a type II instrument and set to an A-weighted slow response.

E. For octave and one-third octave band measurements, filters in accordance with the latest version of ANSI S1.11 shall be used.

F. The noise level shall be measured at approved locations inside the car as follows:

1. Passenger area:

    a. Not less than one (1) foot from finished surface of ceilings, end walls, or side walls on each vehicle level.

    b. At the approximate height of a seated passenger's ears at representative locations throughout the car.

    c. At the approximate height of a standing passenger's ears at representative locations throughout the car

    d. One (1) foot from the geometric center of and perpendicular to each return air grille

    e. At all door locations 24 inches from the finished surface and 63 inches above the top of the finished floor.

2. Operator Cab:

    a. The cab compartment noise shall be measured at the seated operator’s ears when all cab windows are closed, and shall be compliant with the requirements specified in 49 CFR 229.121.

G. These limits may be temporarily exceeded during initial car heating and air conditioning pull-up or pull-down conditions.

H. The allowable noise level shall be reduced by at least 3 dB if significant pure tones in the range from 250 Hertz to 4,000 Hertz are present in the noise.

I. Pure tone noise shall be considered significant in this context if any one-third octave band sound pressure level is 5 dB or more higher than the arithmetic average of the two adjacent bands containing no pure tones.

2.6.3 Exterior Noise Levels

A. The sound level on either side of the car 50 feet (15.24 m) from the track centerline measured at five (5) feet above top of rail in an open area with no fences, sound barriers or other wayside obstruction or sound reflecting surfaces within 100 feet (30.48 m) of the test location shall not exceed an A-weighted sound level using fast meter response, for a married pair, of 70 dB(A) for the cars stationary with all subsystems operating.

B. The sound level on either side of the car 50 feet (15.24 m) from the track centerline measured at five (5) feet above top of rail in an open area with no fences, sound barriers or other wayside obstruction or sound reflecting surfaces within 100 feet (30.48 m) of the test location shall not exceed 85 dBA at 70 mph for any operating condition (acceleration, coasting, braking or emergency braking), and shall not exceed 73 dBA for any operating condition when operated between 0 and 30 mph.

C. In all cases the allowable noise level shall be reduced by at least 3 dB if any pure tones in the range from 250 Hertz to 4,000 Hertz with a one-third octave band sound pressure level 5 dB or more greater than the arithmetic average of the two adjacent bands containing no pure tones are present.

D. The track shall be open, dry tangent ballasted welded rail track meeting FRA Class 4 track characteristics.

E. Sound level measurement shall be made in accordance with ANSI S1.4 requirements for a type II instrument set to an A-weighted fast response, with filters in accordance with ANSI S1.11 used for one-third octave measurements.

2.6.4 Vibration

A. Where more onerous or conflicting requirements are contained in these vibration requirements, more onerous requirements shall supersede any less onerous requirements.

B. All car components shall be designed and mounted to have structural integrity and be operationally reliable for the vibration environment at the point of attachment and shall prevent unacceptable vibration inputs to the attachment structure.

C. The component structure and mounting shall be designed to prevent amplification through component resonance beyond a level twice that of the attachment point.

D. The vibration force output of any rotating component shall not exceed the vibration environment specified for the component.

E. When the car is stationary with all subsystems operating except the traction motor circuit, vertical or horizontal vibrations in any location of the car interior shall not exceed 0.10 inch (0.254 cm) peak-to-peak amplitude between 0 and 1.4 Hertz, 0.01g peak acceleration between 1.4 and 14 Hertz, or 0.045 inch per second (0.114 cm per second) peak vibration velocity above 14 Hertz.

F. All carbody mounted equipment attachments shall be designed to meet the Equipment Attachment requirements of APTA PR-CS-S-034-99.

G. Truck components located above the primary suspension shall be designed to withstand continuous vibrations of at least 6 g at frequencies up to 100 Hertz in all directions, as well as randomly orientated shock loads of 8 g.

H. For truck components carried on the axles the Contractor shall, in conjunction with its subcontractors, jointly determine the most severe shock and vibration values arising from the combination of the proposed equipment and operation on the SEPTA regional rail system so that apparatus suitable for the service intended shall be provided.

I. All equipment shall be designed to meet the shock and vibration requirements as defined in IEC 61373.

2.6.5 Ride Quality

A. The ride quality of the car shall be evaluated according to ISO 2631-1.

B. Measurements shall be conducted over representative portions of the SEPTA Railroad making all local stops while operating at normal scheduled speed.

C. With air bags inflated, the root mean square (rms) acceleration values shall not exceed:

1. Maximum 0.315 m/s2 for each measurement point.

D. With air bags deflated, the rms acceleration values shall not exceed:

1. Maximum 0.62 m/s2 for each measurement point.

E. With air bags inflated, the vibration total value (root sum of squares summation) shall not exceed:

1. Maximum 0.5 m/s2 for each measurement point.

F. With air bags deflated, the vibration total value shall not exceed:

1. Maximum 1.0 m/s2 for each measurement point.

G. Acceleration data shall be evaluated over the frequency range 0.5 to 80 Hz. Where appropriate, use frequency weighting Wb (ISO 2631-4) instead of Wk.

2.7 Catenary Power Supply

A. The cars will be operated over the tracks and catenary system of both SEPTA's Railroad Division, and Amtrak's Northeast Corridor and Harrisburg Line.

B. Both systems employ an overhead catenary system supplying a nominal 11,500 Volts AC at 25 Hertz. Voltage regulation is nominally plus or minus 10 percent.

C. Both systems use a solid-state frequency converter system. The per-car current draw from the catenary system during propulsion, as well as current fed back into the catenary during regenerative breaking, must not exceed a maximum of 150 Amperes at 11,500 Volts. On each revenue trip the car will normally be operated through a phase break.

D. All equipment on the car shall be protected from damage or maloperation caused by random interruptions or termination of the catenary contact line power due to phase break, pantograph bounce, ice, unexpected shutdown, or other conditions. Any equipment that shuts down due to these conditions shall automatically restart when line voltage conditions return to normal. Where the Primary Circuit Breaker is required to open due to phase break or system change, or any other catenary power condition, it shall do so automatically, without operator intervention. When line voltage conditions permit, the Primary Circuit Breaker shall automatically reclose.

E. The catenary power supply system is characterized by significant distortion to the nominally sinusoidal waveform. It shall be the Contractor's responsibility to ensure that all car systems are fully compatible with the existing catenary power supply system encountered during normal operation of the trains. SEPTA will not under any circumstance modify the catenary power supply system to accommodate any shortfall in the design of any car system.

F. For the purposes of ensuring that the proposed high voltage equipment for the car is fully compatible with the catenary supply system, the Contractor shall conduct analyses and measurements of the catenary power supply system as necessary to acquaint itself with all aspects of the overhead catenary system.

G. All necessary measurements and analyses shall be completed prior to Preliminary Design Review (PDR).

H. The results of the analyses and measurements shall be submitted to SEPTA for record purposes. **(CDRL 02-04, Catenary Power Supply Analysis and Measurement Report)**

I. The Contractor shall note that where any characteristics of the actual system are outside of the details provided in this technical specification, the characteristics of the actual system supersede any details included in this technical specification.

2.8 Electromagnetic Interference and Compatibility

2.8.1 General

A. The Contractor shall submit electromagnetic compatibility control and test plans for approval prior to the first design reviews for propulsion and auxiliary power inverter equipment. **(CDRL 02-05, EMC Control and Test Plan)**

B. Please refer to Section 23, System Safety and Security, for more information.

C. Except where more onerous requirements are contained in this specification, the following requirements shall be met by the Contractor:

1. An EMC plan for the vehicles and equipment shall be developed based on APTA SS-E-010-98.

2. Vehicle equipment shall be developed and qualified to meet EN 50121-3-2.

3. The vehicle as a whole shall be developed and qualified to meet EN 50121-3-1.

4. Electrical equipment shall be designed and qualified to meet IEC60077-1 and IEEE Standard 16, including all referenced standards therein.

5. Electronic equipment shall be designed and qualified to meet EN 50155, including all referenced standards therein.

6. Electrical systems shall be compliant with 49 CFR Part 238.225.

7. Power converters (>5kW rating) shall be designed and qualified to meet IEC 61287, including all referenced standards therein.

D. Where more onerous or conflicting requirements are contained in this specification or in the standards noted above, more onerous requirements shall supersede any less onerous requirements.

E. The plans shall ensure that proper emphasis will be placed on the control of interference and adequate attention given to interface and Federal Communications Commission (FCC) requirements from the earliest stages of the vehicle design.

F. The plans shall describe the Contractor's approach to ensure that the specified requirements are met.

G. This Specification requirement is a minimum and does not guarantee elimination of possible EMI conditions with carborne and wayside equipment.

2.8.2 Control

A. The electrical, electronic, and communications systems and subsystems shall operate without either suffering or causing interferences which may impact the system operation and/or safety because of conducted and/or radiated emissions.

B. The Contractor shall employ design techniques, construction methods, and whatever equipment is required to prevent interference caused by internal sources from affecting the proper operation of the car subsystem.

C. In addition to coordinating frequencies, the Contractor shall provide necessary on-board balancing, filtering, shielding, modulating techniques and isolation to maintain signal to noise (S/N) ratios above limits.

D. Shielding, isolating, balancing, and grounding shall be used as required to reduce the undesirable effect of interference.

E. Electrostatic and magnetic shielding methods shall be employed to minimize the effect of stray signals and transient voltages on interconnecting cables.

F. Power and signal cables shall be physically separated.

G. Trainlines shall be located and arranged such as to minimize electrical induction into trainline circuits due to propulsion system, auxiliary power, catenary or other currents, both static and transient.

H. Cellular (wireless) telephones, typical farecards, credit/debit cards, laptop computers, PDAs, and other magnetic storage media such as floppy disks shall not be adversely affected by EMI fields at any location inside and outside the vehicle, including the floor, ceiling, Operator's cab, or in proximity of equipment cabinets.

I. For farecards, an exposure limit of 500 Gauss shall be considered as the standard for farecard insusceptibility.

2.8.3 Emission Limitations

A. Where more onerous or conflicting requirements are contained in these limitations, more onerous requirements shall supersede any less onerous requirements.

B. The Contractor shall ensure that the cars do not produce any radiated emissions that will violate FCC Rules and Regulations, 47 CFR Part 15.103.

C. Electronic components and assemblies classified as intentional radiators in accordance with 47 CFR Part 15.3 (Definitions) shall comply with provisions of 47 CFR 15 or 47 CFR 90 as applicable for specific devices and their operating frequencies.

D. Irrespective of qualification test results, Contractor shall be responsible for resolving EMC issues arising from operation of equipment in service as provided in 47 CFR 15.5 (General Conditions of Operation).

E. In addition, for purposes of design validation, the cars shall not produce radiated emission levels above those permitted by the agreed upon curve taken from SAE-ARP 60493 when measured 100 feet (30.48 m) from the track centerline. Where the test requirements of EN 50121-3-1 are more onerous, the more onerous requirements shall apply.

1. This curve is defined between the frequencies of 0.15 MHz and 30 MHz, the maximum permissible interference limit shall not exceed 20 dB above the limit of Figure 22 (REO5) of MIL-STD-461A.

2. From 30 MHz to 88 MHz, the maximum limit shall be 58 dB above one microvolt/meter/MHz bandwidth.

3. From 88 MHz to 6,000 MHz, the maximum limit shall be 68 dB above one microvolt/meter/MHz bandwidth.

F. The Contractor shall perform a test to measure the radiated emissions from one of the Pilot Cars upon delivery. **(CDRL 02-06, Spectrum Analysis of Pilot Cars)**

1. The radiated emissions of the Pilot Car shall not exceed the level permitted by the above standard at any frequency between 0.15 MHz and 6000MHz.

2. Testing shall be based on the document "Radiated Interference in Rapid Transit Systems, Volume 2 - Suggested Test Procedures, UMTA-MA-06-0153-85-11" for guidance and shall be conducted to the satisfaction of SEPTA.

3. The Contractor shall perform testing to ensure that the vehicle equipment is adequately protected against radio frequency emissions from nearby equipment including, PTC transmitters, mobile and handheld radios, wireless computer networks, and cellular telephones that the equipment can encounter during normal passenger use or Railroads' operations and when operated as close as 6 inches of said equipment, where equipment is safety-critical, and as close as 18 inches of said equipment for other equipment. Other sources of radio frequency emissions include AMTRAK, NJ Transit, and PATCO. The Contractor shall also ensure that radio frequency emissions from vehicle equipment do not adversely affect these communication systems. Circuits which require attention include, but are not limited to, microprocessors, low level signals, and data communication buses.

G. The conductive emissions, as measured by the procedures in "Recommended Practices for Rail Transit Intra-System Electromagnetic Compatibility of Vehicular Electrical Power and Track Circuit Signaling Subsystems, Volume II: Conductive, DOT-TSC-UM204- PM-82-21, II" (UMTA MA06015385-6), shall be below the levels deemed by the signal equipment suppliers to be safety critical for the safety critical frequencies of the carborne and wayside signaling equipment to the satisfaction of SEPTA.

1. This condition shall be met by each individual piece of power equipment as well as the simultaneous operation of all car equipment.

2. The conducted emissions for a married pair with all individual component emissions acting coherently (i.e., in phase) shall not exceed:

    a. Conducted emissions limit as defined by Amtrak Max Harmonic Current Levels Drawing (A-60-7659, rev B) or the per-married pair CE limit as defined by the Carbuilder's EMC Plan specified in TS 2.8.1.

3. The conducted emissions for any length train, with all individual car emissions acting coherently (i.e. in phase), shall not exceed:

    a. Twice the conducted emissions limit as defined by Amtrak Max Harmonic Current Levels Drawing (A-60-7659, rev B) or twice the per-married pair CE limit as defined by the Carbuilder's EMC Plan specified in TS 2.8.1.

4. The Contractor shall formulate a set of criteria governing generation and toleration of electrical disturbances on conductors between assemblies.

5. The criteria shall distinguish the basic types of circuits present on the car and shall define a suitable comprehensive classification of disturbances which could be present in each type of circuit.

6. The criteria shall ensure that each connected assembly will be able to tolerate the disturbances introduced simultaneously by all of the other assemblies to which it could be connected. In this regard, special attention shall be paid to the needs of the cab signal apparatus.

7. The criteria shall include limits on conducted interference into the catenary and running rails, with levels selected to prevent interference with signal and communications systems which use those circuits for their means of operation and communication.

8. These criteria shall be a part of the control plan and shall be submitted for approval prior to issuing purchase specifications for any carborne apparatus.

9. The approved version thereof shall be included in every such purchase specification by the Contractor and each Subcontractor.

H. The inductive emissions, as measured by the procedures in "Recommended Practices for Rail Transit Intra-System Electromagnetic Compatibility of Vehicular Electrical Power and Track Circuit Signaling Subsystems, Volume I: Inductive, DOT-TSC-UM204-PM-82-21," (UMTA MA06015385-8), shall be below the levels deemed by the signal equipment suppliers to be safety critical for the safety critical frequencies of the carborne, cab signal and wayside signaling equipment to the satisfaction of SEPTA.

1. This condition shall be met by each individual piece of power equipment as well as the simultaneous operation of all car equipment.

2. The per car emission limits in the following table shall not be exceeded:

Frequency (Hz)	Emission Limits (mV)

20 to 30	50
50 to 70	50
71 to 500	20
1 kHz to 25 kHz	20*
* Track signals in this frequency range will be used by NJ TRANSIT for Train Control and other signal system components. Harmonic emissions in this range must be stable, predictable, and fully documented.	

I. The Contractor shall formulate a set of criteria governing generation and toleration of magnetically coupled disturbances on conductors between assemblies.

1. The criteria shall distinguish the basic types of circuits present on the car and shall define a suitable comprehensive classification of disturbances which could be present in each type of circuit.

2. The criteria shall ensure that each connected assembly will be able to tolerate the disturbances introduced simultaneously by all other assemblies to which it is magnetically coupled. In this regard, special attention shall be paid to the needs of cab signal apparatus and to holding to the absolute minimum the generation of energy at the cab signal system frequencies.

3. The criteria shall include limits on the inductive interference into the catenary and running rails, with levels selected to prevent interference with signal and communications systems which use these circuits for their means of operation and communication.

4. These criteria shall be a part of the control plan and shall be submitted for approval prior to issuing purchase specifications for any carborne apparatus. The approved version thereof shall be included in every such purchase specification by the Contractor and each Subcontractor.

2.8.4 Compliance to IEEE 519

A. The Contractor shall perform testing to verify that the vehicles comply with IEEE 519 under all modes of operation including any permitted degraded modes.

2.8.5 Electromagnetic Compatibility Design Report

A. The Contractor shall prepare an Electromagnetic Compatibility (EMC) Design Report prior to Final Design Review, and subsequently update it if and when there are any design changes. The report shall consist of two parts, Emissions Report and Susceptibility Report, as described below. **(CDRL 02-07, Electromagnetic Compatibility (EMC) Design Report)**

1. The Emissions Report shall document:

a. EMC emission control methods, including but not limited to equipment layout, circuit routing, frequency coordination and stability, filters, interconnections, grounding, and shielding. The Contractor shall comply with IEEE Standard 1100-2005, Recommended Practice for Powering and Grounding Sensitive Electronic Equipment, unless otherwise approved.

b. Description of each unit with a peak power rating of greater than 5 kW, including the emission characteristics versus operating mode, voltage and loading, as well as line filter, output filter, line input impedance, and circuit and operating mode considerations.

c. The simulated or calculated emissions of the car as a whole.

d. For any consist length from 1 to 12 cars, the simulated or calculated combined emissions in SEPTA's worst-case combination of Section 2.3, Wayside Signal System.

e. Characteristics of any repeating narrow band emissions and frequency stability control measures.

2. The Susceptibility Report shall document:

a. EMC susceptibility control methods, including but not limited to equipment layout, equipment enclosure design, circuit routing, frequency coordination and stability, filters, interconnections, grounding, and shielding.

b. The vehicle high voltage and low voltage circuits, classification, arrangement, separation, and routing.

c. The high voltage and low voltage grounding arrangement, and provisions for worst-case ground or return bus voltages within the car.

d. The normal and fault paths for ground currents.

e. The equipment protection as well as any restrictions on equipment operation or maintenance necessary to ensure susceptibility control, such as not leaving covers off equipment enclosures; and

f. For each type of electrical interface between subsystems or enclosures, such as battery, digital logic, analog, regulated power supplies, and serial data communications:

(1) The driving circuit, including impedance and maximum and minimum output voltage and current levels.

(2) The receiver circuit, including maximum and minimum voltage or current thresholds, margin against error, and destructive threshold.

(3) All aspects of the connection requirements, such as single wire, double wire, twisted pair, shield, and shield grounding; and

(4) Any special circuit or connection provisions needed to ensure EMC.

2.8.6 Transient Protection

A. All equipment on the car shall be self-protected from damage and improper operation due to high voltage transients across the supply terminals of that equipment, high voltages impressed between either supply terminal and the car body, including continuous imposition of the auxiliary supply level, and long-term overvoltage and undervoltage conditions resulting from equipment failure modes. Note the details and requirements of Section 2.7, Catenary Power Supply, concerning catenary voltage.

B. In addition to being capable of withstanding supply voltage surges and transients as defined in EN 50155 and EN 50121-3-2, equipment powered by the low voltage power supply shall be capable of both withstanding a voltage increase of 30 percent above the maximum normal voltage for 0.5 seconds and be capable of withstanding transients of 3.0 kV peak pulse with a total energy of 90 Joules, without damage, improper operation, or shutdown.

C. All wiring and interface circuits shall be carefully planned to avoid electrical interference. All circuits shall be considered including, but not limited to, the frequency sensitive circuits such as the train radio, public address, and cab signal systems. The wiring and interface shall include the use of individually shielded twisted pair cables, chokes, filters, capacitors, and metal enclosures, in accordance with industry standard practice, to avoid possible interference.

D. The voltage or current levels of electrical signals shall be sufficiently high to allow transient filtering without information loss.

E. Adequate voltage transient suppression shall be provided for the protection of panels and circuits incorporating semiconductor devices.

F. Suppressors shall be incorporated across inductive devices to minimize switching transients.

G. All magnet valves and relay/contactor coils shall have free-wheeling diode or metal-oxide varistor arc suppression.

H. Other means of suppression or the absence of suppression for performance reasons shall have the approval prior to use.

I. The number of types of suppression devices shall be kept at an absolute minimum.

J. Equipment enclosures shall shield its equipment from any effects resulting from the operation of a 5 Watt handheld high band VHF radio transceiver when used anywhere within 1 foot 6 inches (0.46 m) of the enclosure.

2.8.7 Human Exposure to Electromagnetic Fields

A. The car shall not produce any health hazard to the public, passengers, guide animals, train crew or maintenance personnel. See details in Section 23, System Safety and Security. The car shall meet the requirements specified in IEEE Std. C95.1, including any referenced standards, including those for medical devices and medical implants.

B. Exposure by passengers and Operators to static magnetic fields shall not exceed 0.5 mT.

C. Exposure to low frequency magnetic fields shall be per ICNIRP Guidelines for Limiting Exposure to Time - Varying Electric and Magnetic Fields (1 Hz – 100 kHz), 2010; Figure 2, Reference levels for exposure to time varying magnetic fields; according to the limit shown for general public exposure.

D. Compliance shall be tested in accordance with EN 50500.

2.9 Performance Requirements

2.9.1 General

A. The acceleration and braking requirements specified are minimums for actual performance of two cars (as a married pair) with new wheels on level track in still air.

B. The propulsion system design shall be such that wheel diameter differences of up to 0.25-inch (0.635 cm) between the axles with motors supplied by one inverter can be accommodated.

C. While the specified acceleration and service braking rates are desired and are believed by SEPTA to be based upon capabilities of existing apparatus designs, alternate rates may be proposed during Conceptual Design review if the benefits of the revised rates can be documented.

2.9.1.1 Calculations and Testing

A. Performance shall be verified by empty car acceptance tests done on all married pairs, as well as loaded car engineering tests done on the Pilot married pairs. Design calculations shall be based on the Davis Formulae for rolling resistance or approved equivalent for a configuration with new wheels. **(CDRL 02-08, Vehicle Performance)**

2.9.1.2 Top Speed

A. The balancing speed for the vehicles in any configuration on level tangent track in still air shall be such as to permit operation at, and acceleration to a minimum of 100 miles/hour (161 km/hour). The maximum motor, gear unit and truck safe speed, with minimum wheel diameter, shall be a minimum of 110 miles/hour (177 km/hour). Note the details and requirements of Section 2.9.2, Acceleration concerning the maximum distances required to reach 80mph and 100mph.

B. Each vehicle shall be capable of continuously operating in commuter service at all sustained speeds up to 100 miles/hour (161 km/hour), with repeated acceleration and braking, without degradation or damage to any part of the vehicle.

2.9.1.3 Propulsion and Voltage

A. The propulsion system shall operate whenever the catenary line voltage is between 9,000 Volts and 13,500 Volts at 25 Hertz.

B. Specified acceleration performance shall be achieved whenever the catenary line voltage is 11,500 Volts or greater. When catenary line voltage is between 9,500 Volts and 11,500 Volts, base speed may be modified in an approved manner coordinated with accelerating tractive effort.

C. The propulsion system shall be designed to achieve stable operation under low catenary voltage conditions. The propulsion system may shut down when the line voltage drops below 9,000 Volts, with details on system hysteresis submitted for approval. **(CDRL 02-08)**

D. The propulsion system shall not be damaged by continuous exposure to catenary line voltages between 0 Volts and 13,500 Volts, or by exposure to higher transient voltages which occur on the catenary.

E. The equipment shall be resilient to, and able to operate with up to 40% total harmonic distortion in the catenary voltage. Note the details and requirements of TS 2.7, concerning catenary voltage.

2.9.1.4 Braking Performance

A. Braking performance shall be met independent of catenary line voltage or its absence.

B. The beneficial retarding effects of train resistance shall not be used when designing brake system capacities.

C. The specified acceleration and braking performance shall be provided over the full range of wheel wear, including new wheels as delivered.

D. The design of the propulsion and braking system shall be coordinated with the ATC/PTC system design so that all requirements are achieved.

2.9.1.5 Performance Simulations

A. As part of the Technical Proposal, performance curves shall be submitted for operation of a two-car train at AW1 load on level tangent track, in still air conditions, at a catenary voltage of 11,500 Volts or greater at 25 Hertz, and maximum speed of 100 miles/hour (161 km/hour). These curves, updated as necessary, shall be resubmitted at Conceptual and Preliminary design reviews. **(CDRL 02-09, Duty Cycle Simulations)**

B. Acceleration and braking rate shall be shown as miles/hour/second, speed as miles/hour and distance in feet. The following curves shall be provided:

1. Acceleration rate and catenary line current versus speed
2. Acceleration rate and catenary line current versus time
3. Speed - time - distance (accelerating)
4. Speed - time - distance (full-service braking)
5. Speed - time - distance (emergency braking)
6. Full service (blended) braking rate versus speed (identify dynamic contribution)
7. Full service (friction only) braking rate versus speed
8. Emergency braking rate versus speed.

2.9.2 Acceleration

A. Acceleration requirements, unless stated otherwise, are with a car weight of AW1 load, a catenary line voltage at 11,500 Volts or greater, and include jerk limitation with 3.0 seconds build up to 3.0 miles/hour/second/second (4.83 km/hour/second/second) .

B. At train speeds below the motor base speed, the tractive effort shall be constant, and the acceleration rate reduced by train resistance.

C. From AW0 to AW1 load, the acceleration rate shall be load-weigh corrected.

D. Above AW1 load, the acceleration rate may decrease as car weight increases.

E. A married pair at AW1 load shall be capable of attaining a speed of 80 miles/hour (128.75 km/hour) from a standing start within 1.25 miles (2.01 km) of level tangent track running.

F. A married pair at AW1 load shall be capable of attaining a speed of 100 miles/hour (160.9 km/hour) from a standing start within 2.75 miles (4.42 km) of level tangent track running.

2.9.3 Service Braking

A. Service braking shall be provided by both the propulsion system (dynamic/ regenerative braking) and the friction braking system.

B. The friction brake system shall have the capability to provide the entire service braking deceleration requirement.

C. Service braking effort shall be normally provided by the dynamic braking system for car weights up to AW2 load to the dynamic brake fade-out speed.

D. Dynamic braking shall be supplemented by the friction brake system at the dynamic brake fade-out for the final stop, for loads greater than AW2, and whenever the dynamic brake alone is not providing the full commanded braking effort.

E. The full-service braking stop distance from 50 miles/hour (80.47 km/hour) with an AW3 load shall not exceed 1,290 feet (393.19 m), measured from the point of initial movement of the brake handle into a braking command.

F. With a car weight of AW0 to AW2 load, and the presence or absence of catenary line voltage, the service braking system shall produce a load-weighed nominal net full-service braking rate of 3.0 miles/hour/second (4.83 km/hour/second), at the conclusion of jerk limiting, at all speeds from 50 miles/hour (80.47 km/hour) to zero miles/hour (0 km/hour) when measured with an inertial accelerometer.

G. The net rate shall decrease linearly from 3.0 miles/hour/second (4.83 km/hour/second) at 50 miles/hour (80.48 km/hour) to 2.0 miles/hour/second (3.22 km/hour/second) at 100 miles/hour (161 km/hour).

H. The friction-only service braking system shall also be capable of producing these braking rates when operated unrestricted at speeds of up to 100 miles/hour (161 km/hour).

I. The dynamic braking system shall have the capability under the above conditions of producing a net full-service braking rate of 3.0 miles/hour/second (4.83 km/hour/ second) from the zero-speed fade-out point up to approximately 37 miles/hour (59.55 km/hour) (or greater if possible), then decreasing linearly to 0.75 miles/hour/ second (1.21 km/hour/second) (or greater, if possible) at 100 miles/hour (161 km/hour).

J. Net rate is the rate developed by the brake system alone without the beneficial retarding effects of train resistance.

K. If packaging or weight savings can be documented or the service life of the friction brake components can be improved, a revised dynamic braking taper may be

proposed during the Conceptual Design review for speeds above 37 miles/hour (59.55 km/hour).

L. The instantaneous variation in dynamic braking rates shall be within plus or minus 5 percent of the nominal value. The instantaneous variation in friction braking rates shall be within plus or minus 20 percent of the nominal value. The blended braking tolerance shall be based on the percentage of each type of braking used.

M. The dynamic brake fade point shall be less than 3.0 miles/hour (4.83 km/hour) or as required by the friction material to maintain a satisfactory surface conditioning. **(CDRL 02-10 Dynamic Brake Fade Point)**

2.9.4 Emergency Braking

A. Emergency braking for stop assurance shall be provided by the friction braking system.

B. The six-car train emergency brake friction-only stop distance from 50 miles/hour (80.47 km/hour) with an AW3 load shall not exceed 1060 feet (323.09 m), measured from the point of initial movement of the brake handle into the emergency braking position.

C. With a car weight of AW0 to AW3 load, and the presence or absence of catenary line voltage, the emergency braking system shall produce a nominal net rate of 3.2 miles/hour/second (5.15 km/hour/second) when measured with an inertial accelerometer at speeds from 50 miles/hour (80.47 km/hour) to zero miles/hour (0 km/hour).

D. There shall be no modulation of brake cylinder pressure with speed during an emergency brake application.

E. Above 50 miles/hour (80.47 km/hour), the minimum emergency braking rate shall be as determined by the characteristics of the braking friction materials, but in no case less than 2.5 miles/hour/second net (4.02 km/hour/second). Net rate is the rate developed by the brake system alone without the beneficial retarding effects of train resistance.

F. The instantaneous variation in the emergency braking rate shall be within plus or minus 20 percent of the nominal value.

2.9.5 Regenerative Braking Efficiency

A. During regenerative braking without friction braking supplement, the propulsion system shall have the capability to return a minimum of 85 percent of the car's kinetic energy to the catenary and the car auxiliary loads for a stop from 100 miles/hour (161 km/hour) to the extent that the auxiliary loads are able to absorb that energy and the catenary is receptive.

B. If packaging or weight savings can be documented, a revised efficiency percentage may be proposed during Conceptual Design review.

2.9.6 Duty Cycle

A. The car shall be capable of operating under all conditions in the electrified service territory of the SEPTA Railroad Division, the Amtrak Harrisburg Line, and the Amtrak Northeast Corridor from Trenton, NJ to Wilmington, DE, including those conditions below, meeting Specification requirements without exceeding the traction or friction braking equipment design ratings and without producing equipment temperatures in excess of those recommended by the equipment manufacturers.

B. Unless otherwise specified, thermal ratings of equipment shall assume a continuous AW1 load.

C. Unless otherwise specified, duty cycle calculations shall be for minimum running time and shall utilize coasting only as necessary to avoid exceeding speed restrictions.

D. Duty cycle calculations shall utilize 30 seconds dwell time for intermediate stops and 7 minutes for end-of-run turnaround time. See Appendix III for route profile information for various SEPTA routes. A married pair with an AW2 load shall be capable of operating with a 25% loss of propulsion in a service comparable with that from Suburban Station to Chestnut Hill East, and also from Suburban Station to Chestnut Hill West, through two roundtrips making all station stops and observing all speed restrictions, without damage to any equipment. Maximum train acceleration shall be reduced in proportion to the remaining number of operable propulsion systems on the train.

E. Propulsion system ratings shall be based on the use of electric braking on cars with fully functioning propulsion equipment, and friction brake only on cars with non-functioning propulsion equipment. Acceleration rates under these conditions will vary in proportion to the number of operable propulsion systems in the train.

F. In the event of dynamic brake failure on a car at any speed or car load, the friction brakes shall provide all of the service braking effort required without producing wheel or brake disc temperatures in excess of those recommended by the wheel or brake disc manufacturer and without exceeding the propulsion system limits.

G. The wheel and brake disc manufacturer's recommended maximum temperatures shall be provided to SEPTA and included in the Contractor's test procedure for this test.

H. The thermal duty capacity of the friction brake system shall allow the car to operate indefinitely in normal scheduled service (all local stops, 30 second station dwell times, 7 minutes terminal turn-around time) with AW1 load from Suburban Station to Paoli, using only the friction brake system, without wheel temperatures exceeding the wheel manufacturer's recommendations.

I. The propulsion, braking and other car systems shall be fully compatible for normal operation in trains of up to 12 cars.

J. Coupling and operation of a normally operating married pair loaded to AW3 to a disabled train of equal length and AW3 loading shall be possible for rescue purposes. Operation from Suburban Station to the end of any line shall be possible for rescue purposes without causing wheel or brake disc temperatures exceeding those recommended by the wheel or brake disc manufacturer and without exceeding any propulsion system limits. The Contractor shall submit for approval details of all restrictions that shall apply for train rescue under any combination of train length and loading condition. **(CDRL 02-11 Train Rescue)**

K. Above listed situations shall be provided as simulations during the design phase, and later verified through vehicle qualification test, see Section 15, Test Program. **(CDRL 02-09, Duty Cycle Simulations)**

2.9.7 Load Weigh System

A. A load weigh system shall be provided to adjust the car propulsion and braking effort to maintain consistent acceleration and braking rates as outlined below.

B. The specified acceleration performance shall be achieved for passenger loads between AW0 and AW1.

C. Above AW1 load, the tractive effort shall be held at the AW1 level.

D. The specified braking performance shall be achieved for passenger loads between AW0 and AW3 to provide for a constant braking rate independent of passenger load, using dynamic and friction brake blending.

E. Under failure conditions, the load weigh system shall not cause accelerating or service braking tractive effort less than that provided for AW0 load, nor more than that provided for AW3 load.

F. Load limiting valve settings for emergency brake application shall be preset and not field adjustable.

2.9.8 Jerk Limitation

A. Changes in tractive effort for acceleration and service braking shall be jerk limited at a rate which is software adjustable, and password protected.

B. The jerk limit rate shall be adjustable between 1.0 miles/hour/second/second (1.61 km/hour/second/second) and 3.0 miles/hour/second/second (4.83 km/hour/second/second) and shall initially be set to 1.0 miles/hour/second/second (1.61 km/hour/second/second), plus or minus 10 percent.

C. Changes in propulsion and braking effort shall develop smoothly.

D. Decreases in accelerating tractive effort arising from interruptions in the catenary power supply shall not be jerk limited.

E. However, reapplication of accelerating power after an interruption shall be jerk limited.

F. Removal of power and application of brakes under emergency braking conditions shall not be jerk limited.

G. Removal of power and dynamic brake effort under wheel slip conditions shall be on a per-truck basis if per-truck propulsion controls are provided and shall not be jerk limited.

H. The reapplication of power and brake effort shall be jerk limited.

2.9.9 Response Times

A. Response times include response to modulation within a mode (power, coast, and brake), and transitions from one mode to another, including emergency braking.

B. Modulation of tractive effort within a mode shall be jerk limited. If the rate change is less than the jerk limit, then modulation of tractive effort shall follow the command.

C. The response time within a mode shall not exceed 300 ms, measured from the time the change is initiated until the acceleration or deceleration transitions to 10 percent of the requested change. The balance of the transition shall be controlled by the jerk limit.

D. Mode change dead times for transitions from one mode to an adjacent mode (propulsion-to-coast, coast-to-brake, and brake-to-coast, shall not exceed 500 ms, exclusive of jerk limiting. Mode change dead times shall be measured from the time the change is initiated until the tractive effort changes to 10 percent of the new commanded value.

E. The friction brake system shall respond with a perceptible braking effort, as measured by an on-board accelerometer, within 0.5 second from the generation of a braking command at the Operator's cab brake controller. From the moment of response, the braking effort shall increase linearly at the jerk limited rate until the full commanded rate is achieved. The exclusive exception to this is Emergency Brake, which shall reach the full commanded rate within 60 percent of the comparable service brake time, from the generation of an emergency command at the brake controller.

F. The mode change time from any mode to emergency braking shall not exceed 200 ms. Including brake build-up time, the time from any mode to emergency braking with a build up to 90 percent of the friction brake effort shall not exceed 1 second.

2.9.10 Wheel Spin and Slide Protection

A. A wheel spin control algorithm shall be provided that ensures that, with the master controller in the maximum power position on the worst-case grade on wet rails, the time needed for the train to accelerate from 5 mph (8km/h) to 15 mph (24 km/h) is no more than 125% of the time needed for the same acceleration on the same grade but with dry rails.

B. An integrated wheel slide protection (WSP) scheme shall be provided.

1. It shall be the fundamental task of the WSP scheme to maintain each wheel continuously at that tangential tread velocity that produces the highest possible coefficient of adhesion between wheel and rail for the prevailing conditions, without instant or latent wheel damage, and within the constraints of car architecture and trade-offs with other design requirements.

2. See Section 10, Propulsion, for wheel slide requirements, and additional wheel spin requirements, specifically associated with the propulsion subsystem. See Section 12, Friction Brake, for requirements associated with WSP in emergency and requirements associated with wheel slide control valves.

C. The efficiency of the WSP scheme, during all specified modes of braking and within the specified limits, shall not be less than 90%.

1. The WSP efficiency shall be defined as the ratio of the actual accelerating or braking rate to the theoretical accelerating or braking rate. The theoretical rate is that which is obtained by continuously using the available track adhesion.

2. Efficiency shall be calculated over the slip or slide affected portions of operation only.

2.10 Cant Deficiency

A. The design cant deficiency shall be greater than five inches, compliant for qualification under the requirements of 49 CFR §213.329 and §213.345 to operate in service at a maximum intended cant deficiency of five inches.

2.11 Standard Keys

A. Three types of standard keys shall be used on the car, a coach (Conductor's) key, a cab control key, and an ATC/Cab Signal locker key.

B. The coach key (referred to in this Specification as the standard key), except as otherwise specified, shall be used as the general key for door control and to open all doors and car interior access covers.

1. All coach key locks shall be the standard SEPTA coach key, J.L. Howard and Co. No. 2383.

2. This key shall operate the Conductor door control panels, side door mechanical locks, end doors, cab door, side window locks, PA/IC system, equipment and storage lockers, crew lockers, and the like.

3. Wherever a switch is operated by the standard door key, the tumbler shall be set back at least 0.5 inch (1.27 cm) from the face and protected by a fixed keyway spacer to prevent operation by a screwdriver or similar device.

C. The cab control key shall be used by the Operator to activate the cab electrical controls and propulsion system master controller.

D. In accordance with Federal Railroad Administration requirements, the access locker to the ATC/Cab Signal equipment rack shall be fitted with a lock with a restricted access key. The SEPTA ATC/Cab Signal key is an Illinois Lock Co. model G341 key.

E. The Contractor shall present for approval a matrix of the key type used in each lock or key switch. **(CDRL 02-12, Key Usage Matrix)**

F. The following quantities of keys shall be sent directly to SEPTA:

1. Coach Keys: 1,000

2. Cab Control Keys: 1,000

3. ATC/Cab Signal Keys: 100

2.12 Delivery Locations

A. All material and equipment to be delivered by the Contractor to SEPTA shall be shipped prepaid at the Contractor's expense using a common or contract carrier of the Contractor's choice. SEPTA shall not be liable for the payment of any shipping, transportation, delivery, customs or unloading costs under this Contract.

B. All written or printed matter to be delivered to SEPTA, such as technical correspondence, submittals, publications, drawings, etc., and all computer equipment shall be delivered to:

SEPTA - New Rail Vehicles
1234 Market Street, 14th Floor
Philadelphia, PA 19107-3780

C. All cars shall be shipped to a SEPTA facility to be determined by SEPTA at the appropriate time. If shipping via freight rail, SEPTA facility access is available near Woodbourne station.

1. Each car shall be delivered orientated in the proper direction at delivery as instructed by SEPTA, and must be fully assembled, tested, and ready to run following the removal of any special shipping equipment or requirements.

2. The Contractor shall make all arrangements to use its own reporting marks for car movement, and to have these reporting marks properly registered with the AAR UMLER reporting mark database.

3. In addition, the Contractor shall equip both sides of each car with a properly encoded AAR radio frequency transponder (electronic tag) unit mounted on the underside of the carbody for shipping, encoded with the Contractor's reporting marks, which the Contractor shall remove following delivery.

4. Each car shall also be equipped with a GPS-based tracker, reporting its current location to a web-based site accessible by SEPTA.

D. All spare parts, specialized tooling, diagnostic test equipment (other than computers) and other hardware, material and equipment shall be shipped freight prepaid to:

SEPTA
Wayne Junction Electric Car Shop
Attention: Silverliner VI Material
4500 Germantown Avenue
Philadelphia, PA 19144-3009

E. The Contractor shall be responsible for making all arrangements for delivery of all Contract material at its own expense.

1. Every shipment of materials, spare parts, etc. shall have a fully itemized packing slip detailing all contents by quantity, name, part number, etc.

2. Shipments using multiple packages shall be identified by a coding system or other approved method.

3. A bar or SQR code system shall be used for all itemized parts per Section 25, Program Management and Commissioning.

2.13 Contract Deliverable Requirements List (CDRL)

The following contract deliverables have been identified in this section; however, the Contractor is responsible for providing and submitting anything necessary to fulfill the requirements of this contract, including those not identified by CDRL number.

CDRL 02-01, Energy Efficiency Report 2-4
CDRL 02-02, Vehicle Clearance Diagrams 2-10
CDRL 02-03, Car Weight Report 2-14
CDRL 02-04, Catenary Power Supply Analysis and Measurement Report 2-18
CDRL 02-05, EMC Control and Test Plan 2-19
CDRL 02-06, Spectrum Analysis of Pilot Cars 2-21
CDRL 02-07, Electromagnetic Compatibility (EMC) Design Report 2-23
CDRL 02-08, Vehicle Performance 2-26
CDRL 02-09, Duty Cycle Simulations 2-28

CDRL 02-10 Dynamic Brake Fade Point.....2-30
CDRL 02-11 Train Rescue 2-32
CDRL 02-12, Key Usage Matrix.....2-35

2.14 CDRL Details

This section lists the expected content for each CDRL required above. The lists provided for each CDRL are an outline only and should not be considered exhaustive, all CDRLs are subject to SEPTA review and approval.

CDRL 02-01 Energy Efficiency Report

1. As part of the proposal package, the Contractor shall perform and submit energy consumption simulations and predictions as detailed in EN 50591. The simulations and predictions shall be updated and submitted as a report at Conceptual and Preliminary Design Reviews.

2. After recording efficiency data for relevant systems during the qualification testing of the train, prepare and submit for approval a report containing the results of the energy usage comparisons for each identified system.

3. The report shall provide an overall result that identifies the percentage deviation at system level and at vehicle level between the predicted energy consumption and the actual energy consumption.

CDRL 02-02 Vehicle Clearance Diagrams

1. Prepare and submit for approval a complete set of clearance diagrams for the car at Conceptual Design Review.

    a. The diagrams shall include static and dynamic clearance envelopes relative to the wayside allowances, lean allowance, clearances for all parts of the truck, and identification of the center of gravity and roll center.

    b. A diagram shall be included of the car superimposed on the car clearance diagram in Appendix I along with all supporting calculations and all necessary cross sections, which shall show the worst-case clearance to the outline including offset due to curve compensation.

    c. All supporting calculations and conditions shall be provided as part of this deliverable.

    d. Roll angle shall be demonstrated to comply with 49 CFR Part 213.57 (d).

    e. Single point suspension failures as well as truck and wheel wear shall be included in the calculations.

2. The clearance diagrams shall be updated and resubmitted at each design review stage, and as necessary following any relevant changes to the vehicle.

CDRL 02-03 Car Weight Report

1. Prepare and submit for approval a car weight report at Conceptual Design Review.
2. The report shall present:
    a. Car weights, including a breakdown of the weights of components that comprise the car, imbalance, and axle loading.
    b. Center-of-gravity data.
    c. Breakdown of car weight by subsystem.
    d. Weights for truck-mounted and carbody- mounted components separately before totaling them.
    e. The weight report shall include estimated margins of error for each major component or sub-system that has not yet been weighed and shall include an estimated margin of error for the overall car weight.
3. Contractor shall include the report with each monthly project update, as specified in Section 25, Program Management and Commissioning.
4. Where relevant, the report shall note the impact of weight reduction recommendations, as part of this report.
5. The weight report shall be refined through the manufacturing stage as actual equipment is weighed, and actual weight values shall be used to replace predicted weight values in the report as they become available.
6. Actual weight values shall be tabulated and car weights from pre-shipment inspections shall be reported for each car.
7. The weight report shall be maintained and be updated as necessary through the warranty period.

CDRL 02-04 Catenary Power Supply Analysis and Measurement Report

1. Prepare and submit for approval at Preliminary Design Review a report containing analyses and measurements of the catenary power supply system.
2. The report shall contain:
    a. Details of analyses and measurements of the catenary power supply system that have been conducted as necessary to acquaint the contractor with all aspects of the overhead catenary system.
    b. The report shall contain sufficient details to demonstrate that the proposed high voltage equipment for the car is fully compatible with the catenary supply system.

c. Details of any characteristics of the actual system that are outside of the details provided in this technical specification.

3. The report shall be updated as necessary after conclusion of vehicle dynamic qualification testing.

CDRL 02-05 EMC Control and Test Pan

1. Prepare and submit for approval at Conceptual Design Review an EMC plan for the vehicles and equipment.

2. The EMC plan shall:

   a. Be developed based on APTA SS-E-010-98.

   b. Detail how the vehicle equipment shall be developed and qualified to meet EN50121-3-2.

   c. Detail how the whole vehicle shall be developed and qualified to meet EN50121-3-1.

   d. Detail how electrical equipment shall be designed and qualified to meet IEEE Standard 16, including all referenced standards therein.

   e. Detail how electronic equipment shall be designed and qualified to meet EN 50155, including all referenced standards therein.

   f. Detail how electrical systems shall be designed and demonstrated to be compliant with 49 CFR Part 238.225.

   g. Detail how power converters (>5kW rating) shall be designed and qualified to meet IEC 61287, including all referenced standards therein.

   h. Detail the design measures that shall be taken to ensure that the car shall not produce any health hazard to the public, passengers, guide animals, train crew or maintenance personnel, including those for medical devices and medical implants.

CDRL 02-06 Spectrum Analysis of Pilot cars

1. The Contractor shall perform a spectral analysis of one of the Pilot Cars upon delivery. Testing shall be based on the document "Radiated Interference in Rapid Transit Systems, Volume 2 - Suggested Test Procedures, UMTA-MA-06-0153-85-11" and shall be conducted to the satisfaction of SEPTA.

2. Details of the spectral analysis shall be included in a report that shall be submitted. The report shall include all test results, analyses and conclusions required to clearly demonstrate that the vehicles comply with all specified spectral requirements.

CDRL 02-07 Electromagnetic Compatibility (EMC) Design Report

1. The Contractor shall prepare and submit an Electromagnetic Compatibility (EMC) Design Report prior to Final Design Review.

2. The report shall be updated if any relevant part of any design changes.

3. The report shall consist of two parts, Emissions Report and Susceptibility Report, as described below.

    a. The Emissions Report shall document:

        i. EMC emission control methods, including equipment layout, circuit routing, frequency coordination and stability, filters, interconnections, grounding, and shielding.

        ii. Description of each unit with a peak power rating of greater than 5 kW, including the emission characteristics versus operating mode, voltage, and loading, as well as line filter, output filter, line input impedance, and circuit and operating mode considerations.

        iii. The simulated or calculated emissions of the car as a whole.

        iv. For any consist length from 1 to 12 cars, the simulated or calculated combined emissions in SEPTA's worst-case combination of Section 2.3, Wayside Signal System.

        v. Characteristics of any repeating narrow band emissions and frequency stability control measures.

    b. The Susceptibility Report shall document:

        i. EMC susceptibility control methods, including equipment layout, equipment enclosure design, circuit routing, frequency coordination and stability, filters, interconnections, grounding, and shielding.

        ii. The vehicle high voltage and low voltage circuits, classification, arrangement, separation, and routing.

        iii. The high voltage and low voltage grounding arrangement, and provisions for worst-case ground or return bus voltages within the car.

        iv. The normal and fault paths for ground currents.

        v. The equipment protection as well as any restrictions on equipment operation or maintenance necessary to ensure susceptibility control, such as not leaving covers off equipment enclosures; and

vi. For each type of electrical interface between subsystems or enclosures, such as battery, digital logic, analog, regulated power supplies, and serial data communications:

(1). The driving circuit, including impedance and maximum and minimum output voltage and current levels.

(2). The receiver circuit, including maximum and minimum voltage or current thresholds, margin against error, and destructive threshold.

(3). All aspects of the connection requirements, such as single wire, double wire, twisted pair, shield, and shield grounding; and

(4). Any special circuit or connection provisions needed to ensure EMC.

CDRL 02-08 Vehicle Performance

1. Performance curves shall be submitted at conceptual design review for operation of a two-car train at all specified loads on level tangent track, in still air conditions, at a catenary voltage of 11,500 Volts or greater at 25 Hertz, and maximum speed of 100 miles/hour (161 km/hour). Acceleration and braking rate shall be shown as miles/hour/second, speed as miles/hour and distance in feet. The following curves shall be provided:

   a. Acceleration rate and catenary line current versus speed

   b. Acceleration rate and catenary line current versus time

   c. Speed - time - distance (accelerating)

   d. Speed - time - distance (full-service braking)

   e. Speed - time - distance (emergency braking)

   f. Full service (blended) braking rate versus speed (identify dynamic contribution)

   g. Full service (friction only) braking rate versus speed

   h. Emergency braking rate versus speed.

2. Details on hysteresis to be used for propulsion system shut down under low line voltage conditions shall be submitted for approval.

CDRL 02-09 Duty Cycle Simulations

1. As part of the Technical Proposal, performance curves shall be submitted for operation of a two-car train at AW1 load on level tangent track, in still air conditions, at a catenary voltage of 11,500 Volts or greater at 25 Hertz, and maximum speed of 100 miles/hour (161 km/hour).

2. The Contractor shall update the performance curves and augment the submittal with duty cycle simulations and submit them for Conceptual and Preliminary Design Reviews.

3. The submittal shall contain the following details:

    a. Curves for Acceleration rate and catenary line current versus speed under different car loading conditions.

    b. Curves for Acceleration rate and catenary line current versus time under different car loading conditions.

    c. Curves for Speed - time - distance (accelerating) under different car loading conditions.

    d. Curves for Speed - time - distance (full-service braking) under different car loading conditions.

    e. Curves for Speed - time - distance (emergency braking) under different car loading conditions.

    f. Curves for Full service (blended) braking rate versus speed (identify dynamic contribution) under different car loading conditions.

    g. Curves for Full service (friction only) braking rate versus speed under different car loading conditions.

    h. Curves for Emergency braking rate versus speed under different car loading conditions.

    i. Regenerative Braking Efficiency.

    j. Duty cycle simulations:

        i. Over the electrified service territory of the SEPTA Railroad Division,

        ii. Over the Amtrak Harrisburg Line, and

        iii. Over the Amtrak Northeast Corridor from Trenton, NJ to Wilmington, DE,

        iv. A married pair with an AW2 load operating with a 25% loss of propulsion in a service comparable with that from Suburban Station to Chestnut Hill East, and also from Suburban Station to Chestnut Hill West, through two roundtrips making all station stops and observing all speed restrictions.

        v. Coupling and operation of a normally operating train of up to 6 cars loaded to AW3 to a disabled train of equal length and AW3 loading operating from Suburban station to the end of any line (Contractor to determine worst case for simulation purposes) for rescue purposes.

vi. The simulations shall contain sufficient details to demonstrate that the equipment meets Specification requirements without exceeding the traction or friction braking equipment design ratings and without producing equipment temperatures exceeding those recommended by the equipment manufacturers.

k. Details of all restrictions that shall apply for train rescue under any combination of train length and loading condition.

CDRL 02-10 Dynamic Brake Fade Point

1. Submit details for the dynamic brake fade point as part of each design review meeting (CDR, PDR, FDR).

2. The submittal shall include (but not be limited to):

   a. Details of how satisfactory surface conditioning for the friction material shall be maintained.

   b. Details for the interface between brake and propulsion systems, and how the interfaces between each system will be controlled to ensure a smooth transition from dynamic to friction brake.

CDRL 02-11 Train Rescue

1. Submit for approval during Final Design Review details of all restrictions (including, but not limited to speed restrictions) that shall apply for train rescue under any combination of train length and loading condition.

CDRL 02-12 Key Usage Matrix

1. The Contractor shall submit for approval for Preliminary Design Review a matrix of the key type used in each lock or key switch.

2. The matrix shall be updated with any changes through the end of the warranty period.

2.15 Referenced Standards

The following standards are referenced in this Section:

36 CFR Part 1192	Americans with Disabilities Act (ADA) Accessibility Guidelines for Transportation Vehicles
40 CFR Part 201	Noise Emission Standards for Transportation Equipment; Interstate Rail Carriers
47 CFR Part 15	Radio Frequency Devices

49 CFR	Title 49 of the Code of Federal Regulations – Transportation
49 CFR Part 27	Nondiscrimination on the Basis of Disability in Programs or Activities Receiving Federal Financial Assistance
49 CFR Part 37	Transportation Services for Individuals with Disabilities (ADA)
49 CFR Part 38	Americans with Disabilities Act (ADA) Accessibility Specifications for Transportation Vehicles
49 CFR 200 series	Portion of 49 CFR covering Federal Railroad Administration (FRA) regulations
49 CFR Part 210	Railroad Noise Emission Compliance Regulations
49 CFR Part 213	FRA Track Safety Standards
49 CFR Part 229	Railroad Locomotive Safety Standards
49 CFR Part 238	Passenger Equipment Safety Standards
Alvin R. Tilley (Author)	The Measure of Man and Woman: Human Factors in Design
Amtrak A-60-7659, rev B	Max Harmonic Current Levels Drawing
ANSI S1.4	American National Standard Specification For Sound Level Meters
ANSI S1.11	Electroacoustics - Octave-Band And Fractional-Octave-Band Filters - Part 3: Periodic Tests (A Nationally Adopted International Standard)
APTA PR-CS-S-034-99	Design and Construction of Passenger Railroad Rolling Stock
DOT-TSC-UM204- PM-82-21, II	Recommended Practices for Rail Transit Intra-System Electromagnetic Compatibility of Vehicular Electrical Power and Track Circuit Signaling Subsystems, Volume II: Conductive (UMTA MA06015385-6)
DOT-TSC-UM204-PM-82-21	Recommended Practices for Rail Transit Intra-System Electromagnetic Compatibility of Vehicular Electrical Power and Track Circuit Signaling Subsystems, Volume I: Inductive" (UMTA MA06015385-8)
EN 50591	Railway Applications - Rolling Stock - Specification and verification of energy consumption

EN 50121-3-1	Railway applications - Electromagnetic compatibility - Part 3-1: Rolling stock - Train and complete vehicle
EN 50121-3-2	Railway applications - Electromagnetic compatibility Part 3-2: Rolling stock - Apparatus
EN 50155	Railway applications - Rolling stock - Electronic equipment
IEC 60077-1	Railway applications - Electric equipment for rolling stock - Part 1: General service conditions and general rules
IEEE Std. 16	IEEE Standard for Electrical and Electronic Control Apparatus on Rail Vehicles
IEEE Std. 1100	IEEE Recommended Practice for Powering and Grounding Electronic Equipment
IEEE Std. C95.1	IEEE Standard for Safety Levels with Respect to Human Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 Hz to 300 GHz
IEC 61287-1	Railway applications – Power converters installed on board rolling stock – Part 1: Characteristics and test methods
IEC 61373	Railway applications - Rolling stock equipment - Shock and vibration tests
ISO 2631-1	Mechanical vibration and shock – Evaluation of human exposure to whole-body vibration – Part 1: General requirements
ISO 2631-4	Mechanical vibration and shock – Evaluation of human exposure to whole-body vibration – Part 4: Guidelines for the evaluation of the effects of vibration and rotational motion on passenger and crew comfort in fixed-guideway transport systems
MIL-STD-461A	Military Standard: Electromagnetic Interference Characteristics Requirements for Equipment
SAE-ARP 60493	EMC and Interference Control for Rapid Transit Vehicles
UMTA-MA-06-0153-85-11	Radiated Interference in Rapid Transit Systems, Volume 2 - Suggested Test Procedures

SECTION 3
CARBODY

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3.1 General

3.1.1 Scope

A. This Section describes the carbody structural functions and design requirements including, but not limited to, finish, strength, construction, materials, and fastening.

1. The design and construction of the cars shall comply with the applicable requirements of FRA Regulations, APTA Standards, and Recommended Practices available at the time of NTP.

2. Where there is a conflict, the most restrictive shall apply.

3. The cars shall be easy to clean and maintain using SEPTA's existing equipment, procedures, and practices, and shall include considerations for the safety of the car occupants including the crew and maintenance personnel.

4. The design shall provide for the maximum possible ease and safety of passage from car to car through the end doors.

5. Crevices, pockets, and hidden areas, where moisture, dirt and debris can accumulate, shall not be allowed in the design.

6. Details of the design arrangement and installation of the carbody equipment and apparatus shall be submitted. **(CDRL 03-01, Carbody Equipment and Apparatus Details)**

3.1.2 Finished Edges

A. The Contractor shall ensure that all surfaces of the carshell are free from surface defects, sharp edges, corners, and protrusions at any place where passengers, crew, or maintenance personnel may come in contact.

B. All corners shall be rounded, and edges of the carshell shall be qualified in accordance with the Underwriters Laboratory Standard UL 1439, Standard for Test for Sharpness of Edges on Equipment. This requirement shall apply to equipment or components furnished by suppliers as well as to the Contractor's own manufacture.

C. Alternatively, workmanship samples, identifying edge sharpness criteria for specific applications, may be proposed for Approval.

3.2 Structure - Materials

3.2.1 General

A. Materials used in carbody construction shall be in accordance with APTA-PR-CS-S-034-99, PR-CS-S-004-98, PR-CS-015-99, Aluminum Design Manual of 2020, and the requirements of Section 16, Materials and Workmanship.

B. Each production shell shall be serialized with a stainless serial number plate at the forward most jacking pad, visible from the side of the car.

C. Each production shell shall have traceability to the mill certifications used in its fabrication.

D. Material specifications of each material in the carbody structure shall be submitted in summary tables. Tables shall include chemical composition limits and physical property limits in all conditions of hardness and post welding, for both static and fatigue analysis. **(CDRL 03-02, Material Specifications)**

3.2.2 Steel

A. The carbody may be constructed of American Iron and Steel Institute (AISI) type 301LN stainless steel or Approved equivalent.

B. The end underframe may be fabricated from American Society for Testing and Materials (ASTM) A588 low alloy high tensile steel (LAHT), or Approved equal. Proposed alternative steels shall have inherent corrosion resistance equal to or greater than the required steel when evaluated per ASTM G101, paragraph 6.3.1.1.

3.2.3 Aluminum

A. The carbody may be constructed of aluminum. If an aluminum carbody is proposed, the Contractor shall show an aluminum extensive experience with past FRA Approved designs.

B. Ease of structural repair, for example after a grade crossing collision, shall be explained in the proposal.

C. Sufficient analysis must be provided during preliminary design reviews to show suitable strength and resiliency in vehicle strikes, rollovers, and side swipes. Any components or structural members susceptible to damage in head on collisions shall have replacement processes available at design review.

D. 2000 and 7000 series alloys shall not be used.

E. Methods and process for isolating dissimilar materials shall be shown to last the intended life of the vehicle.

3.2.4 Exterior Finish

3.2.4.1 General

A. All stainless steel exterior surfaces of the carbody shall be unpainted, with a uniform grit finish unless otherwise specified in this Specification.

1. Specifications and samples for all external surfaces meeting the grit requirement of Section 16 Materials and Workmanship shall be submitted for review and Approval within 120 days of NTP. A single set of preliminary samples can

be provided for grit selection and replaced at FDR. **(CDRL 03-03, Exterior Finish Samples)**

2. Depending on carbody conceptual proposals, SEPTA may request samples of all types of visible configurations, such as spot welds, laser welds, and sidewall to underframe splice welds.

3. Approved samples shall then be used throughout the program as references to maintain quality.

4. One set of samples, as Approved, shall be permanently marked as to application, date of Approval, and Specification requirements, and be kept by the Contractor in a sample file for reference throughout the Contract as required.

5. Samples of major weld seams visible from to the exterior shall be provided upon request.

B. If aluminum exterior surfaces are proposed, the proposal shall identify a method of corrosion protection to maintain the appearance of the exterior.

C. All visible exterior welds shall have regularly spaced patterns and be sufficiently finished to be unnoticeable except by close visual inspection.

D. If used, exterior laser welding shall be minimally visible from the platform, if at all.

3.2.4.2 Cosmetic Imperfections

A. Cosmetic aspects of the carbody are of great importance to SEPTA. The Contractor shall be responsible for manufacturing techniques to fabricate flat carbody surfaces.

B. All exposed surfaces (side, end walls, and roof) shall be as smooth as possible on the outside with a maximum variation from a straight line on flat surfaces, measured in any direction, of 0.0984 inch (2.5 mm) gradual discontinuity over 36 inches and 0.0625 inch (1.5 mm) within a distance of 12 inches on the sides of the car.

C. For the roof and end walls, deviations of 0.1875 inch (4.7 mm) over a 36 inch span and 0.125 inch (3.2 mm) over a distance of 12 inches will be allowable provided the area involved cannot be seen from the platform level.

D. For conditions where discontinuities within the flatness form have wave, ripple, or crease effects, acceptance criteria shall additionally not exceed 1/300 the span of each individual imperfection.

E. Dents, gashes, or other surface imperfections shall not be permitted.

F. The Contractor shall, at all phases of manufacturing, control and properly support large assemblies during repositioning, lifting, storing, or moving such assemblies so as not to cause flexing that will enable or cause distortions or unflat conditions of the assembly to occur.

G. All structural components, sub-assemblies, and carshells not in the final vehicle assembled condition, shall be stored in climate-controlled storage or their storage configuration and/or corrosion remediation plan submitted for Approval. Fully assembled bare carshells shall at a minimum be fully wrapped if stored outside climate-controlled storage areas.

3.3 Carbody Structure Arrangement and Details

3.3.1 General

A. The design of the carbody shall equal or exceed the Tier I requirements of 49 CFR 238 and the latest revision at the time of NTP for APTA PR-CS-S-034-99.

B. In lieu of the applicable forward end structure of cab cars requirements contained in 49 CFR 238.211 and/or 238.213, as well as APTA PR-CS-S-034-99, Rev. 3 Section 2.3.1 and/or 2.3.2, the carbody may comply with the requirements of 49 CFR Part 238 Appendix F.

C. In lieu of the applicable anti-climbing and collision post requirements contained in 49 CFR 238.205 and/or 238.211 as well as APTA PR-CS-S-034-99, Rev. 3 Section 2.3.1 and/or 2.3.2, the carbody may comply with the requirements of 49 CFR Part 238.211.d for semi-permanently coupled consist.

1. If such alternative is chosen, a documented engineering analysis shall be submitted for review and Approval per 49 CFR Part 238.211.d. The report shall verify the semi-permanent coupling system and supporting structure is capable of preventing disengagement and telescoping. **(CDRL 03-04, Articulated Alternative to Collision Post*s)***

D. If used, the Crash Energy Management (CEM) design shall follow the recommended practice in Section 6 of APTA PR-CS-S-034-99 rev 2. The use of CEM shall keep the carshell weight to a minimum subject to the car maximum weight limitations. The carbody analysis and test plan shall incorporate analysis plan and CEM test plan for SEPTA review and approval, and the CEM system design validation shall be carried out according to an approved CEM test and analysis plan.

3.3.1.1 Carbody Camber

A. The car shall be designed and constructed so that, for the life of the car, the camber between bolsters will be positive, but not in excess of 1/2 inch at AW1 load, and shall not be less than zero under AW3 load.

B. Carbody camber shall be defined as its vertical curved shape as viewed in side elevation. Carbody camber shall be a smooth arc from end to end of the carbody, and shall be measured from a datum line drawn between the intersection of the arc with the centerline of the body bolsters to a line tangent to the arc midway between bolsters.

C. The maximum difference between the camber of each side sill, measured at the location of maximum deflection, shall not exceed 0.125 inch.

D. The difference in height Above Top of Rail (ATOR) of the four corners of the finished car shall not exceed 0.375 in. measured at the end sills. The measurement shall be made on the completely assembled and equipped car mounted on its completed trucks. The measurement may be made from any suitable structural member of the underframe.

E. As an alternative the above requirements, aluminum carshells can have a negative camber no more than ½ inch at AW1 load.

3.3.1.2 Manufacturing Consistency

A. A sufficient number of jigs, fixtures, and templates shall be used to assure inter-changeability of components and uniformity of structure throughout the fleet.

B. Such parts of the bodies, as underframes, side frames, end frames, and roofs, shall be built on jigs.

C. All weld and bolt patterns shall be identical on all cars.

D. All equipment hangers shall be interchangeable on all cars without the use of shims.

E. Alterations to the carbody structure, such as drilling, cutting, welding, heating, burn-ing, etc., during fabrication assembly not previously incorporated on the drawings as of FDR, is expressly forbidden without written Approval.

F. Carbody drawings shall show the location of all principal framing members, their cross-sectional area, material, metal thickness along with detailed type and method of joining and applicable references to Welding Procedure Specifications. Bill of Materials shall be provided to link the drawing number and location of each part in its assembly level drawing. This information shall be of sufficient detail to permit manufacture of any structural parts necessary to repair damage to a car.

3.3.1.3 Watertightness and Sealant

A. The carbody shall be designed to provide watertight performance up to the maximum operating speed without requiring topically applied sealant. Only where unavoidable, the use of sealant in the carbody structure shall be submitted for Approval. The submittal shall include product specification sheets, application procedures, maximum thickness allowed, and locations allowed. The sealant shall only be applied in compression between assembled parts.

B. The carbody shall be designed to be watertight for a service life of at least 40 years, without maintenance.

C. Structural pockets and enclosed areas shall be kept to a minimum. Open pockets, water traps, and all other areas where water or moisture may accumulate, shall be sloped for self-draining.

3.3.1.4 Structural Connections

3.3.1.4.1 Strength and Overload Considerations

A. All connections between structural members shall be capable of developing the full strength of the weaker member. The anchor rod bracket is a permitted deviation.

3.3.1.4.2 Carshell Fabrication Restrictions

A. Plug or slot welds shall not be used unless individually Approved.

B. Ring welds shall be kept to a minimum and their locations shall be outlined for review during PDR.

C. Stud welding to non-load carrying stiffeners and secondary structure shall only be permitted when specifically Approved.

D. With the exception of the attachment points for floor panels, interior panels, and trim, there shall be no tapped holes in the car structure.

3.3.1.5 Carbody Strength

A. The carbody strength shall be sufficient to permit operation with up to AW3 loading for the design life of the car without structural damage including fatigue cracks.

B. Stability calculations of any stainless steel elements shall include consideration of the effects of the anisotropic behavior of stainless steel, and of reductions in elastic moduli with increasing stress. Calculations shall follow the methods described in Lincoln and Watter's Strength of Stainless Steel Structural Members as Function of Design, or the AISI Stainless Steel Cold Formed Structural Design Manual, or the ASCE Specification for the Design of Cold-Formed Stainless Steel Structural Members (with safety factors modified as noted above), or another Approved method.

C. The stresses in the carbody under full AW3 load shall not exceed the lesser of 50 percent of the guaranteed minimum material yield strength or the buckling strength.

3.3.2 Underframe Structure

3.3.2.1 Underframe

3.3.2.1.1 General

A. The underframe assembly may be composed of the center sill (if used) end under-frames, floor beams, sub-floor, cross bearers, and body sills.

B. All parts of the underframe shall be constructed of stainless steel, low alloy high tensile steel, aluminum or Approved equal.

C. The flooring and its supporting substructure shall be designed together to meet the loading and flatness requirements in Section 14, Interior and Exterior Appointments. The conformance of these requirements shall be presented in the Stress Analysis Report.

D. Center sills and side sills, if used, shall be of one-piece members extending between body bolsters to the greatest extent possible.

E. Crevices, pockets, and hidden areas, where water, dirt and debris can accumulate on the exterior of the underframe, shall not be allowed in the design to the greatest extent practical.

3.3.2.1.2 Hat Section

A. The underframe shall also include supports for seat and floor installations. Placement shall be based on the standard pedestal location as described in Section 14, Interior and Exterior Appointments.

B. Where seats are to be mounted, within the "hat" of the hat section, a full length tapping plate capable of meeting the minimum strength requirements of ASTM F594, Grade 5 nuts shall be permanently affixed to the support's surface for engaging seat pedestal mount bolts.

C. The tapping rails shall be equidistant from the car's longitudinal centerline to allow for the application of diverse seat types. The tapping rail hat section side profile prior to the surface of the flange shall be the thickness of the floor panels in addition to a single strip of elastomeric tape at the panel's mounting surface after being fully secured by a countersunk screw fastener.

D. Where hat sections span across floor beams, and potentially along the side structures supports, a shim of the same thickness of the hat section flange shall be installed to create a level surface for floor panel installations. No step-downs due to flange thicknesses shall be allowed.

E. Alternative designs to the requirements above may be proposed but shall be demonstrated to provide equal or better benefits to SEPTA.

3.3.2.2 End Underframe

A. An end underframe unit, including but not limited to the body bolster, draft sill, end sill, draft gear pocket, coupler support structure, and collision post stubs (if used) (see Section 3.3.4.2), shall be provided at each end of each car.

B. The end underframe shall be assembled by arc welding in accordance with Section 16, Materials and Workmanship using complete penetration groove welded joints. The use of prequalified welding procedures is permissible.

C. Fusion welding of one-sided joints in the fabrication of the end underframe shall incorporate the use of back-up strips where 100% penetration of a single beveled weld is desired.

D. The prequalified partial joint penetration groove welded joints may be used where primary loads are carried in shear along the length of the weld.

E. Fillet welds may be used in joints which do not carry primary loads.

3.3.2.2.2 Coupler Carrier

A. The coupler carrier, and those portions of the carbody to which it is attached, shall be designed to withstand the loads caused by supporting one end of the car on the coupler carrier with the truck attached such as might occur during emergency jacking or lifting with a crane in the event of a derailment.

B. Under this coupler carrier load, the allowable design stress of the coupler carrier, or any part of the carbody structure to which it is attached, shall be the yield, critical buckling stress, or 80 percent of the ultimate, whichever is lower.

C. The coupler carrier element on which the coupler shank slides shall have a non-metallic wear plate, manufactured of Nylatron or Gatke material or Approved equivalent. This part and its supporting springs shall be interchangeable among cars.

D. The coupler carrier and coupler connection to the carbody shall meet the climb, by-pass, and overturn resistance of APTA PR-CS-S-034-99.

3.3.2.2.3 Body Bolster

A. The design shall provide clearance for the truck in all positions and accessibility for truck maintenance and de-trucking.

B. Positive stops shall be provided on the carbody and truck bolsters to limit the vertical and transverse movement of suspended trucks when the carbody is lifted.

C. The stops shall meet the recommended practice of APTA PR-CS-S-034-99.

3.3.2.3 Sub-Floor Pan

A. A sub-floor pan shall be provided throughout the length and width of the car.

B. The sub-floor pan shall be seal welded all around and not permit entrance of water into the carbody.

C. The sub-floor pan interior shall contain the underfloor thermal and acoustic insulation.

D. The pans shall be suitably stiffened to prevent resonant noise and vibration and "oil canning" under any operating condition.

3.3.3 Roof

3.3.3.1 General

A. No through roof mechanical fastening is permitted.

3.3.3.2 Loads and Strength

A. All parts of the roof structure, sheets, equipment covers, roof walkway, screens, and other guards shall have sufficient strength to withstand, without exceeding the yield

strength, 80 percent of the ultimate strength and critical buckling stress under any of the following conditions:

1. The loads imposed by a mechanical car washer consisting of a pressure of 60 pounds per square foot over a 12 inch wide band extending transversely across the carbody,

2. Three concentrated loads of 250 pounds each, each applied over a 3 in. by 3 in. area and spaced 30 inches apart, applied anywhere on the roof, and

3. Uniform load of 15 pounds per square foot.

3.3.3.3 Roof Walkway

A. A roof walkway shall be provided for safe passage between roof mounted equipment. The walkway shall be identified through an approved non-slip surface treatment (e.g. spray-on).

3.3.3.4 Shrouds and Drainage

A. Shrouds or other Approved aesthetic treatment shall be erected to conceal roof mounted equipment, as proposed by the Contractor's Industrial Designer and Approved.

B. Shrouds shall be made of the same material as roof sheets, designed to harmonize with the car design, and not interfere with any ventilation requirements of roof mounted equipment or air intakes.

C. All side and end openings in the shrouds shall be screened as required for ventilation.

D. Perforated stainless steel screening or equivalent as Approved may be used.

E. All roof arrangements shall prevent accumulation of leaves, water, car wash cleaner, snow, ice, or excessive dirt.

F. The design arrangement and installation of roof equipment shall not permit accumulation of water.

G. All areas of the roof and roof equipment shall drain along the exterior of the carshell unless drain piping integrated into the sidewalls is Approved.

H. Drainage provisions shall be provided. **(CDRL 03-05, Roof Equipment Drainage Provisions)**

3.3.3.5 Emergency Roof Access

A. Roof emergency access shall be in accordance with FRA 49 CFR Part 238.123.

B. The perimeter of the cut-zone shall have a retro-reflective sign demarcating the opening, and clearly indicating the purpose, instructions, and other emergency signage per APTA Standard PR-PS-S-006-23 and PR-PS-S-002-98.

C. A report with cross sections of the fully assembled vehicle shall be provided at the emergency roof access locations to validate the entire cut-zone has uniform cutting thickness and the space below is free from all obstructions and secondary structure. The Emergency Roof Access report shall be updated during each design review phase. **(CDRL 03-06, Emergency Roof Access Zone Design)**

D. Emergency roof access procedures for emergency responders shall be provided for each vehicle configuration. **(CDRL 03-07, Emergency Roof Access Procedure)**

3.3.4 Structural Side Frame Posts

3.3.4.1 Loads

A. Passenger seats shall be supported by continuous structural members fastened to the side frame posts.

B. Seat pedestals are allowed for the three-person seats located towards the F-end of the car

C. The carbody side and side frame posts in that area shall be capable of supporting the full seating loads with a minimum safety factor of 2.0, and a maximum seat frame deflection not to exceed 0.25 inches.

3.3.4.2 Collision Posts

A. Car ends which do not utilize semi-permanent couplers and utilize collision posts to meet telescoping regulations shall meet the following requirements:

1. The components used to meet the shear requirements shall be fully welded to the bottom and top of the underframe and shall extend 18 inches above the top of the underframe connection, then gradually taper to a point not less than 30 inches above the top of the underframe connection.

B. If used, the components used to meet the shear requirements of the cab end reinforcement shall be continuous from the bottom of the end sill up to at least 30 inches above the top of the underframe connection, then gradually taper to a point not less than 42 inches above the top of the underframe connection.

3.3.4.3 Corner Post

A. The components used to provide the shear requirements of the corner posts shall be fully welded to the bottom and top of the underframe.

3.3.5 Equipment Boxes and Mounting Supports

3.3.5.1 Attachment Methods

A. All equipment boxes and attachments shall meet the requirements of APTA-PR-CS-S-034-99.

1. Equipment within an equipment box need not meet the above criteria provided it can be shown that the equipment will not penetrate the walls of the equipment box when exposed to these g levels.

2. For equipment under 150lb, stress analysis may be requested for review at the discretion of SEPTA.

B. The equipment box shall conform to these load criteria with the rearranged equipment in addition to its normal arrangement.

C. In no case shall the strength of a fastener or the shearing of the fastener through the base material be the limit of the carrying capacity of a member.

D. Brackets and other means of support for the equipment shall be designed and installed to facilitate access for maintenance and servicing and for removal and reapplication. Fasteners shall be conveniently accessible.

E. An attachments analysis plan shall be created including or tracking the revision and correspondence for submitting each equipment attachment analysis. **(CDRL 03-08, Equipment Boxes and Apparatus Supports)**

3.3.5.2 Mounting Restrictions

A. No apparatus over 25 pounds shall be supported by vertically oriented bolts which are the primary vertical load-bearing mechanism.

B. The Contractor may submit an Approved alternative apparatus support design utilizing bolts in tension provided that such design includes an adequate stand by support arrangement.

C. The design of the standby support arrangements shall include the effect of the equipment dropping from its mount.

D. Apparatus requiring removal and replacement for other than accident damage shall be supported so that both the bolts and nuts are accessible.

E. Bolts used to mount or support underfloor equipment shall not be less than 3/8 inch diameter.

F. Equipment supported on resilient mounts shall have safety straps or other devices which will support it in case of a failure of the resilient mounts.

G. The design of the safety straps shall include the effect of the equipment dropping from its mounts.

H. No equipment shall be supported by bolts in holes tapped into the underframe.

3.3.5.3 Pantograph Attachment

A. The pantograph shall be sacrificial. An attachment break-off analysis shall be submitted for review and approval as part of **CDRL 03-08**. The analysis must demonstrate

that the carbody will support the pantograph without permanent deformation to any element of the carbody structure in the event of catastrophic removal of the pantograph.

3.3.6 Gutters

A. Water deflecting gutters shall be installed over all side doors. They shall prevent water from dripping into or in front of the side door opening when the car is stopped.

B. Gutters shall be made from the same material as the shell, roof, and side sheets.

C. Gutters shall be MIG welded to ensure an esthetic view from the platform. An alternative weld configuration can be proposed for Approval, especially if the welds cannot be seen from the platform.

3.3.7 Jacking Pads

3.3.7.1 General

A. The carbody structure shall be designed so that jacks may be used for lifting the car at the jacking pads.

1. Eight minimum 2 1/2 inch by 6 inch jacking pads, with the longer dimension parallel to the longitudinal centerline of the car, shall be installed on the side sill in Approved locations to prevent damage to the carbody structure when lifting a car. See Appendix II for shop jacking pad locations.

2. The Contractor shall coordinate with SEPTA to permit the use of existing shop permanent jacking systems (see Appendix IV). **(CDRL 03-09, Jacking Pad Locations)**

3. The car shall be designed to permit jacking of either of the car end for truck removal or rerailing with the opposite end of the car resting on its truck without damage to the truck attachment, underframe, or any of the underfloor apparatus. It shall be permissible on the cab car to remove the pilot to fulfill this requirement.

4. Jacking pads shall extend one half (1/2) to 1 inch below the bottom of the side sill.

3.3.7.2 Loads and Strength

A. Symmetric Loading: The empty carbody, with trucks attached (AW0), shall be capable of being lifted on any symmetric jacking pads without exceeding 80% yield.

B. Diagonal Loading: The empty car, with trucks attached, shall be capable of being lifted on diagonally opposite inboard or outboard jacking pads without permanent deformation in any element of the carbody structure or jack pads.

C. Localized Loading: The localized strength around each of the jacking pads shall be designed for a vertical load of one half the weight of the car at AW0 (including trucks) and a simultaneous horizontal load of 10% of the vertical load.

1. The allowable design stress shall apply only to the localized structure to which the pads are attached.

3.3.8 Snowplow Pilot

A. A snowplow pilot, which meets the requirements of 49 CFR 229.123, shall be provided at each cab end.

B. A complete Approved package, consisting of all detail drawings for each part of the snowplow, maintenance and adjustment procedures, and an FEA on the structure and its attachment to the car, shall be submitted. **(CDRL 03-10, Snowplow Pilot Complete Approved Package)**

C. The snowplow pilot shall be constructed of stainless steel or low alloy high tensile steel properly coated for corrosion resistance in accordance with Section 16, Materials and Workmanship.

D. It shall be as large, as wide, and as low as possible to prevent objects from being rolled under the car.

E. The pilot shall not hit the running rail under worst case conditions of carbody vertical displacement, including completely deflated air springs and wheels worn to the condemning limit.

F. Pilots shall be interchangeable among cars.

G. The snowplow pilot shall be strong enough to perform its intended functions but, as a minimum, shall be designed to resist loadings not less than the following:

1. Longitudinal load at rail location at bottom of pilot:

   75,000 pounds on each side applied simultaneously

2. Longitudinal load at centerline of car at bottom of pilot:

   50,000 pounds, applied separately

3. Lateral load on single lower edge transverse member:

   50,000 pounds, applied separately

H. The allowable design stress of the plow shall be yield but the allowable design stress of the connection and supporting structure of the carbody shall be 80% of yield.

I. Snowplow pilots shall be attached to the carbody by mechanical fasteners; the connection shall be designed and constructed to facilitate installation and removal and to permit interchangeability among cars.

J. The pilot shall incorporate an adjustable, bolted, readily replaceable, sacrificial blade at the bottom of the pilot to prevent damage to the pilot in case of rail contact. The blade shall be adjustable to extend 2 inches below the pilot structure under all running conditions unless otherwise Approved.

K. The design shall provide for easy removal of the pilot when required for jacking of the car from one end.

3.3.9 Truck to Carbody Connection

A. The carbody stress analysis must assess the carbody's compliance with the truck-to-carbody connection criteria detailed in Section 11, Trucks.

B. This assessment shall use the reaction loads derived from the truck-to-carbody connection evaluation presented in Section 11, Trucks.

3.3.10 Bolster Anchor Brackets

A. If used, bolster anchor rods and brackets shall transmit the longitudinal loads between the carbody and the truck while meeting the following requirements:

1. They shall be positioned to minimize longitudinal vibration to the carbody.

2. Two bolster anchor rods and brackets shall be provided on each truck.

3. The bolster anchor rods each shall resist a longitudinal load in either direction of not less than two times the complete truck weight without exceeding the yield of the materials used or the critical buckling stress.

4. Loads used for the design of the anchor rod bracket shall, as a minimum, be three times the complete truck weight.

5. In addition, the strength of the anchor brackets and attachments to the carbody shall exceed that of the radius rods such that under conditions of extreme loading, the rods will fail without causing permanent deformation to the anchor brackets, their attachments to the carbody, or the carbody structure.

6. The anchor rod bracket shall be frangible, i.e., the anchor rod bracket shall fail and fall away under load before the carbody structure is damaged. A specially designed joint, which breaks at a predetermined load, is permitted.

7. Any horizontal load, which develops the ultimate load carrying capacity of the anchor rod bracket, shall not develop a stress greater than yield, 80 percent of ultimate yield, or the critical buckling stress in the side sill or other car structure.

8. The load shall be applied in any direction in the horizontal plane of any part of the anchor rod bracket below the side sill.

9. The attachment of the anchor bracket to the carbody shall be by mechanical fasteners, designed and constructed to permit interchangeability among cars, and arranged to permit removal of the bracket from outside of the carbody without interference from the car structure.

10. The bolster anchor rods are described in Section 11, Trucks.

3.4 Side Doors

3.4.1 General

A. Adequate stainless-steel handrails and stanchions shall be provided at each side of each doorway to permit ease of ingress and egress when using the lower-level steps and are detailed in Section 14, Interior and Exterior Appointments

B. Low level boarding doors shall be located either at each end of the car, or at approximate quarter point positions adjacent to high level boarding doors.

C. High level boarding doors shall be located at approximate quarter point positions inboard of the trucks. A single high level boarding door at the center of the car is not allowed

3.4.1.1 Side Door Framing

A. The low level side door framing shall have structure meant to impact wayside debris without crumpling any sheeting.

3.4.1.2 High-level Boarding Conversion Kit

A. Design and Mockup

1. A retrofit kit shall be designed and presented conceptually at each design review which converts the low-boarding entry points into high-level boarding in case SEPTA chosen to perform this conversion later in the life of the vehicle.

2. The conversion process shall be designed without the need for any alterations or adjustments within the door system's existing structure, mechanisms, or functionality.

3. The retrofit shall minimize the gap between the closed door and the new floor to the greatest extent practical and shall be Approved.

4. The design shall provide a safe, stable passageway which meets or exceeds all ADA requirements.

5. Provide all design information in **CDRL 06-07**.

B. Demonstrations

1. The retrofit shall be demonstrated at the car mock-up stage.

2. The retrofit kit shall be formally demonstrated during or prior to vehicle FAI. If performed during vehicle FAI, such retrofit must subsequently be reversed.

C. Documentation

1. An FEA report at PDR and testing report at FAI shall show the retrofit has the same, or better, strength and stiffness characteristics as the adjacent floor.

2. If the retrofit is welded into the carshell SEPTA may require justification FEA showing other vehicle load case results are not made worse after installation.

3. Fully detailed installation instructions shall be provided which include tools needed, step-by-step instructions, high-resolution illustrations, and drawing and part number references in the instructions.

4. All drawings, including but not limited to piece-part, assembly, weldment, and installation shall be provided at FDR. Drawings shall contain enough detail to allow SEPTA to procure the retrofit kits independently.

5. QA inspection of the interfacing points shall be included in the carshell documentation to ensure future conversions are not impacted by tolerance issues.

D. Material Delivery

1. Kits to retrofit 6 fully assembled vehicles shall be provided at the delivery of each of the first 6 vehicles.

3.5 Stress Analyses

3.5.1 General

A. The sequence of carbody analyses submittals below shall be adhered to:

1. Within 120 days of NTP, a stress analysis and test plan shall be submitted and shall be approved prior to submittal of the stress analysis report. **(CDRL 03-11, Carbody Stress Analyses and Test Plans)**

2. Electronic copies of the preliminary Finite Element (FE) model and a model report shall be submitted before submittal of the preliminary stress analysis results. **(CDRL 03-12, Carbody FEA Model and Model Report)**

3. Within 60 days of submittal of the analysis and test plan, preliminary stress analysis results shall be submitted. **(CDRL 03-13, Carbody Preliminary Stress Analysis Report)**

4. The stress analysis report, including crashworthiness analysis if used, and all carbody drawings shall be submitted and approved prior to the manufacturing

of any carbody structural parts and prior to submittal of the structural test procedures. **(CDRL 03-14, Carbody Stress Analysis Report)**

5. The carbody testing report and validation of stress analysis report shall be submitted within 45 days of commencement of structural testing. **(CDRL 03-15, Carbody Validation of Stress Analysis Report)**

B. Interior fittings and equipment attachment shall be in accordance with 49 CFR 238.233, APTA-PR-CS-S-034-99 Section 2.7 and APTA Standard PR-CS-S-006.

C. The Contractor shall use the stress analysis as an engineering tool to aid in the design of the lightest weight car in compliance with the requirements of the Specification.

D. The stress analyses shall indicate the calculated and allowable stresses and Margins of Safety for all elements for all specified load conditions.

E. The stress analyses shall, as a minimum, include finite element analyses (FEA) using recognized computer programs such as NASTRAN, ANSYS, STRUDL, ALGOR, or Approved equal, supplemented as necessary by manual or computer calculations of stresses at joints.

F. The preliminary stress analyses results shall require assumptions as to configurations, weights, and the method of manufacture all of which may require reevaluation and change as the designs are developed. As changes are made to the original assumptions, the stress analyses shall be revised and submitted for review.

G. The final stress analyses report shall be for the carbody in the as built configuration. All changes to the design of the carshell after the first submittal of the stress analysis report shall be submitted for Approval as a form of configuration control.

H. Each material, and its welded condition, shall meet the strength requirements of this section during all operational temperatures. Low temperature performance concerns shall be addressed in the Analysis and Test Plan and SEPTA may require material testing.

I. The following meanings shall apply in performing the stress analyses:

1. Permanent Deformation - A member shall be considered as having developed permanent deformation if any one of the following conditions is met:

a. The minimum yield strength as published by ASTM for the specified material and grade is exceeded. For materials or grades not covered by an ASTM specification, the minimum yield strength as guaranteed by the manufacturer is exceeded. For materials without a specific yield point, the 0.2 percent offset method shall be used to determine yield strength if Approved.

b. The material has buckled or deformed and does not return to its original shape or position after the load is released.

2. Ultimate Load Carrying Capacity - the maximum load that the member can support before it experiences material separation or completely fails as a column.

3. Margin of Safety:

$$MS = \frac{Allowable\ Stress}{Calculated\ Stress} - 1$$

The calculated stress shall include the applicable load factors. MS shall be a minimum value but a positive number.

3.5.2 Stress Analyses and Test Plans

A. Separate plans shall be prepared for each car type. However, a table of the different car types shall be provided in each plan.

B. The plan shall address the requirements of this specification, any applicable CFR, including but not limited to, 49 CFR Parts 27, 37, 38, and the latest APTA-PR-CS-S-034-99.

C. The stress analysis and test plan shall be discussed during the first design review meeting.

D. The plan shall be a working document. Initially, it may contain only basic and potentially incomplete information, and it will be progressively updated as the design evolves. When the plan for the analyses and testing is revised, it shall be updated and resubmitted no more frequently than monthly.

E. Separate plans shall be provided for each carbody type; however, each plan shall include a table listing the various carbody types. For any carbody type that uses an analysis or test from another carbody type for validation, this must be explicitly referenced within the plan.

F. Carbodies which have different component drawings or part numbers but utilize the same validation analysis or test should encompass detailed comparisons of design differences in their design review package.

G. The Stress Analyses and Test Plan shall detail the general methods and approach that will be used to analyze and test the carbody.

H. It shall also include the following, with references to standards and publications as appropriate:

1. A comprehensive table of material specifications detailing the chemical composition and engineering properties of each grade, temper, and post welding condition used in the carbody. This table shall include the FEA material property inputs and literature references or testing reports supporting these selections.

2. Detailed and high-resolution illustrations of each material's respective locations.

3. A numbered listing of each load condition for analysis and test, including load magnitudes and points of application, with CFR, APTA, and Specification references.

4. Acceptance criteria for each load condition.

5. Diagrams displaying loads applied and points of support for each load condition for analysis and for testing.

6. A description of the software settings, model setup, and meshing quality assurance.

7. Description and examples of methods for analyzing, evaluating, and reporting high and low stressed areas.

8. Description and examples of methods for analyzing, evaluating, and reporting the critical structural connections for static and fatigue (all major joint types shall be included; IE resistant and laser welding). Examples should include partial penetration welds if used (IE resistant and laser welding).

9. Fatigue joint testing plan for joint designs not covered by AAR, AWS, Aluminum Association Aluminum Design Manual, EN15085, DVS1608, or equivalent alternative.

10. Descriptions and examples of methods used in past projects to evaluate and justify stress singularities and stress concentrations in the FEA results.

    a. While APTA-PR-CS-S-034-99 allows for highly localized yielding in the design and testing of the carshell, such an allowance is not listed in 49 CFR 238. Justifications for stress singularities shall not rely on the highly localized yielding provision of APTA-PR-CS-S-034-99.

11. Table of all interior fittings to be analyzed and vehicle equipment over 150 lbs shall be provided with their respective mass and locations.

12. Description of structural manufacturing work done outside the Contractors main manufacturing facility.

13. If applicable, description of design process for dissimilar metal connections to isolate and prevent any galvanic reactions.

14. Description of the revision control procedures for the different models and their applicable submittals throughout the carbody design.

3.5.3 Finite Element Models and Model Report

A. The FE model and model report shall be resubmitted for each car type for each analysis submittal.

3.5.3.1 Finite Element Models

A. The following shall be included in the FE Model and shall be indexed to the appropriate load case in the model report:

1. Element mesh
2. All Assumptions
3. Boundary conditions
4. Contact parameters (if used)
5. Material properties
6. Component thicknesses

B. The formats of the submitted FE models shall be agreed upon between the Contractor and SEPTA, and can utilize formats such as HyperView Player.

C. As part of the carbody FAI, the carbuilder shall provide reports, models, illustrations, and drawings for SEPTA to audit and verify the final FEA model represents the final condition of the carbody structure.

D. If the FEA model does not represent the final condition of the carbody structure such as welds or holes to accommodate interfacing subsystems, these differences shall be summarized and justified.

E. Car types claiming to use the same carbody structure shall be similarly validated.

F. FE Model stress result files shall be provided for the tested load cases and the fatigue load cases.

3.5.3.2 Model Report

A. All aspects of the FE model shall be detailed in the model report, including but not limited to the software used, software settings, element mesh types, mesh quality, all assumptions, loads, boundary conditions summed totals of reactions forces and moments, area properties and material properties, units used, joint modeling methods, AW0 mass scaling methods, standing passenger representation, detailed weight tables, methods for mesh refinement, detailed in the model report.

B. The FEM report shall include a structural diagram (layout) of the carbody (including sheathing) showing the locations of all members and shapes and indicating the material and dimensions of each. Methods of joining shall be completely defined.

C. As a minimum, the following views shall be included on the carbody structural sketch: side elevation, top view of the roof and the underframe, and typical cross-sections of the carbody at a window, side doors, and full-height side frame posts.

D. Cross sections of the structural members with shape, dimensions, material, and thickness shall be shown.

E. The FEM report shall include a list of drawings with revision levels used to develop the model. As drawings are revised, the model shall be updated to reflect the changes, or there shall be documentation to indicate that the drawing changes do not affect the FEA results to be included with the next FEM submittal.

F. The model report shall contain detailed revision notes to explain changes between each model revision.

G. Diagrams shall be provided of the interior floor which detail the standing area calculations and shall use all floor space clear of equipment or seats above it, except space designated for seated passengers' extremities.

3.5.4 Carbody Stress Analysis Report

3.5.4.1 General

A. The stress analysis shall show the calculated and allowable stresses and Margins of Safety for all elements for all specified load conditions.

B. The stress analysis shall include calculations of stresses in joints, joint elements, and other important elements. It shall include FEA results, connection, buckling, natural frequency, and fatigue analyses.

C. In computing the shear strength of a beam, only that portion of the beam which is in line with the force vector shall be considered as resisting the force. If the force is skewed to the web of the beam, the force vector shall be divided into components, one in line with the web and the other in line with the flange. The shear resistance shall then be computed separately for each component.

D. There shall be a table showing geometric properties such as area and section moduli.

E. The report shall demonstrate that all structural members satisfy the requirements of this Specification in compliance with each design load and condition.

F. The report shall be organized and in sufficient detail so that SEPTA can readily follow the theory and its application to the car.

G. The Contractor shall certify that the analysis and calculations have been reviewed and checked before the report is submitted.

H. A summary of the results of calculations of stresses in all structural framing members and shear panels shall also be included. The locations, where calculated stress levels equal or exceed 80 percent of the allowable stress criteria specified in Section 3.5 and

Section 11, Trucks, shall be shown in a separate table along with the design and operating conditions (loads) which precipitate them.

I. The report shall include detailed calculations of stresses with Margins of Safety (MS) in all structural framing members and sheathing.

J. There shall be a summary table listing the Margins of Safety of all major members and any other member where the Margin of Safety is less than 0.20 together with the affected joints under all specified loads. The table shall include:

1. The identity of the member
2. Its location
3. The load condition
4. The Margin of Safety
5. The page on which the analysis can be found
6. The material of that member
7. The allowable stress of the members

K. Methods of joining shall be completely defined.

L. A preliminary stress analysis results shall be prepared and submitted for review and Approval not later than 60 calendar days after Approval of the analysis and test plan. Preliminary results of all load cases shall be included. The format of the preliminary results (i.e., PowerPoint) shall be agreed upon between the Contractor and SEPTA.

3.5.4.2 Finite Element Analysis

A. As part of the stress analysis, a linear-static finite element analysis (FEA) of the complete carbody shall be performed.

B. The FEA shall be a recognized computer program such as NASTRAN, ANSYS, Algor, STRUDL, or Approved equal.

C. The purpose of the carbody FEA, along with other analysis types, shall be to show that the design meets the requirements of the Specification.

D. The submittal input and output shall have each page numbered, and columns of data shall be clearly labeled on each page using terms, symbols, abbreviations, and units defined in the analysis report.

E. At the discretion of SEPTA, finite element models (FEM) and results shall be reviewed during the conferences conducted within three weeks after each submittal.

F. At these conferences, SEPTA shall have full access to the FEM input, output, and use of the software on the computer used for the analysis.

G. Color plots shall be prepared showing Von Mises stresses and deflections in all three axes.

1. Where requested by SEPTA, the Contractor shall provide the following:

a. Maximum and minimum principal stresses

b. Direction of maximum and minimum principal stresses

c. Meshing accuracy index

d. Maximum shear stress

H. All plots shall show the maximum and minimum values and all values which are greater than 80 percent of the specified maximum value.

I. Each plot shall include a triad showing the direction of the global axes.

J. Plots at high magnification shall be keyed to a plot showing the structure to an extent sufficient to orient the high magnification plots.

K. The report shall include all reaction forces, summed totals of reaction forces and moments, and a table to show static equilibrium for each load case.

L. Upon completion and Approval of the final design, the FEA model and analysis report shall be updated to represent the final configuration of the structure.

3.5.4.3 Critical Connections

A. The report shall include static and fatigue analyses of all structural hardware and/or critical weld joint connections of major structural elements under all specified load conditions.

B. Critical connections, which cannot be adequately analyzed, shall be prototyped, and tested to demonstrate compliance with the requirements of the design and the Specification.

C. The report shall include analyses of all critical and highly loaded connections showing that the joint is stronger than the weakest member being joined as required by Section 3.3.1.5.

D. The FEA shall be supplemented, as necessary, by manual or computer calculations of stresses at joints.

E. A critical connections map shall be created utilizing the requirements of this section. The map shall utilize a critical connection index that indexes categorizing details of each critical connection.

3.5.4.4 Buckling

A. The inelastic buckling strength of structural members subjected to any combination of compression and shear shall be calculated.

B. The variation in compression modulus with stress shall be considered in calculating compressive stability of members.

C. The buckling values shall be used as the basis for the allowable stress values for the specified load cases.

D. Any member in any of the elastic static analyses with a calculated compressive stress equal to or greater than 35 percent of its material's yield strength shall be included.

3.5.4.5 Natural Frequency

A. The natural frequency of the carbody under AW3 load supported at the secondary suspension points and modeled as a free-free beam shall be not less than 2.5 times the natural frequency of the car's secondary suspension system.

B. An analysis of the natural frequency of the car shall be submitted as required. Calculation of the car's secondary suspension system shall be included in the report. **(CDRL 03-16, Natural Frequency Analysis)**

3.5.4.6 Fatigue

A. An analysis of the fatigue life of the carbody shall be included in the stress analysis report.

1. It shall include a tabulation of the Contractor's selection of allowable fatigue stresses with data sources and assumed fatigue stress ranges for structural members which are critical in fatigue.

2. Particular attention shall be taken for truck/carbody connections such as the traction rod anchor bracket.

B. The minimum allowable fatigue stress range for the carbody is computed by multiplying the static stress at the AW2 load by the dynamic factor.

C. The dynamic factor shall be determined by the Contractor but shall not be less than ±20% vertically, ±20% laterally and ±10% longitudinally. The allowable fatigue stress range shall be based on a calculated car shell lifetime of 10 million cycles. This stress range must be within the design fatigue stress range obtained from one of the following sources as Approved:

1. For carbon and low alloy steel members, the stress range shall be obtained from AAR C-II, Chapter VII, or AWS D1.1, latest edition.

2. For aluminum structures, the stress range shall be obtained from AWS D1.2, Aluminum Design Manual of 2020, EN15085, or DVS1608.

3. For welded joints not covered by the above standards (spot welds, laser welds, friction stir welds, etc.), the Contractor shall conduct a sufficient number of

fatigue tests to determine the fatigue properties of the welded structure. Alternatively, methods of industry accepted publications can be submitted for Approval.

D. The fatigue analysis section of the stress analysis report shall include table(s) showing the minimum static and fatigue strengths of single and multiple layered spot welds. Values shall be given for each material, temper, weld size, and thickness combination used in the carbody. The source of the data shall be provided.

3.5.4.7 Manual Analysis

A. A manual analysis shall be conducted to closely examine details of the carbody (weld connections, welded and/or bolted joints, fatigue conditions) that are not readily handled by the FEA.

B. The manual analysis format shall consist of a title, sketch of item to be analyzed with dimensions and applied forces, drawing reference, material properties, allowable stress, detailed stress analysis, and conclusions.

C. A manual analysis may need to be performed on the following items if the FEA model does not provide adequately validation:

1. An analysis of the critical connections of the major structural elements and the critical loading conditions

2. An analysis of the strength of the connections of the trucks to the carbody including calculated vertical and horizontal connection load limits

3. An analysis of equipment hangers

3.5.5 Validation of Stress Analysis

A. Validation of the FEM shall be accomplished by comparing the carbody structural test results for each test required by Section 15, Test Program, with the corresponding stress analysis results or other method as Approved. This information shall be tabulated and submitted with the carbody structural test reports for each test.

B. In the test procedure for each test to be used for validation, there shall be a preselected list of strain gauges to be used for the comparison which shall not be less than half of the total number of strain gauges used during the test.

1. This table shall include a gauge number, element number, location, stress analysis strain value in the direction of the gauge, direction of the gauge on the carbody, a column for the strain gauge value, and a column for notes.

2. The test report shall include tables that compare stresses calculated from the test strain gauge readings with analytical stresses from the FEA and shall include the test stress value, the analytical stress value, the percent difference between the two values, and a space for annotation.

3. The report shall include a graph, plotted in MS Excel, comparing the stresses calculated from the test strain gauge readings with analytical stresses from the FEA.

C. For gauges applicable to the individual tests, the percent difference between the two values shall be within ±15% for 80% of the compared values of the test results and analytical results for each gauge type, with none beyond ±30%. This shall not include load cells. It is assumed all gauges of interest will target areas of stress over 35% of the allowable stress.

1. Additional strain gauges can be used for experimental or reference only purposes but shall not help satisfy the gauge count requirements and shall be clearly identified as such in all documentation.

2. Such experimental gauges may be applied on or extremely close to weld joints with no penalty to the correlation requirements but are not exempt from the yielding requirements and thus must measure and record data the same as the required gauges.

3. If the analyses results do not agree with the test results within the above specified tolerance, the Contractor shall revise the stress analyses, update the FEM, and rerun all FEA.

a. All manual analyses using data from the FEA shall be recalculated using the corrected values.

b. This process shall be repeated until agreement of results is within the specified tolerance.

c. The stress analysis report shall be revised and re-submitted.

d. All results from re-analysis shall meet Specification requirements.

e. The design shall be corrected if such requirements are not met.

D. Analytical values which disagree with the test value by more than 15% shall include an individualized and detailed explanation of the reasons for the variance in the carbody test report for individual review and Approval by SEPTA. This explanation may include supporting manual calculations.

1. Approval of the carbody test report shall depend, in part, on the adequacy of the analyses of excessive variance between analytical and test stress values.

3.5.6 Reports

A. The Contractor shall submit the required stress analysis report in compliance with the format and content specified herein.

1. If a cited reference is not readily available to SEPTA, the Contractor shall provide the reference or copies of the pertinent pages in English.

B. In addition to the body of the analysis, the stress analysis report shall include, at a minimum, the following:

1. The algebraic statement of all formulas and equations before the related calculations are performed along with the definitions of all terms and the values and units to be applied to these terms. In addition, the pages that show the development and interpretation of the formulas or data shall be included.

2. Units with all quantities.

3. References for all formulas, calculation procedures, buckling coefficients, material strengths, fatigue strengths, and other physical and mechanical properties where these items appear in the stress analysis.

4. Each page, including all stress analysis sheets, shall be numbered, dated, and initialed by the author or analyst and checker, and in the event of a revision, the revision letter, date, and initials of the analyst and checker.

5. Particular reference to, but not limited to, the following:

   a. Side sill

   b. Body sills (if used)

   c. End sill

   d. Anti-climber

   e. Draft sills

   f. Coupler supports

   g. Side frame rails

   h. Side frame posts

   i. Transverse and longitudinal sections at doorways

   j. Body bolster

   k. Floor and floor beams

   l. Collision posts

   m. Corner posts

   n. Structural shelf

   o. Roof structure

   p. Equipment supports

q. Connections between structural elements

6. If tests are conducted to provide the necessary data, the entire test report shall be submitted. This report shall show the test procedure, raw data as well as reduced data, and summary with detailed discussion of the results.

7. A table, listing and defining all symbols and abbreviations used in any analysis, shall be included.

8. A table providing the physical properties of each material (grade and temper) used for the carbody. This table shall include yield strength, ultimate strength, elongation, tension, compression, and shear moduli. Minimum Approved values shall be used and shall be selected from the ASTM (or equal) material specification.

9. A tabulation of the Contractor's selection of allowable fatigue stresses for the carbody material and each type of weld joint and assumed applied fatigue stress ranges for members and weld joints which are either highly or critically loaded.

3.6 Diaphragms

3.6.1 General

A. The "A" end of each married pair (non-cab end) shall have a tubular diaphragm installed. The diaphragms shall permit a married pair to negotiate specified extreme conditions of vertical and horizontal curvature simultaneously, without damage or interference.

B. Under the most extreme condition of horizontal curvature, the passageway between coupled cars shall be restricted to not less than 1 foot 4 inches in width. Diaphragms shall provide a tight seal under all normal operating conditions.

C. Each diaphragm shall consist of two vertical tubes flanking the doorway, with a horizontal top, all constructed of cloth-reinforced neoprene. The diaphragms shall either be of an integral molded tube design, or formed from sheet neoprene clamped in a tubular section. The horizontal section over the doorway shall have an integral vulcanized water deflector. Removable elbow sections shall connect and seal the horizontal tube to the vertical tubes Attachments to the carbody shall be by stainless steel fasteners, designed for ease of installation. The Contractor shall submit designs for applying an exterior coating to the neoprene tubes that will allow them to slide easily on each other and enhance their life. The design shall be approved by the Engineer.

D. Floor plates shall utilize wear plates/sliding elements to provide smooth quiet movements in revenue service. Floor plates shall be so designed to permit coupled cars to negotiate minimum radius curves and crossovers, without any binding of the mechanism.

E. Wear plates and bellows shall have a minimum life of 8 years. All other components shall be designed to last the life of the vehicle.

F. Tripping hazards and pinch points shall be eliminated by design.

G. Passenger vertical hand rails shall be provided on both sides of the passageway.

H. Attachment points, regardless of mounting location, and any portion of the equipment carbody to which the equipment supports are attached shall not exceed their fatigue limit for the design life of the car. Fatigue life shall be demonstrated by analysis.

I. The design shall provide a safe, stable passageway between two coupled cars which meets or exceeds all ADA requirements.

J. The design shall permit a married pair to negotiate specified extreme conditions of vertical and horizontal curvature simultaneously, without damage or interference.

K. A design description outlining the diaphragm design, materials, installation and servicing requirements shall be provided to the Engineer for review

3.6.2 Performance Requirements and Validation

A. Clearance testing shall be performed to ensure that the most extreme track conditions, including turnouts and reverse S-curves, can be negotiated. See Section 2, Design and Dimension Criteria, for dimensional data, track geometry and clearance requirements. See Section 15, Test Program, for testing.

3.7 Contract Deliverable Requirements List (CDRL)

The following contract deliverables have been identified in this section; however, the Contractor is responsible for providing and submitting anything necessary to fulfill the requirements of this contract, including those not identified by CDRL number.

CDRL 03-01, Carbody Equipment and Apparatus Details....3-1
CDRL 03-02, Material Specifications....3-2
CDRL 03-03, Exterior Finish Samples....3-3
CDRL 03-04, Articulated Alternative to Collision Posts....3-4
CDRL 03-05, Roof Equipment Drainage Provisions....3-9
CDRL 03-06, Emergency Roof Access Zone Design....3-10
CDRL 03-07, Emergency Roof Access Procedure....3-10
CDRL 03-08, Equipment Boxes and Apparatus Supports....3-11
CDRL 03-09, Jacking Pad Locations....3-12
CDRL 03-10, Snowplow Pilot Complete Approved Package....3-13
CDRL 03-11, Carbody Stress Analyses and Test Plans....3-16
CDRL 03-12, Carbody FEA Model and Model Report....3-16
CDRL 03-13, Carbody Preliminary Stress Analysis Report....3-16
CDRL 03-14, Carbody Stress Analysis Report....3-17

CDRL 03-15, Carbody Validation of Stress Analysis Report 3-17
CDRL 03-16, Natural Frequency Analysis 3-24
CDRL 03-17, Diaphragm Details 3-29

3.8 CDRL Details

This section lists the expected content for each CDRL required above. The lists provided for each CDRL are an outline only and should not be considered exhaustive, all CDRLs are subject to SEPTA review and approval.

CDRL 03-01 Carbody Equipment and Apparatus Details

1. Separate drawings shall be provided of each vehicle configuration showing outlines of all major carbody equipment and apparatus. At a minimum all equipment and apparatus over 150lb shall be included. The inclusion of additional equipment and apparatus shall be at the discretion of SEPTA. The drawings shall be submitted at CDR and can be illustrated as rudimentary diagrams. The drawings shall be re-submitted at FDR with complete detail of the structure, equipment, and apparatus. The drawings shall be revised and resubmitted to show the latest design at FDR and again when the vehicle is delivered to include the as built design.

CDRL 03-02 Material Specifications

1. Material specifications of each material in the carbody structure shall be submitted in summary tables at each design phase, with updated information as the design progresses. Stress-strain curves shall be provided for all materials used in non-linear analysis. The documentation must include, at a minimum, the guaranteed minimum yield strength, ultimate strength, elongation, Young's modulus, and allowable fatigue stress data shall be provided for each material in all conditions present in the design. If Cem is used, material testing data shall be included. All material property values shall match those used in all structural analyses. If the selected values are not derived from standard publications, comprehensive documentation justifying their selection must be provided.

CDRL 03-03 Exterior Finish Samples

1. The specifications and samples for all external surfaces shall be provided within 120 days of NTP to allow Approval of the proposed grit appearance. The samples should be no smaller than 6" by 12". If manual grit via grinding is planned on any visible structure of the exterior, a sample of the worst-case appearance shall be provided at FDR. All major weld joints visible from the exterior should be supplied at FDR unless otherwise Approved.

CDRL 03-04 Articulated Alternative to Collision Posts

1. If alternative compliance for anti-climbing and collision posts is chosen, a documented engineering analysis satisfying 49 CFR 238.211.d shall be provided. The analysis shall provide verification of the semi-permanently coupling system and the

prevention of disengagement and telescoping by the supporting structure. Per 49 CFR 238.211.d, SEPTA shall submit this document to the FRA to meet the alternative end structure requirements. This document shall be provided at Preliminary and Final Design Reviews. This document may require revision after input from the FRA.

CDRL 03-05 Roof Equipment Drainage Provisions

1. Drainage provisions for the roof of the carbody shall be provided at each design phase with progressively detailed information provided as the design progresses. The documentation must provide comprehensive details covering all areas of the roof sheeting and equipment, demonstrating how water accumulation is prevented. Methods for minimizing debris accumulation in these areas must also be included. Any service proven design features should be thoroughly outlined. If Approved, complete assembly and piece-part drawings of the drain piping integrated into the sidewalls must be submitted.

CDRL 03-06 Emergency Roof Access Zone Design

1. A report with cross sections of the fully assembled vehicle shall be provided at the emergency roof access locations to validate the entire cut-zone has uniform cutting thickness and the space below is free from all obstructions and secondary structure. The Emergency Roof Access report shall be updated during each design review phase with progressively detailed information provided as the design progresses. Location dimensions shall be provided at each design phase. Drawings of each vehicle configuration shall be included during the FDR submittal. The report shall be updated and resubmitted at the delivery of the first vehicle if illustrations have changed due to the as-built condition.

CDRL 03-07 Emergency Roof Access Procedure

1. Emergency roof access procedures for emergency responders shall be provided during Final Design Review for each vehicle configuration. The procedures shall outline the conceptual step-by-step instructions for first responders to gain access into the passenger occupied space of the vehicle, while the vehicle is on either of its sides.

CDRL 03-08 Equipment Boxes and Apparatus Supports

1. The attachments analysis plan must be submitted, outlining the process for tracking revisions and correspondence related to the submission of each equipment attachment analysis. All equipment and apparatus weighing over 150 pounds that are attached to the carbody structure must be evaluated in accordance with APTA-PR-CS-S-034-99. This plan shall specify the criteria for selecting which attachments will undergo analysis, detail the methods and extent of such analyses, and track the progress of each analysis report. A comprehensive list of equipment mounted to the structure shall be provided, indicating which of the attachments will be analyzed. The criteria of this list must be approved (ie equipment over 100lb, 75lb, or other). The attachments analysis plan shall be updated during each design review phase with progressively detailed information provided as the design progresses. If any

analyses remain outstanding at the time of the carbody FAI, the plan must be resubmitted following the delivery of the first vehicle.

CDRL 03-09 Jacking Pad Locations

1. Jacking pad locations of the carbody structure shall be provided. The submittal shall include drawings of each vehicle configuration and shall be updated during each design review phase with progressively detailed information provided as the design progresses. The drawings shall provide dimensions on the size of the pads and all locating dimensions in each direction of the vehicle. These drawings may be combined with the carbody equipment and apparatus details drawings.

CDRL 03-10 Snowplow Pilot Complete Approved Package

1. Detail drawings of all components of the snowplow, maintenance and adjustment procedures, and an FEA of the structure and its attachment to the carbody shall be updated during each design review phase with progressively detailed information provided as the design progresses. The drawings shall include weldment instructions, material, piece-parts, paint, hardware, fabrication details, as well as installation, maintenance, and adjustment instructions. The snow plow FEA can be included in the carbody FEA report and referenced in this document.

CDRL 03-11 Carbody Stress Analyses and Test Plan

1. A stress analysis and test plan of the carbody shall be provided within 120 days of NTP and updated during each design review phase with progressively detailed information provided as the design progresses. Details can be found in the Stress Analyses and Test Plan section.

CDRL 03-12 Carbody FEA Model and Model Report

1. Electronic copies of the preliminary FE model and a model report shall be provided prior to the submittal of the preliminary stress analysis results during PDR and updated during FDR. The FE model corresponding to each analysis report submittal shall be submitted at the same time. Details can be found in the Finite Element Models and the Model Report section.

CDRL 03-13 Carbody Preliminary Stress Analysis Report

1. Within 60 days following the submission of the analysis and test plan and during the PDR, initial results from the stress analysis must be provided. These preliminary results are intended to regularly inform the project team of the ongoing status and advancements in both the stress analysis and the design process. Updates must be submitted bi-monthly. The format for these updates should be straightforward, such as screenshots within a PowerPoint presentation, yet comprehensive enough to fully convey the progress of the analysis and design efforts. Each update document should begin with a concise table and summary that clearly outlines the advancements in the analysis and design to date. It is expected that the most design impactful and critical load cases will be presented first, even if their results do not meet the final analysis report's pass/fail requirements. The report should include all

load cases with roughly 75% meeting the structural requirements before approval and closure of PDR.

CDRL 03-14 Carbody Stress Analysis Report

1. The stress analysis report shall be provided during FDR. Any crashworthiness analysis, if used, shall also be provided. Details can be found in the Carbody Stress Analysis Report section.

CDRL 03-15 Carbody Validation of Stress Analysis Report

1. The carbody testing report and validation of the stress analysis report shall be provided within 45 days of the commencement of structural testing.

CDRL 03-16 Natural Frequency Analysis

1. The analysis of the car's natural frequency can be included in the Preliminary Stress Analysis Report and the Carbody Stress Analysis Report. Alternatively, it may be submitted as a separate document, provided it aligns closely with the content and timing of the aforementioned reports, both during PDR and FDR.

3.9 Referenced Standards

49 CFR Part 27	Nondiscrimination on the Basis of Disability in Programs or Activities Receiving Federal Financial Assistance
49 CFR Part 37	Transportation Services for Individuals with Disabilities (ADA)
49 CFR Part 38	Americans with Disabilities Act (ADA) Accessibility Specifications for Transportation Vehicles
49 CFR Part 229	Railroad Locomotive Safety Standards
49 CFR Part 238	Federal Railroad Administration, Department of Transportation, Passenger Equipment Safety Standards
AA ADM-2020	Aluminum Association Aluminum Design Manual of 2020
AAR Section C-II	Association of American Railroads – Manual of Standards and Recommended Practices Section C-II – Design, Fabrication, and Construction of Freight Cars
APTA PR-CS-S-004-98	Austenitic Stainless Steel for Railroad Passenger Equipment
APTA PR-CS-S-006-98	Attachment Strength of Interior Fittings for Passenger Railroad Equipment
APTA PR-CS-S-015-99	Aluminum and Aluminum Alloys for Passenger Equipment Carbody Construction

APTA PR-CS-S-034-99	Design and Construction of Passenger Railroad Rolling Stock
APTA PR-PS-S-002-98	Emergency Signage for Egress Access of Passenger Railroad Equipment
APTA PR-PS-S-006-23	Emergency Egress/Access Signage and Low-Location Exit Path Markings for Passenger Rail Equipment
ASTM A588	Standard Specification for High-Strength Low-Alloy Structural Steel, up to 50 ksi [345 MPa] Minimum Yield Point, with Atmospheric Corrosion Resistance
ASTM F594	Standard Specification for Stainless Steel Nuts
AWS D1.1	American Welding Society – Structural Welding Code – Steel
AWS D1.2	American Welding Society – Structural Welding Code – Aluminum
DVS 1608	Design and strength assessment of welded structures from aluminum alloys in railway applications
EN 15085	Welding of Railway Vehicles and Components
HH-P-151F	Federal Specification: Packing; Rubber-Sheet, Cloth-Insert
UIC 561	International Union of Railways (UIC), Means of intercommunication for coaches
UL 1439	Tests for Sharpness of Edges on Equipment

SECTION 4
COUPLER AND DRAFT GEAR

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4.1 General

A. Each "F" End (Cab End) of Silverliner VI (SLVI) cars shall be equipped with an Automatic Coupler system mechanically compatible with the existing SEPTA Silverliner IV and V fleets at a minimum.

B. The Silverliner VI automatic couplers shall automatically make all mechanical, pneumatic, and electrical trainline connections when mated.

C. Electrical couplers shall be provided with the mechanical couplers to automatically connect trainline circuits. Electric couplers are only required to be compatible with other Silverliner VI electric couplers.

D. Suitable mechanism shall be provided to prevent electrical coupling when cars are mechanically coupled to other fleets.

4.1.2 "A" End (Non Cab End)

A. The non-cab end of married pair cars shall be equipped with a drawbar providing inter-car mechanical connection and transfer of forces.

B. The Electrical trainline connection shall be done by means of connectorized trainline cables.

C. Pneumatic trainline connection shall be done by hoses, with vented cutouts at end of each car.

4.2 Automatic Coupler Equipment

4.2.1 Coupler Equipment Requirements

A. The Automatic Couplers, consisting of mechanical coupler heads, shanks, operating mechanisms, coupler heaters, wear plates, bushings, yokes with replaceable bushings, pneumatic couplings, and electric coupler mounting.

B. The Silverliner V fleets are equipped with WABTEC model N-2-A automatic couplers, part number 0578797.

C. The coupler shall mechanically, electrically, and pneumatically couple automatically when two cars are buffed together.

D. The draft gear shall be an elastomeric design, or approved equal, consisting of elastomeric draft gear elements, divider plates and follower plates.

E. Other associated coupler equipment and car features such as coupler mountings, coupler carriers, shims, brackets, and coupler stops shall be provided as necessary.

F. Coupler assemblies shall be interchangeable with each other without modification to the mountings and shall utilize the same draft gear and yoke assemblies, carriers and stops.

G. It shall be possible to automatically or manually uncouple two coupled cars when their couplers are in a buff or neutral load condition.

H. The coupler system supplied shall be capable of mechanical coupling without use of an adapter with the existing fleet of SEPTA's Silverliner V electric multiple unit cars and establish all mechanical and pneumatic connections. Electrical trainline connections are not required.

I. All coupler equipment shall conform to the requirements of 49 CFR Parts 229.61, 229.141, 238.203, 238.205 and 238.207, as well as any Association of American Railroads (AAR) Mechanical Division Circulars for couplers and applicable AAR material standards and recommended purchasing practices.

J. The coupler height of a car at AW0 conditions shall be 34.5 inches (+0 in.,-0.5 in.) when measured from the top of rail to the centerline of the coupler.

K. The coupler shall be capable of interfacing with SEPTA's existing N-2 to AAR Knuckle adapters WABTEC PN: 0574985.

The proposed coupler system including system functional description and outline drawings shall be submitted **(CDRL 04-01, Coupler System Design Package) .**

4.2.2 Coupler Equipment Loading Requirements

A. The coupler equipment, drawbar, and automatic couplers (excluding the elastomeric draft gear elements), when coupled to another coupler on straight level track, shall be capable of withstanding a 500,000-pound static draft load and an 800,000-pound static compression load without permanent deformation.

B. The mechanical couplers, when coupled shall be capable of withstanding a static vertical load of 100,000 pounds without failure.

C. The drawbar shall be capable of withstanding a static vertical load of 100,000 pounds without failure when coupled.

D. The draft and buff loads and vertical load are individual load requirements and are not to be combined with each other for product validation.

E. The elastomeric elements of the draft gear shall be capable of withstanding without permanent deformation a 200,000 pound load when the coupler system sustains a 200,000 pound load in draft or buff.

F. The Contractor shall supply, for approval, calculations which demonstrate the tensile, buff, lateral, and vertical load capability of the coupler system. **(CDRL 04-02, Coupler Load Analysis)**

4.2.3 Gathering Range and Movement

A. The gathering range of the coupler shall be sufficient for two cars with correctly adjusted couplers, one in new condition and one in fully worn condition, to automatically couple on tangent track. In no case shall the coupler gathering range be less than the existing SEPTA car coupler ability of 3.75 inches of radial misalignment between opposing coupler centerlines.

B. The cars, when coupled and with up to 6 inches of vertical misalignment due to equipment conditions, shall be capable of negotiating SEPTA's under worse-case curve conditions identified in Section 2, Design and Performance Criteria curves as well as track irregularities permitted for Class 1 track by FRA regulations without hitting the coupler stops or damaging any elastomeric components.

C. The Contractor shall supply drawings showing required coupler swing (including all cables and hoses) when coupled to another car under worst case track conditions and minimum radius curves, and drawings showing electric coupler cover actuation under worst case conditions. **(CDRL 04-03, Coupler System Curving Analysis)**

4.3 Components

4.3.1 Mechanical Coupler Components

4.3.1.1 General

A. Coupler heads and shanks shall be made of AAR Specification M-201 Grade C cast steel or other cast steel of equivalent or improved properties to achieve strength requirements, and shall be manufactured in a facility conforming to AAR requirements for manufacturing and quality assurance.

B. The coupler shank, where it meets the coupler carrier, shall be provided with a replaceable wear plate fabricated from stainless steel or other material compatible with the carrier wear plate. Thickness of the wear plate shall be suitable such that the wear plate does not require replacement prior to coupler overhaul.

C. Coupler pivots shall be provided with replaceable bushings of suitable material such that replacement is only required at overhaul.

D. Coupler shall include both pneumatic and electric portions such that all coupling features between SLVI cars is automatic.

4.3.1.2 Yoke and Draft Gear

A. Yokes shall be AAR Specification M-201 Grade E cast steel or other cast steel of equivalent or improved properties to achieve strength requirements. Fabrication of the yokes shall conform to AAR Specification M-211.

B. The draft gear shall be of the double acting, single cushion type such as Wabtec Passenger Transit part number 0D09639-3001, or approved equal.

C. The load deflection curve of the SLV couplers is available through Wabtec drawings 00X1314 and 00X1315.

4.3.1.3 Carriers

A. One spring-supported type coupler carrier shall be provided at each coupler.

B. The coupler carrier shall provide a means for adjusting the coupler height in 0.5 inch increments up to 1.5 inch to compensate for wheel wear.

C. Carriers shall be designed so that they will not be longitudinally loaded when the coupler is in worst case buff and draft at any lateral displacement angle. The coupler carrier shall be provided with service proven, replaceable non-metallic side and end wear pads and wear plate where it contacts the coupler shank. The coupler carrier shall comply with the requirements of 49 CFR Part 229.141 a(2) and a(3).

4.3.1.4 Stops

A. Coupler stops shall be provided to limit the lateral and vertical coupler swing to prevent damage to any electrical cables or air hoses.

B. The lateral stops shall be attached by bolts so that they are easily replaceable. Lateral stops shall be sacrificial to the end underframe members to which they are attached.

4.3.1.5 Centering Device

A. A passive spring centering device shall be provided.

B. The centering device shall be designed to allow the coupler to be manually moved off center to provide proper coupling alignment.

C. The car frame attachment brackets and hardware shall permit tension adjustment of the centering device, easily detachable if required when coupling on a curve.

4.3.2 Pneumatic Coupler

A. A pneumatic coupler portion having separate tappet valves for both the brake pipe trainline and the main reservoir pipe trainline shall be provided as part of the mechanical coupler.

B. It shall be capable of connecting the brake pipe and main reservoir pipe with Silverliner IV, and Silverliner V cars.

C. The pneumatic flow capacity shall be equivalent to a minimum 1.0 inch diameter iron pipe.

D. The equivalent length for either trainline shall not exceed that of an AAR standard 22-inch-long brake pipe air hose having a model FP-5 "glad hand" connector.

E. Both pneumatic trainlines shall be equipped with spring loaded tappet valves and suitable face seals, such that both trainlines are automatically connected when couplers mate.

F. Uncoupling of the pneumatic coupler shall cause a loss of pressure in the brake pipe sufficient to initiate an emergency brake application (via close proximity brake pipe venting devices) on both sections of an unintentionally uncoupled train, and on the uncontrolled section of a train during an intentional uncoupling. Uncoupling of the pneumatic coupler shall cause the main reservoir pipe trainline to close and retain main reservoir pressure.

G. Hoses shall be secured in a manner that prevents fowling through all range of motion and suspension conditions.

H. Compatibility with Locomotives or Conventional Railroad Cars

1. To provide brake pipe pneumatic compatibility when the car is coupled to a locomotive or a conventional railroad car, the following shall be provided in general compliance with APTA Recommended Practice RP-M-001-97:

a. An AAR standard 22-inch-long brake pipe air hose, including:

(1) Model FP-5 "glad hand" connector

(2) 1.25-inch diameter brake pipe end cock with locking handle.

4.3.3 Electric Coupler

4.3.3.1 General

A. The electric coupler shall be attached to the mechanical coupler and shall be a button contact style or equivalent design with at least 15 years of satisfactory operation.

B. The electric coupler shall have the required number of contacts and current capacity for trainline circuit transmission. Network transmission capabilities through the electric coupler shall be incorporated to meet the network system requirements as specified in Section 17, Network and Trainline Control.

C. The electric coupler shall be supported by the mechanical coupler, be designed to ensure positive electrical circuit contact under all conditions, and withstand all coupling impacts to which the car will experience in normal SEPTA Railroad Division service.

D. There shall be no damage to SEPTA electric couplers when vehicles other than Silverliner VI cars are mechanically coupled together assuming proper coupler operation or usage of adapter when coupling to AAR type couplers.

E. The electric coupler shall include heaters to prevent frosting of contacts during all environmental conditions outlined in Section 2, Design and Performance. Heater performance shall be verified through qualification environmental testing.

F. The electric coupler and cover system shall be rated to IP55 or higher.

4.3.3.2 Spare Circuits

A. The electric coupler shall contain sufficient contacts to meet all Specification requirements, plus 6 trainline spares, and two spares capable of handling high speed data networks or passenger information systems with video.

B. The contact arrangement shall be such as to maximize creepage distances between adjacent contacts and to metal components which are at the carbody potential. Assignment of contact functions shall be carefully thought out from a safety standpoint to minimize the hazard of short circuits.

C. Each of the 6 spare circuits shall have continuity from one coupler contact through the car to the coupler contact at the opposite end, and shall be routed through an assigned terminal in the trainline junction boxes.

D. Since cars may be turned in service, contacts shall be mirrored.

4.3.3.3 Contacts

A. Contacts shall be individually spring loaded to provide positive pressure against opposing coupler contacts. The contact spring shall be stainless steel and isolated from the current conduction path.

B. Contact tips shall be of sufficient hardness and strength to prevent distortion during assembly and normal service.

C. Each contact shall have sufficient capacity to carry a minimum of 20 amps continuously at the maximum voltage, and shall have ample surface capacity, suitable shape, and positive action to prevent unacceptable contact resistance when coupled.

D. Contact spacing shall be suitable to prevent arcing between contacts on the same coupler head.

E. All contact faces shall be suitably plated to provide corrosion free electrical connections for the life of the contact, 15 years at a minimum.

F. Contact tips shall be replaceable from the front face of the coupler and shall be secured to prevent loosening by a suitable means.

G. When uncoupling, the operation of the contacts shall be sufficient to avoid excessive arcing.

H. Alternate contact types from button style for specific functions, such as network connections, may be proposed for approval.

4.3.3.4 Manual Interruption

A. A mechanism to permit circuits to be interrupted while cars are coupled shall be provided.

B. A switch shall be included to provide logic that the electrical isolation has been performed.

C. A means to close necessary loop circuits for cab makeup in the event of electric coupler failure shall be provided.

4.3.3.5 Insulation Blocks and Housing

A. The insulation block(s) shall be made of a high density, non-hygroscopic and mechanically strong approved dielectric material, impervious to acids and alkalis found in the SEPTA Railroad Division environment, such as but not limited to car wash cleaning solutions. It shall be injection molded of virgin material and not contain any reburn material.

B. The housing shall be made of corrosion resistant material such as stainless steel. Any cast aluminum parts shall be A356 aluminum alloy with T6 heat treatment, or approved equal.

C. All fasteners threaded into cast aluminum parts shall be threaded into stainless steel helicoils, and have threads coated with an approved anti-seize compound.

D. The interior of the housing shall be covered with an insulating coating. Welding of the housing shall be done in accordance with AWS D1.3.

4.3.3.6 Cover

A. The coupler contacts shall be protected by a retracting cover which automatically swings clear when mating couplers engage, and completely closes in a positive fashion when couplers are separated.

B. When couplers are engaged, the accumulation of snow shall not be permitted within the coupler head.

C. A snow shield may be used to deflect snow from entering the retraced cover gap. Snow shields shall not require any maintenance and be adjustable to avoid rubbing or snagging with the coupler assembly.

D. The gasket shall be one piece mechanically attached to the housing and provide water and snow entry resistance when either coupled or uncoupled. The gasket shall be replaceable without requiring disassembly of the electric coupler head.

E. The coupler contacts and trainline signals shall be unaffected by seal leaks. The cover shall be impact resistant, made of corrosion resistant material, and either clear the contacts by 0.125 inch in accordance with APTA Recommended Practice RP E-004-98, or have an insulating liner.

F. The pivot points shall have synthetic bushings to provide low friction operation and not require lubrication.

G. An integral spring-retracted prop rod shall be provided to permit the cover to be held in the open position when desired for maintenance of the contacts, insulation block and gasket.

H. The cover shall withstand normal coupling cycles without damage.

4.3.3.7 Cables

A. Connections from the electric coupler to the carbody and across the couplers between the non-cab end of married pairs shall be by means of watertight cables with cable connectors at both ends which meet the requirements of Section 16, Materials and Workmanship.

B. All cables shall meet the life cycle test requirements of Section 15, Test and Commissioning.

C. The connectors at the electric portion shall be the same as those at the carbody, so the cable may be used in either orientation.

D. The cable receptacle on the electric coupler body shall be a separate replaceable unit so that it can be replaced without disturbing the coupler wire harness.

E. The trainline cable receptacle on the non-cab ends of married pairs shall be located towards the center of the car.

Cables shall be secured in a manner that prevents fowling through all range of motion and suspension conditions.

4.3.3.8 Critical Trainlines

A. The following critical trainlines shall be clustered near the vertical or horizontal centerline of the coupler in a manner so that identified trainlines will be commonly available for future contracts.

1. Emergency Trainline
2. Buzzer
3. Doors Closed and Locked
4. All Brake Released
5. Spare, one minimum
6. Associated Grounds

4.3.4 Married Pair Coupling

4.3.4.1 Drawbar

A. A mechanical drawbar shall be provided between married pairs.

B. The drawbar shall be manufactured of AAR Specification M-201 Grade C cast steel or other cast steel of equivalent or improved properties to achieve strength requirements and shall be manufactured in a facility conforming to AAR requirements for manufacturing and quality assurance.

C. Single piece and two piece drawbar designs may be proposed. The mechanism for securement of the two drawbar halves shall be service proven and submitted for Approval. Separation of drawbar halves shall be accomplished without the use of special tools.

D. Lifting points shall be provided to facilitate moving the drawbar assembly during installation and removal from the cars.

E. The draft gear shall be interchangeable between ends of the car.

F. Drawbar design and vehicle integration shall be provided. **(CDRL 04-04, Drawbar System Design Package)**

4.4 Coupler Auxiliary Components

4.4.1 Controls

A. Controls shall be provided in each cab and at ground level to uncouple cars. Manually controlled, electropneumatic operation shall be provided at the cab end of each car to control the adjacent coupler.

B. Coupler control shall be enabled with a standard key. Pressing the uncouple pushbutton in a cab shall cause electrical and pneumatic trainline connections to be interrupted, and opening the locking mechanism of the mechanical coupler so cars can be separated.

C. Brake release and propulsion shall be permitted only on that car from which the uncoupling pushbutton is operated, to permit the car to be backed away.

D. Manual uncoupling controls shall also be provided at ground level and must be compatible with the existing SEPTA car couplers.

E. No remote uncoupling control shall be provided at the non-cab end coupler of a married pair.

F. Provision shall also be made for manual mechanical (non-pneumatic) uncoupling from the sides of the car, in accordance with FRA regulations. If the mechanism to accomplish this involves the use of a removable handle, provisions for storage of this handle shall be included on each car adjacent to the "F" end. Manual isolation for pneumatic uncoupling devices shall be accessible from the side of the car.

4.5 Contract Deliverable Requirements List (CDRL)

The following contract deliverables have been identified in this section; however, the Contractor is responsible for providing and submitting anything necessary to fulfill the requirements of this contract, including those not identified by CDRL number.

CDRL 04-01, Coupler System Design Package 4-2
CDRL 04-02, Coupler Load Analysis 4-2
CDRL 04-03, Coupler System Curving Analysis 4-3
CDRL 04-04, Drawbar System Design Package 4-9

4.6 CDRL Details

This section lists the expected content for each CDRL required above. The lists provided for each CDRL are an outline only and should not be considered exhaustive, all CDRLs are subject to SEPTA review and Approval.

CDRL 04-01 Coupler System Design Package

1. It shall be submitted as part of each design review meeting (CDR, PDR, FDR).
2. It shall include the following details:
    a. System functional description discussing the system design for the automatic coupler, electric coupler, and support equipment.
    b. System functional instruction shall include description of coupling and uncoupling process for both Silverliner VI and Silverliner V cars.
    c. Outline drawings for the primary components of the coupler system.

CDRL 04-02 Coupler Load Analysis

1. It shall be submitted prior to Preliminary Design Review and must be approved by Final Design Review.
2. It shall provide analysis and calculations which demonstrate the load carry capacity in the following conditions:
    a. Tensile
    b. Buff
    c. Lateral
    d. Vertical

CDRL 04-03 Coupler System Curving Analysis

1. It shall be submitted prior to Preliminary Design Review and must be approved by Final Design Review.
2. Drawings shall provide worst case horizontal and vertical curving conditions to validate clearance between coupler and all other car systems during operation including:
    a. Normal configuration
    b. Suspension failures

CDRL 04-04 Drawbar System Design Package

1. It shall be submitted as part of each design review meeting (CDR, PDR, FDR).
2. It shall include the following details:
    a. Drawbar design explanation defining drawbar and its coupling mechanism (if 2 piece design is provided)

b. Drawing of the drawbar components

4.7 Applicable Standards

Code of Federal Regulations:

49 CFR Part 229	Railroad Locomotive Safety Standards
49 CFR Part 238	Federal Railroad Administration, Department of Transportation, Passenger Equipment Safety Standards

AAR Specifications:

M-201	Castings, Steel
M-211	Foundry and Product Approval Requirements for the Manufacture of Couplers, Coupler Yokes, Knuckles, Follower Blocks, and Coupler Parts

APTA Recommended Practices:

APTA-PR-M-RP-001-97	Air Connections, Location and Configuration of, for Passenger Cars Equipped with AAR Long Shank Tight Lock or Similar Long Shank Type Couplers
APTA-PR--E-RP-004-98	Gap and Creepage Distance
AWS D1.3	Structural Welding Code – Sheet Steel
EN 60529	Degrees of protection provided by enclosures (IP Code)

SECTION 5
OPERATOR'S CAB

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5.1 Cab Arrangement

5.1.1 General

5.1.1.1 Layout

A. Comply with the following: An Operator's cab conforming to FRA requirements shall be provided at the "F" end of the "A" and "B" cars of the married pair. The compartment shall have an Operator's control console on the right side of the car. All controls and panels shall be sufficiently compact to enable the Operator's freedom to move about the cab with minimal restriction. The Operator's control area panels, switches, and displays shall be organized logically. Details of the design, arrangement of the cab, and locomotive controls shall be submitted. **(CDRL 05-01, Cab Design Details)**

B. The Operator's compartment and all equipment and appointments shall conform to FRA requirements.

C. The operating cab shall be a full-width design. If a low level boarding door at the F-end is provided, a trap door shall fully cover the stairwell.

D. The Operator's compartment shall be separated from passenger seating areas by a full-width partition with door.

E. The cab shall be spacious, well insulated from sound, and arranged to have the most ergonomic layout possible to avoid repetitive motion injury.

F. The interior of the cab shall present a clean pleasing appearance and shall be free of sharp edges and protrusions.

G. The cab shall be designed so that all devices and equipment are integrated (built-in and flush-mounted) into the console, walls, ceiling, or floor. The design shall group controls and instruments for function, maintenance, and servicing. All equipment shall be attached with machine screws to either tapping plates or captive nuts.

H. The cab shall have upper, side panels, front display panel, and a desk console located directly in front of the Operator's position. The cab equipment layout and console configuration shall be designed to ergonomically accommodate Operators ranging from the 5th percentile female to the 95th percentile male as described in Section 2, Design and Performance Criteria. Seat placement shall consider the Operator's relationship to the console and the windshield.

I. The relationship between the Operator and the windshield shall be designed to optimize the field of view. The cab layout shall provide the Operator with an effective field of view to the right and left of the direction of travel. Obstructions to the field of

view shall be minimized. The field of view from the seated position at the right side of the cab, shall:

1. Allow for the Operator's minimum clear viewing distance from the seated position to be no more than 40 feet to the top of rail and no more than 40 feet to catenary at a point 18 feet above top of rail.

2. The Operator shall be able to see the coupler for coupling operation.

3. This shall apply to Operators ranging from a 5th percentile female to a 95th percentile male as described in Section 2, Design and Performance Criteria.

J. Primary console features shall be positioned to be accessible and functional from the Operator's seated position with all primary operating controls and displays mounted within the Operator's console desk. Normal operation shall not require awkward or unnatural positioning, extension, or excessive movement by the Operator. All primary console controls shall have unobstructed access and sufficient clearance for normal operation.

K. Secondary controls, switches, indicators and features not used for train operation shall be placed on panels more remote but accessible to the Operator. Electrical and control enclosures shall be designed to preclude the intrusion of water and dust. To the extent possible, indicator lights shall be grouped together in a panel with a single push to test button.

L. All controls, switches, and indicators shall be IP54 rated.

M. The cab area shall be laid out so as to be neat and orderly in appearance, with all apparatus designed and arranged in a manner that will not cause confusion to the Operator. The layout shall maximize the use of available space and shall employ sound ergonomic and industrial design principles in its development as required in Section 2, Design and Performance Criteria, yet shall be designed to be rugged and easily maintained.

N. Cab noise levels shall be subject to 49 CFR 229.121 for stationary noise level and 49 CFR 227 for dynamic noise level.

O. Upon preliminary approval of a layout, a Cab Soft Mock-up of the layout of the complete cab shall be provided by the Contractor per Section 25, Program Management and Commissioning to ensure proper apparatus fit and ergonomics. After design approval, the mock‑up shall be delivered at no cost to SEPTA for use as a training tool. The final layout shall be Approved prior to any production.

P. Upon preliminary approval of a layout, a mock-up of only the cab center console, including the under windshield display panel at the back of the center console and side panels including the most frequently used switches and controls, shall be provided by the Contractor for design review per Section 25, Program Management

and Commissioning using the controls specified in this Section. After design approval, the mock-up shall be delivered at no cost to SEPTA for use as a training tool.

Q. Upon preliminary approval of a layout, a mock-up of the layout of the complete car-wide cab shall be provided by the Contractor per Section 25, Program Management and Commissioning to ensure proper apparatus fit and ergonomics. After design Approval, the mock-up shall be delivered at no cost to SEPTA for use as a training tool. The final layout shall be Approved prior to any production.

R. For mock-ups that are to be delivered to SEPTA, the Contractor shall deliver each mock-up to a location designated by SEPTA, perform all required set-up and assembly as required, and maintain the mock-ups on-site, current with the design. Any disassembly or re-assembly for moving the mock-ups or for performing replacements shall be the Contractor's responsibility.

S. The cost of incorporating any required change in the mock-ups and design of the car shall be borne solely by the Contractor.

5.1.2 Interior Design

A. Certain critical displays as identified herein shall be located adjacent to the windshield, and under the windshield in the Operator's plane of normal forward vision, for ease of viewing.

B. Utility shall not be sacrificed to aesthetics, although a pleasing and comfortable environment for the Operator shall be a design objective.

C. Controls shall be arranged so that those that are most often used or are of critical importance are the most convenient to the Operator, and others shall be located such that the hazard of misuse is minimized.

D. The cab flooring shall be installed to permit its removal (including the floor panels) without the need to disturb or remove the cab partitions or electrical locker. It shall be the same as used in the car interior and shall comply with Section 16, Materials and Workmanship. The cab floor, side wall, and end sheets shall be insulated in accordance with Section 14, Interior and Exterior Appointments.

E. The cab compartment linings shall be made of highly durable, scuff and scratch-resistant materials, such as fiberglass reinforced plastic or melamine covered with Tedlar composite laminate, or other approved materials.

F. All interior panels shall be designed with large radius corners (0.5-inch minimum) and smooth transitions to facilitate cleaning and prevent injuries. The number of exposed fasteners, seams, and moldings shall be minimized.

G. The control panels facing a seated Operator shall be provided with a dull black finish to eliminate glare.

H. Exposed fasteners used to retain components shall be captive and have a black anodized finish to match the surrounding area.

I. The cab shall be arranged and finished to minimize injury to an Operator in the event of an accident or collision and shall be free of sharp edges, protruding objects, safety hazards, and floor obstructions, as described in Section 2, Design and Performance Criteria

J. The right side of the cab will be closed off and locked when not in use.

K. Cab equipment shall be mounted in modules and/or panels to be easily replaceable from the front or top of the mounted positions. Pneumatic devices shall be fed from non-kinking hoses to permit ready panel removal.

L. All annunciator lights shall use light-emitting diodes (LEDs) and shall have a separate test switch to verify operation.

M. All controls and indicators shall be identified by adequate labeling on the console panel. Multi-position controls shall have all positions identified. This labeling shall be done by an overlay with backlighting on all panels, or other approved techniques with equal permanence.

N. Modular console construction shall be used, with quick-opening captive stainless steel fasteners used for the attachment of console panels.

5.1.2.1 Documentation and Review

A. The arrangement of the cab shall be under the direction of the Industrial Designer, who shall verify all human factors data.

B. The Contractor shall submit for approval a series of general arrangement diagrams of the interior of the Operator's cab compartment, illustrating the location of all features and appointments, as well as general arrangement diagrams of the Operator's control consoles, illustrating the location of all features, appointments, controls, switches, gauges, meters, and indicators. **(CDRL 05-02, Interior General Arrangement Drawings)**

1. The Contractor shall submit plans to reduce the size of the full width cab to increase passenger seating capacity at a future date. These plans shall describe the resulting seating layout and identify all required materials, drawings, and modification instructions and shall be submitted for Approval.

C. Fields of view, legroom provisions, and ranges of arm movement for a seated Operator of the specified percentile range shall be included.

D. The review period for these initial cab and controls arrangement drawings shall permit SEPTA internal review by all relevant departments.

E. The final console arrangement shall be submitted for approval during drawing and design review and at cab mock-up reviews called for in Section 25, Program Management and Commissioning. **(CDRL 05-03, Final Console Arrangement)**

F. The entire cab area shall be properly heated, ventilated, and cooled, be draft-free, and insulated against noise and thermal loss.

5.1.3 Cab Enclosure

A. The cab shall be a full-width cab, and on the right side shall contain an Operator's control console located below the windshield, a right and left side vertical panel on either side of the windshield, a vertical display panel under the windshield above the rear of the center console, and an overhead panel located above the windshield.

B. The Operator's rear wall shall be a transverse partition extending from the side wall to its intersection with the longitudinal cab partition and shall contain a circuit breaker panel on its upper portion. This transverse partition shall also form part of the computer/electric locker.

C. To the Operator's left shall be a longitudinal partition extending from the forward portion of the cab to its intersection with the transverse rear panel and shall contain the cab door and door header.

D. Also supplied shall be a transverse partition that shall extend from the left side wall to an intersection with the longitudinal partition, containing a doorway and door header at the aisle into which the cab door will close.

E. The door when located across the aisle will complete the transverse partition to create a full-width cab.

F. The cab door shall be lockable in two positions, transversely to create a full-width cab in the front end of the train, and longitudinally to enclose the console and other controls and permit the use of the aisle and the left side of the cab area to the low level doorway and end door, if provided.

G. The cab door shall be capable of swinging 180 degrees from the longitudinal position and being secured in this open position by means of a door keeper.

H. These partitions shall be constructed of aluminum honeycomb faced with integrally colored FRP covered with Tedlar composite laminate, or other approved materials:

1. The exterior face shall match the styling of the car interior, and the interior face shall match the Operator compartment styling.

2. Vertical drop sash windows shall be provided on the sides per Section 5.3.2.

3. The cab partitions shall be securely mounted to run from floor to ceiling and be of adequate structural integrity to withstand all normal or extraordinary loading from passenger contact, such as from vandalism.

4. Each partition, when mounted, shall withstand a horizontal load of 330 pounds applied at any location without permanent deformation.

I. If offered, the left side of the cab shall include a low level door panel, stairwell, and doorway for passenger ingress and egress, as described in Section 6, Passenger Doors, and shall meet the following requirements:

1. The left side doorway shall have a hinged trap door that will be latched in the down position when the cab is in the full width configuration to fully cover the stairwell and latched in the up position when configured for passenger use. It shall automatically latch and lock in the up position and require the use of the standard coach key to unlock. The latches shall be standard J.L. Howard trap door holders and locking devices.

2. The top of the trap shall be covered with flooring that matches the interior flooring or other approved anti-skid material. The bottom of the trap shall have a handhold similar in design to that used on the SEPTA Silverliner V vehicle traps and subject to Approval.

3. When the lowered trap door is unlatched for raising, it shall be supported by an adjustable torsion spring so that the outer edge will rise approximately 10 inches, for ease of grasping. The design of the trap door and latching shall not present a tripping hazard.

J. Lighting in the low level doorway, stairwell when configured for passenger use, and center aisle when configured for pass through to the end door shall be as described in Section 8, Lighting.

K. Incorporated into the rear wall of the cab in an Approved, easily accessed location shall be a crew tablet/mobile computing device locker:

1. This locker shall be solidly constructed and lined with stainless steel, and have a hinged door secured by a slam lock operated by the standard key.

2. The door shall be mounted with a stainless steel hinge and have an external face treatment matching the cab decorative effect.

3. The minimum inside dimensions shall be determined at design review.

4. The locker shall also be arranged for locking with a padlock supplied by the train crew, and a stainless steel scuff plate shall be provided to protect the interior finish from the padlock.

One 120-volt AC grounded duplex GFI-protected receptacle, protected for 15 amps service, shall be located inside the locker.

5.1.4 Cab Door

5.1.4.1 General

A. The Operator's cab shall have a fully hinged door, hinged on the rear door post, that shall swing outward, toward the center aisle.

B. The cab door shall contain a fixed window and a fixed louvered grille.

C. The door shall be of hollow stainless steel construction with a phenolic foam core and brushed exterior finish.

D. Minimum thickness of exterior sheathing shall be 0.050 inches.

E. Each door shall be provided with adequate stainless steel reinforcements for the attachment of all hardware.

F. The door shall be bound on all four edges by welding, rolled seams, or a combination.

G. The cab door shall be hung on a continuous, full-length, stainless steel hinge having a stainless steel hinge pin, located at the outboard edge of the door.

H. When closed, the door shall bear against a neoprene elastomer cushioned door stop across the top and both sides.

I. The cab door shall be of sufficiently rigid and strong construction to withstand when mounted and closed, a horizontal load of 330 pounds applied at any point without permanent deformation.

J. The door shall not rattle or squeak in any position and shall be sealed when closed in either position to provide a highly soundproof barrier.

K. The door shall be capable of:

1. Closing off the Operator's control station when not in use to permit passenger movement from car to car and provide access to the Observer's side of the cab for the low level doorway, if provided.

2. Closing off the Operator's full width compartment by swinging to the rear partition.

3. Swinging 180 degrees from the position it is in when the Operator's control station is closed off.

4. Meeting 49 CFR 238.439(c) and include a feature to allow the Operator to exit quickly in the event of an emergency.

5.1.4.2 Window

A. Each door shall have a fixed window, positioned toward the upper quarter of the door, of sufficient size to provide a full view for the Operator control area when closed off. The window on the cab door shall align with the front window in the End Door when the cab door is locked in the full cab position.

B. The window material shall be mar-resistant polycarbonate and tinted to a level as Approved.

C. A cab window shade using an adjustable roll-down opaque non-reflective shade shall be provided in each cab for each cab door window. The shade shall be positional over the full length of the window and shall maintain position. Vibration and normal vehicle motions shall not cause the shade's adjusted potion to change.

D. The window shall be glazed in a neoprene rubber section and mounted to the door using a two-piece frame (inner and outer) aluminum extrusion, which shall be satin-finished and anodized.

E. The exterior face shall either have no exposed fasteners or fasteners facing the aisle.

5.1.4.3 Grille

A. A sight-tight, louvered, heavy-duty, nonadjustable stainless steel or anodized aluminum air grille shall be located in the lower part of the cab door for ventilation.

B. The louvers shall be a minimum of 0.125-inch thick, and shall be reinforced with two 0.125-inch thick vertical stiffeners.

C. The size of the grille shall be approximately 7 inches vertically by 9 inches horizontally and located on the centerline of the door, at least 12 inches above the floor.

5.1.4.4 Lock, Hardware, and Closer

A. The cab door shall have an Approved J.L. Howard snap-type deadbolt lock to preclude any unauthorized entry into the cab by forcing the latch head back, which shall hold the door closed and can only be opened from the aisle side, when either closing off the right side operator controls or in the full-width cab configuration, by the standard key identified in Section 2, Performance and Design Criteria.

B. The design of the lock case on the aisle side shall have a security cover plate to preclude any unauthorized entry into the cab by forcing the latch head back.

C. A large horizontal bar push-type, "panic bar" handle shall be provided on the cab side of the door to facilitate rapid unlatching and exit without the use of the key.

5.1.5 Windshield Wiper

5.1.5.1 Wiper System

A. An Approved, heavy-duty, automatic electric windshield wiper powered by the low voltage power system shall be installed at the top of the Operator's windshield at each cab.

B. The wiper motor shall be thermally protected against stall conditions, have RFI suppression, and shall be easily accessed and removable from inside the end of the car, using quick disconnect fittings.

C. A super heavy-duty transit quality tubular low wind lift pantograph wiper arm shall be used, with all visible parts having a black finish.

D. A curved-glass type black finished heavy-duty wiper blade with a replaceable rubber element sufficiently long to wipe 80 percent of the glass shall be used, mounted with a saddle-type connector.

E. The system shall operate successfully in rain or snow at wind speeds (vehicle plus ambient) of 100 miles/hour.

F. A windshield wiper control knob shall be provided in the cab arranged for ease of Operator use. It shall have an off position, a variable delay of approximately 10 to 0.5 seconds between each cycle, and either a variable speed of approximately 30 to 90 cycles per minute or two fixed speeds.

G. The wiper shall automatically move to a park position to the left of the Operator when turned off.

5.1.5.2 Washer System

A. An Approved, service-proven electrically or pneumatically operated windshield washer, with fan-type pattern spraying nozzles mounted on the windshield wiper arm, shall be provided for the Operator's windshield.

B. The washer system shall effectively cover the entire portion of the windshield within the sweep range of the wiper.

C. When activated the wiper arm shall be delayed at the far left end of the sweep for 0.5-2 seconds to allow time for the washer fluid to cover the windshield. The exact delay time to be determined during pilot car testing.

D. A windshield washer reservoir of 5-gallon capacity shall be mounted under the car. It shall be easily accessible and refillable from track level, and require no special hardware for filling.

5.1.6 Sun Shades

A. Approved, adjustable sun shades shall be installed in each cab that meets the flammability, smoke and toxicity emission requirements of Section 16, Materials and Workmanship, and Section 23, System Safety and Security.

B. Sun shades shall be mounted on the right side windshields and right drop sash windows of each cab.

C. The shades shall be an adjustable roll-down opaque non-reflective shade. The shade shall be positional over the full length of the window and shall maintain position. Vibration and normal vehicle motions shall not cause the shade's adjusted position to change.

D. A handle or string type pull down handle shall be provided for each shade.

E. The shades and handles shall be securely attached to withstand extraordinary handling.

5.1.7 Mirrors

A. On the right and left side of the cab at the forward edge of the side window shall be an exterior locomotive style adjustable mirror. It shall contain an integral vertical tilt mirror and be arranged to swing flat against the carbody. The size of the mirror shall be approximately 6 inches by 10 inches. Mirrors shall be manually adjustable and accessible from the cab for easy access and adjustment.

B. The mirror mounting and support shall be designed so that when overloaded the mirror will break away without damage, scuffing, or deformation of the carbody.

C. Located at the upper outboard corner of the cab windshield shall be an exterior convex mirror, arranged to allow the Operator to observe any passengers who may be crossing directly in front of the train. It shall be mounted as close as possible to the carbody.

D. The final location and arrangement of all mirrors shall be as Approved, and determined at the front end mock-up detailed in Section 25, Program Management and Commissioning.

5.1.8 Operator's Seat

5.1.8.1 General

A. Each cab shall be equipped with a heavy-duty, vinyl upholstered Operator's seat supported on a center pedestal designed to provide satisfactory comfort and proper access to cab controls with good visibility. The seat shall be USSC part #9009-100003-001 or an approved equal meeting the requirements specified in this section (5.1.7). Seat attachments shall be in compliance with the requirements of 49 CFR Part 238.233.

B. The cab seat shall be mounted in line with the transverse centerline of the windshield and provide a minimum of 0.5-inch clearance from the back wall when in the rearmost position.

C. The seat design shall take into account the limited amount of space available in the cab, and also the possible standing of the Operator to look out of the side cab window.

D. The seat assembly shall incorporate failsafe operating features and adjustment methodology to prevent sudden seat failures during the life of the car to avoid Operator injuries.

5.1.8.2 Compliance Criteria

A. All strength, performance, and other criteria defined within this Section shall be considered minimums.

B. The seat and its attachment shall comply with the requirements of 49 CFR Part 238.233.

C. In addition, the seat shall comply with the requirements of APTA standard SS-C&S-011-98, Standard for Cab Crew Seating Design and Performance, but may be supplied without a rotation feature.

D. Where conflicts exist, the most restrictive shall apply.

5.1.8.3 Aesthetic and Ergonomics

A. The details and colors of the seat design shall be as proposed by the Industrial Designer and Approved.

B. The Industrial Designer shall consider utilizing darker colors in areas that tend to accumulate dirt and stains, such as the headrests and the armrest caps.

C. As part of the Design Review efforts, the Contractor shall present an ergonomic analysis and report of the seating system.

One sample seat shall be submitted by the Contractor for approval following completion of testing. **(CDRL 05-04, Sample Operator's Seat)**

5.1.8.4 Suspension and Seatback Design

A. The seat suspension shall have a scissor mechanism with a pendulum design to eliminate lateral wobble and shall use service-proven bearings at all moving points.

B. A protective bellows shall encase the suspension system mechanism.

C. The seat back height shall be coordinated with the cab arrangement.

D. The seat back shall have an infinitely adjustable mechanical lumbar support and a back shell to protect the rear cab wall from damage.

E. There shall be no sharp edges or surfaces that could cause injury.

5.1.8.5 Mechanical Adjustments

A. The seat shall contain mechanical components only and shall provide simple, smooth adjustments while an Operator is seated.

B. The seat shall have a minimum of 6 inches fore/aft adjustment (9 inches being desirable if the cab arrangement permits) with roller bearing slides each having locking mechanisms.

C. The seat height adjustment range shall be a minimum of 6 inches and shall not allow the seat to "free fall".

D. The seat bottom cushion shall have a range of 8 degrees of tilt, and the back cushion shall have a range of 20 degrees of tilt past the vertical if car arrangement permits.

E. Recliner mechanisms shall be double gear with a tooth and sprocket on both sides of the seat. Adjustment devices using simple notched cam plates with flat sides for setting heights or pitch are prohibited.

5.1.8.6 Components and Materials

A. The seat assembly shall meet the smoke, flame and toxicity requirements of Section 16, Materials and Workmanship and Section 23, System Safety and Security.

B. The seat frame shall be of tubular steel construction designed for hard usage.

C. The seat bottom and back cushions shall be properly contoured to provide adequate lumbar, back, side, and thigh support, and shall be constructed from foam material meeting the requirements of Section 16, Materials and Workmanship.

D. A vinyl upholstery having an Approved color and weave pattern meeting the requirements of Section 16, Materials and Workmanship, shall be used.

E. All upholstery seams shall have high mechanical strength, and bottom cushion transverse seams in the area of the top front corner are to be avoided.

F. The Contractor shall make every reasonable effort to minimize the number of unique parts (especially adjustment mechanisms and knobs) used in its construction and installation. No seat component shall be removable without tools.

5.1.9 Horn

A. A Nathan (Windham Machine Company) Air chime model K3L, or approved equal, pneumatic horn with bell frequencies of 311, 370, and 470 Hertz, with all bells facing outward shall be installed on the roof at each cab end of every car, operated by an electrical spring return joystick located in the center of the center cab console.

B. The joystick shall have prior successful use in this application, and a high cycle life.

C. The air supply to the horn shall be through a vented cutout cock mounted in the ceiling.

D. The horn shall be tilted slightly downward, and each bell shall be provided with a stainless steel metal screen or deflector to prevent accumulation and packing of debris and snow in the bell mouth. The method of debris and snow deflection shall be subject to approval.

E. A restriction choke shall be installed in the base of the horn as required to prevent excessive sound level. The horn shall be tested as required by 49 CFR Part 229.129 and calibrated to the lower end on the FRA required sound level in 49 CFR Part 229.129.

F. To reduce vibrations transmitted into the carbody, the horn shall be mounted on a 0.5-inch thick rubber mounting pad.

G. Activation of the horn by the horn control joystick shall cause the auxiliary light control in Section 8, Lighting, to operate as Approved.

H. Details of the horn installation shall be submitted. **(CDRL 05-05, Horn Installation Details)**

5.1.10 Miscellaneous Cab Items

A. The following shall be provided on the right side of each cab:

1. White reading lights and red nighttime illumination shall be provided in accordance with Section 8, Lighting.

2. Ceiling air diffusers shall be provided as per Section 7, HVAC, a floor heater element per Section 7, HVAC, and a forced air heater per Section 7, HVAC. The cab heater shall have a rotary switch, per Section 7, HVAC.

3. A communications buzzer and pushbutton shall be located in the cab, along with a crew intercom speaker with integral volume control that cannot be muted, per Section 13, Communications. A PA control shall also be provided for announcements to passengers, per Section 13, Communications.

4. The cab windshields (left and right side) shall be heated per Section 7, HVAC.

5. A permanent car number identification plate per Section 3, Carbody shall be applied to the console in a prominent location, to be determined during design review.

6. One 8.5 inches by 11 inches "blue form" inspection card frame with transparent cover, conforming to FRA document size requirements, shall be located on the inside face of the rear partition electric circuit breaker locker door, as Approved and in accordance with 49 CFR Part 229.23 (d).

7. An "air slip" inspection form clip holder for a 3 inches by 5 inches daily inspection form shall be transparent and located on the rear partition wall near the cab door.

8. A stainless steel tubular Operator's footrest shall be provided as Approved.

9. A clipboard-type spring-loaded holder shall be installed with a clear area sufficient to hold 8.5 inches by 11 inches bulletin orders shall be located within easy reach of the Operator.

10. A cupholder to retain a coffee cup or soft drink container shall be mounted on the side wall forward of the right side window drop sash and forward of the Operator's seat, or other Approved location. It shall be a rugged design with a bottom drain hole, designed for ease of cleaning. The inside diameter should be 3.25+/-0.03 inches and have a depth of 3.00+/-0.03 inches.

11. One 120-volt AC grounded duplex GFI-protected receptacle, protected for 15 amps service, shall be located in the cab.

12. The destination sign control system shall be installed in the rear cab partition wall, just inboard of the cab door, per Section 13, Communications.

13. A two-position key switch operated by the standard key shall be included in the cab console in an Approved location, for use by the train crew in a trailing cab of the train. When this switch is turned 90 degrees to the right, it shall power the cab ceiling lights and train interior lights per Section 8, Lighting, the communications system (radio, public address, and crew intercom), per Section 13, Communications, and shall enable control of the headlights, auxiliary lights,

marker lights, horn, windshield wiper and windshield defroster. The key shall be captive in the On position.

14. A flag holder and a fireproof closed metal container for fusees shall be provided in accordance with 49 CFR Part 229.119 (f), and as Approved. It shall be lockable using the standard Key.

15. A blue flag light and enclosure shall be provided at top left of the Operator's windshield. It shall be a blue LED visible inside the cab and outside through the Operator's windshield, per Section 8, Lighting.

16. The blue flag light shall be fully enclosed to match the operator cab interior and to avoid unintended glare or reflections from interior lights.

17. A blue flag key switch shall be provided on the Upper Left Console Control Panel to turn the blue flag light on and off. It shall operate using the standard SEPTA derail key, The key switch shall have two positions: ON and OFF, per Section 8, Lighting. The key shall be removable in both positions. And this information shall be sent to the event recorder. Additional information of the key will be provided after NTP.

18. A panel housing exposed circuit breakers for the control of various functions, subject to design review, shall be provided on the rear wall behind the Operator. The circuit breakers shall be separated and protected to prevent accidental tripping of circuit breakers. The wiring and terminals of the circuit breakers shall be covered with a panel so that only the switch levers are exposed. Plastic guards with provision for sealing each shall be provided as determined by SEPTA.

19. A Secure Positive Train Stop Release (SPTSR) Keypad shall be provided on the rear partition, per Section 20, Automatic Train Control and Positive Train Control.

20. A Positive Train Stop Order (PTSO) button shall be provided on the rear partition adjacent to the SPTSR Keypad, per Section 20, Automatic Train Control and Positive Train Control.

21. A Conductor's valve shall be provided at each end of each car, near the body end door, and in each cab on the Operator and Observer sides, per Section 12, Friction Brake.

B. The following shall be provided on the left side of each cab:

1. Two flush, heavy-duty, spring-loaded coat hooks with integral rubber bumper shall be located on the rear partition.

2. An Observer's Seat shall be provided. Folding jump seats shall be provided on the left side of the cab compartment facing the windshield. The seats shall automatically flip up individually.

3. An Observer's control station featuring limited cab controls shall be provided on the left-hand side of the cab located behind a locked panel accessible by the standard key. The Observer shall be able to operate two accessible RJ45 ports for Portable Test Equipment access, windshield wiper, windshield washer, electric windshield defroster, and cab gimbal light from this console. When the controls are required, the locked panel shall open and latch in a fully open position which will not interfere with the operation of the equipment. Windshield washer and wiper, and reading lamp controls shall not be functional unless the master controller in that cab is activated, except as specified elsewhere or Approved.

4. The cover panel used for the Observer's control station shall have a rugged latch and lock arrangement as Approved. It shall automatically latch and lock when closed. The hold-open device shall be designed and demonstrated to release before the metal latch is deformed.

5.2 Cab Controls

5.2.1 Arrangement of Controls

5.2.1.1 General

A. The Operator's cab shall feature a desk-type, primary control console centered below the windshield, with vertical instrument, display and control panels located above the windshield and under the windshield above and at the rear of the center console, and on either side of the windshield.

B. Consoles and panels shall be neat in appearance, with all equipment, indicators, devices, and controls arranged in an orderly manner.

C. The console and panels shall be constructed of a stain, burn, and corrosion-resistant, integrally colored, non-glare material as Approved.

D. The console cabinet color and design shall match the adjacent cab lining scheme.

E. Displays, indicators, switches, and annunciator lights shall be positioned centrally to the Operator's forward line of sight, arranged so they do not cause reflections in the Operator's windshield, shaded against direct sunlight and readily visible under all ambient light conditions, and provided with intensity adjustment capability.

F. The cab console shall be illuminated for day and night operation without causing reflections on the windshield.

G. The console lighting shall be located so as to properly illuminate all switches and gauges necessary for train operation and shall be controlled by a dimmer switch.

H. All control panels except for the center desk console shall have backlighting to illuminate the switches, controls, and their identifying markings. The backlight color shall be an orange reddish color to preserve the operator's night vision. The backlighting shall be dimmable and controlled by a separate dimmer switch. Backlighting arrangement and intensity to be proposed at CDR and demonstrated on the cab mock-up for evaluation, and shall be as described in Section 8, Lighting.

5.2.1.2 Ergonomics

A. The arrangement of controls to satisfy the ergonomics of a wide range of Operator physical sizes shall be given particular attention by the Contractor.

B. All controls shall be positioned for ease of access for Operators of the size percentiles identified in Section 2, Design and Performance Criteria.

C. The Train Operator's Display 1 (TOD1) and Train Operator's Display 2 (TOD2), on the display panel under the windshield, shall be angled to permit optimal viewing by the Operator.

D. The car number sign shall be located on the vertical panels on either side of the windshield, positioned from the horizontal to a 15-degree downward range of a 50th percentile adult male Operator's eye position.

E. The layout of the cab shall be a major responsibility of the Industrial Designer and shall be incorporated into the cab and car mock-ups per Section 25, Program Management and Commissioning, and subject to review by SEPTA staff.

F. All aspects of the cab design shall be Approved.

5.2.1.3 Traction Controls

A. Traction power shall be controlled by the Operator by means of a master controller, positioned for ease of operation by the left hand, which shall contain a reverser control handle and a controller handle for power level selection.

B. Braking shall be controlled by the Operator by means of a brake controller, located for ease of operation by the right hand.

5.2.1.4 Control Panels and Labels

A. The vertical instrument and control and display panels flanking the windshield shall be arranged to be angled toward the Operator so that critical displays are located at the right angle to the Operator's field of view.

B. All indicators and annunciators shall be LEDs and shall have a lamp test switch feature.

C. A rotary dimmer switch shall be incorporated in the cab to control the intensity of all indicators and annunciators from Bright to Dim, and shall not have an Off position.

D. All operating controls, displays, and indicators shall be positioned within the Operator's normal reach and normal line-of-sight when seated.

E. Controls shall be located, such that they can be conveniently operated, based on their importance or frequency of use.

F. Controls or indicators, associated with a specific side of the train, shall be positioned on the associated side of the console or indicator panel.

G. All switches, controls, displays, and indicators on the control console or adjacent panels shall be rugged, high-quality devices suitable for rail vehicle application and readily available from commercial sources. Switches, controls, and indicators shall be standardized to the extent possible.

H. A minimum number of different types of devices shall be used, and individual functional designations shall not be marked on the device.

I. Designations shall be attached by an overlay mask to the console and all control panels, or other means as Approved.

J. Multi-position controls shall have all positions identified. Adhesive bonded tags shall not be permitted.

K. All device types shall have a high cycle life.

5.2.2 Center Console

A. The center console located in front of the Operator at the bottom of the windshield and below the vertical display panel shall be generally arranged as a flat desk sloped downward toward the Operator. All control devices shall be logically installed to provide an integrated appearance. Mounting hardware and all interface connections for the propulsion and braking controllers shall provide ease of access for maintenance or removal.

B. The console shall be designed and sloped so that liquid spilled on the surface will not damage or interfere with the operation of components, apparatus, or wiring. It shall be designed to prevent the intrusion of and damage from liquids. Its finish shall be easily cleaned with a soap and water solution.

C. The center console shall contain all necessary controls including, but not limited to the controls listed in **Table 5-1, Cab Operator Area-Center Console - Train Operation Controls.**

Table 5-1, Cab Operator Area-Center Console - Train Operation Controls

Switch/Control Function	Switch/Control Identification	Switch/Control Location
Headlight Switch	HEADLIGHTS	Desk Center Console, to the far left or right side of the controllers so as not to be accidentally activated or deactivated
Horn Joystick Switch	HORN	Desk Center Console
Cab Signal Acknowledge Switch	CAB SIGNAL ACKNOWLEDGE	Desk Center Console
Master Controller	MAIN CONTROLLER	Desk Center Console, Left Side of Console
Cab Control Key Switch	CAB CONTROL KEY	Desk Center Console
Run/Test Switch	RUN/TEST	Desk Center Console, Brake Control Handle Unit
Brake Control Handle Selectors	BRAKE CONTROL HANDLE SELECTOR	Desk Center Console, Brake Control Handle Unit
Cut-In/Cut-Out Switch	CUT-IN/CUT-OUT	Desk Center Console Right Side of Console, Brake Control Handle Unit
Brake Pipe Charging Button	BP CHARGING	Desk Center Console, Right Side of Console
Propulsion Reset/Cutout Switch	PROPULSION RESET/CUTOUT	Desk Center Console

5.2.3 Vertical Under Windshield Train Operator's Display Panel

A. The vertical display panel under the windshield at the back and above the center console shall contain the following displays, which shall be dimmable:

1. Train Operator's Display 1 (TOD1) (Right Side of Panel)

a. This shall be an industrial LCD or similar type display, appropriately sized to display all required information in an easily readable layout, which shall be subject to SEPTA review and Approval. It shall prominently display train speed in MPH. It shall also display Brake Pipe Pressure, Brake Cylinder Pressure, and Main Reservoir Pressure values in PSI.

b. It shall display indicators that give the status of train functions and equipment status:

(1) Brake Applied/Released

(2) Tractive and Electric Brake Effort

(3) Snow Brake

(4) Doors Open/Closed

(5) Alerter

(6) Wheel Spin/Slide

(7) All other indicators and functions as detailed in Section 18, Monitoring and Diagnostics.

(8) It shall allow access to the VMDS as described in Section 18, Monitoring and Diagnostics.

2. Train Operator's Display 2 (TOD2) (Left Side of Panel)

a. This shall display the same items as described above for TOD 1 and allow access to the VMDS as described in Section 18, Monitoring and Diagnostics.

b. TOD1 and TOD2 shall have a "wake up" feature without use of the standard key in the conductor's key switch or by cab start up and shall display the information detailed above and in Section 18, Monitoring and Diagnostics.

5.2.4 Left Side Panel

A. The vertical instrument and control panel on the left side of the windshield shall contain the following components, generally from top to bottom:

1. Electric Park Brake Applied indicator (On when Park Brake Applied, Flashing when applying or fault). Park Brake Released Indicator (On when fully released).

2. Car Number Plate (at optimum viewing location)

3. Radio Control Head (other than radio transmit pushbutton), this shall be placed at the lowest position.

4. All necessary controls including, but not limited to the controls listed in Table 5-2, Cab Operator Area Left Side Control Panel - Train Operation Controls

Table 5-2, Cab Operator Area-Left Control Panel - Train Operation Controls

Switch/Control Function	Switch/Control Identification	Switch/Control Location
Auxiliary Light Control Switch	AUXILIARY LIGHTS	Lower Left Console Control Panel
Cab Light, Red/White/Off	CAB LIGHTS	Lower Left Console Control Panel
Radio Transmit Switch	RADIO TRANSMIT	Lower Left Console Control Panel
Marker Lights Switch	MARKER LIGHTS	Lower Left Console Control Panel
Communication Control Panel	Labels on Panel	Left Console Control Panel
Electric Park Brake Apply Switch	PARK BRAKE APPLY	Left Console Control Panel
Electric Park Brake Release Switch	PARK BRAKE RELEASE	Left Console Control Panel
Blue Flag Switch	BLUE FLAG	Upper Left Console Control Panel
Lower Trainline Pantograph Switch	LOWER TRAINLINE PANTOGRAPH	Upper Left Console Control Panel
Raise Trainline Pantograph Switch	RAISE TRAINLINE PANTOGRAPH	Upper Left Console Control Panel
Snow Brake Switch	SNOW BRAKE	Upper Left Console Control Panel
Conductor Key Switch	CONDUCTOR KEY SWITCH	Upper Left Console Control Panel
Propulsion Mode Switch	Mode	Left Control Panel

B. A Propulsion Mode switch shall be provided on the left panel. It shall be labeled as MODE and have positions for Yard, Normal, and Carwash. The positions shall be labeled as such and shall function as described in Section 10, Propulsion and High Voltage System, and Section 17, Network and Trainline Control. All interlocks, contacts, controls, and safety requirements required to initiate movement of the vehicle under normal conditions shall be enforced in all switch modes and it shall not function when operated above zero speed.

5.2.5 Right Side Panel

A. The vertical instrument and control panel on the right side of the windshield shall contain the following components:

1. Bulletin Order Clipboard

2. ATC/PTC Display (Bottom of Panel) this shall be as described in Section 20, Automatic Train Control and Positive Train Control, at the lowest position.

3. A Propulsion and Auxiliary power reset switch shall be provided. When turned to the left it shall reset the Propulsion system as per Section 10, Propulsion and High Voltage System, when released it shall spring back to the center normal position. When turned to the right it shall reset the auxiliary power system and shall reset overload or other fault conditions, per Section 9, Auxiliary Power, when released it shall spring back to the center normal position. The left and right positions shall be appropriately labeled.

4. All necessary controls including, but not limited to the controls listed in Table 5-3, Cab Operator Area – Right Side Control Panel - Train Operation Controls

Table 5-3, Cab Operator Area-Right Control Panel - Train Operation Controls

Switch/Control Function	**Switch/Control Identification**	**Switch/Control Location**
Light Dimmer Control Switch	LIGHT DIMMER	Right Console Control Panel
Backlighting Dimmer Control Switch	BACKLIGHTING DIMMER	Right Console Control Panels
Couple/Uncouple Key Switch	COUPLER	Right Console Control Panel
Cab Heater	CAB HEATER	Right Console Control Panel
ATC/PTC ADU	Self Labeled	Lower Right Console Control Panel
Non Cab Signal Territory Switch	NON CAB SIG TERRITORY MODE	Lower Right Console Control Panel
Windshield Heater Switch	WINDSHIELD HEATER	Lower Right Console Control Panel
Lamp Test Button	LAMP TEST	Upper Right Console Control
PA, Passenger Emergency Intercom, Intercom Operation Control Panel	Labels on Panel	Upper Right Console Panel
Propulsion and Auxiliary Power Reset Switch	RESET	Upper Right Console Panel

5.2.6 Upper Panel

A. The area above the windshield shall be used for infrequently used devices. Located in this area shall be the following components:

1. Speaker and Volume Control Panel

2. Indicator lights (LED) for various car functions, subject to design review.

B. All required audible alarms and signals shall be provided in the cab, located so as to be clearly audible to Operator and Observer, and be readily accessible for maintenance. Audible signals requiring different actions shall have different sounds.

C. Audible signals shall be no louder than necessary to be clearly audible in the cab under worst case conditions such as passing another train in the tunnel. The final levels shall be determined during Pilot Car testing. The audible signals shall, include but not be limited to:

1. Cab Signal Audible Alarm

2. PTC Audible Alarm

3. Alerter Audible Alarm

4. Conductor Signal Buzzer

5.2.7 Lower Cab

5.2.7.1 General

A. The area under the console and above the floor shall be clear of all piping and obstructions to provide room for the Operator's feet and legs.

B. An Approved full-width footrest shall be provided as well as all specified foot switches, which shall be arranged as Approved.

C. A properly identified and recessed horn system pneumatic cutout cock shall be located in the floor and shall be easily reached by the Operator.

5.2.7.2 Deadman Function

A. A Deadman function that is comfortable to use for extended periods shall be provided by means of a large foot pedal which must be held depressed by the Operator's right foot in order to operate the train.

B. A stainless steel cover shall be provided over the deadman petal. It shall be designed to allow a seated operator to rest the right foot on the cover and activate the deadman feature.

C. A stainless steel tongue shall extent beyond the cover to allow a standing operator to comfortably activate the deadman function.

D. Release of foot pressure shall result in the application of full service brakes except when either the propulsion master controller deadman is properly activated, the brake controller has been placed in the suppression position, or the brake controller has been deactivated (cut-out).

E. Activation of any deadman feature shall be subject to a 2-second delay, to allow for recovery from an accidental activation without penalty.

5.2.7.3 Acknowledge Function

A. An Acknowledge foot pedal shall be provided that will be depressed by the Operator's left foot. It shall function as described in Section 20, Automatic Train Control and Positive Train Control.

5.2.8 Rear Partition

A. The rear partition behind the Operator shall contain all the necessary controls including, but not limited to the controls listed in **Table 5-4, Cab Operator Area – Rear Partition - Train Operation Controls**

Table 5--4, Cab Operator Area- Back Partition - Train Operation Controls

Switch/Control Function	**Switch/Control Identification**	**Switch/Control Location**
Secure Positive Train Stop Release (SPTSR) Keypad	SECURE POSITIVE TRAIN STOP KEYPAD	Back Partition, Right Side
Dead Battery Start Button	DEAD BATTERY START	Back Partition, Right Side
Local Car Pantograph Lower Switch	LOCAL CAR PANTO DOWN	Back Partition, Right Side
Propulsion/Door Bypass Switch	PROPULSION/DOOR INTERLOCK BYPASS	Back Partition, Right Side, Sealed
Zero Speed Interlock Bypass Switch	SPEED INTERLOCK BYPASS	Back Partition, Right Side, Sealed
Friction Brake Interlock Bypass Switch	BRAKE INTERLOCK BYPASS	Back Partition, Right Side, Sealed

Traction Master Bypass Switch	MASTER BYPASS	Back Partition, Right Side, Sealed
Regenerative Braking Cutout Switch	REGENERATION CUTOUT	Back Partition, Right Side, Sealed
Shutdown Button	SHUTDOWN	Back Partition, Right Side
Left Cab Area Lighting Switch	LEFT CAB AREA LIGHTING	Back Partition, Right Side
Spare Button Switches (2)	Unmarked	Back Partition, Right Side

B. A Shutdown button switch shall be provided on the rear partition and shall function as described in Section 9, Auxiliary Power, and Section 17, Network and Trainline Control.

C. The following switches are to be toggle switches covered and sealed in the normal (down) position or Approved equal. The seal must be broken to open the cover. A 0.1015 inch (No. 38 drill) diameter hole shall be provided in each switch toggle cover. When the cover is flipped up the robust toggle switch can be moved to the bypass position, when the cover is flipped down the toggle switch shall move to the normal position.

1. Propulsion/Doors Interlock Bypass Switch
2. Speed Interlock Bypass Switch
3. Friction Brake Interlock Bypass Switch
4. Traction Master Bypass Switch
5. Regeneration Cutout.

5.2.9 Master Controller

5.2.9.1 General

A. The propulsion commands for the train shall be produced by manipulation of a compact, all-electric master controller provided in each cab.

B. Activation of the master controller and the cab controls shall be accomplished by the use of the cab control key described in Section 2, Design and Performance Criteria.

C. The master controller and the cab control key switch shall be furnished by the supplier of the propulsion equipment.

D. The proper ergonomics of the design and operation of the master controller is of great importance, and it shall be as proposed by the Contractor's Industrial Designer and Approved, taking into account the human factors guidelines referenced in Section 2, Design and Performance Criteria.

5.2.9.2 Controls and Deadman Design

A. The master controller shall directly produce a DC loop P-wire trainline command signal that will function as described in Section 10, Propulsion and High Voltage System, and Section 17, Network and Train Control. It shall be directly driven by a single handle to control all operations of the propulsion system.

B. A mechanically interlocked reverser activated by the cab control key switch driving a smaller camshaft shall select the direction of motion.

C. The master controller handle movement shall operate in a longitudinal vertical plane, with an ergonomically comfortable travel, and a maximum movement force to be determined at design and mock-up reviews.

D. A quarter-turn rotating handle type deadman function shall be used, having a positive, yet comfortable spring force as low as possible.

E. The controller shall be rugged and designed for the railroad or transit cab environment.

F. The deadman feature design shall be as simple as possible. Deadman handle rotation of approximately 60 degrees from the release position toward the operating position shall initially satisfy the deadman circuit. Once the handle is released, handle rotation of approximately 60 degrees from the operating position toward the release position shall initiate a deadman application unless the foot pedal deadman switch is satisfied.

G. It shall not be possible to latch or fasten the master controller handle in its operating position.

H. Rubbing surfaces shall be enclosed to exclude dust and dirt.

I. Internal components shall, as much as possible, consist of parts common to the propulsion system of this car or other recently produced cars, and where not possible shall be of an equal quality level.

J. The master controller top plate shall be removable without any disassembly of the controller mechanism other than handle and knob removal.

K. The details of the controller shall be submitted. **(CDRL 05-06, Master Controller Details)**

L. Demonstrate operation of the master controller during the mock-up and the cab FAI.

5.2.9.3 Master Controller Function

A. The master controller shall have a Coast position, which shall be closest to the Operator, a minimum power level and maximum traction level in the forward-most position.

B. Each position shall not have a detent.

C. The handle shall be movable from the Coast position without the need for the handle deadman to be rotated.

D. The controller top shall have an Approved mask with markings to easily identify each position. The master controller shall be integrated into the desktop.

E. Power shall be applied by moving the handle forward away from the Operator.

F. The deadman feature shall function similarly to the deadman foot pedal.

5.2.9.4 Cab Control Key

A. The cab control key and main controller handle shall be interlocked mechanically as described below.

B. The main controller handle shall be permanently attached.

C. It shall be possible to move the cab control key only with the master controller handle in the Coast position.

D. With the cab control key in the neutral position or in the "Off" position, the master controller handle shall be mechanically immobilized in the Coast position.

E. The mechanical interlocking mechanism shall be robust and require no lubrication, cleaning, or maintenance other than during the major overhaul periods for the rest of the propulsion equipment.

F. The electrical connections between the controller and the car wiring shall be by means of sealed electrical connectors per Section 16, Materials and Workmanship. The controller shall be bolted to the cab.

G. The bolts shall have open access, and the entire controller shall be easily removed and replaced for maintenance purposes.

5.2.10 Control Functions

5.2.10.1 Logic

A. The cab control key interface of the master controller shall have four positions, "Off", "Reverse", "Neutral", and "Forward", and shall control other car equipment to produce the following functions:

1. In the "Off" position, the car shall have all operating systems other than the low voltage power supply, cab signal/ATC/PTC equipment rack, crew access switches, and marker lights shut down, unless layover lighting, layover heating or cooling is requested or as otherwise commanded by control trainlines, as detailed in this Technical Specification.

2. In "Neutral" all operating systems other than propulsion control shall be powered, and the master controller handles shall remain mechanically locked.

3. In "Forward" and in "Reverse" all systems shall be operable.

B. The cab control key shall be removable in the "Off" and "Neutral" positions.

C. Logic circuits shall be provided so that only one cab per train can be functional in "Neutral", and only one cab in a train can be controlling in "Forward" or in "Reverse."

5.2.11 Cab Interlocks

A. Operation of a train in any direction shall be possible from any active cab in the train by means of a master controller as described in Section 5, Operator's Cab.

1. When any one cab has its controls activated, all other cabs on the train shall be rendered ineffective as regards controlling the movement of the train.

2. Having more than one cab in a train with controls activated shall inhibit train operation, i.e., interlocks necessary for the train to operate shall not make up.

3. Multiple car operation shall be possible with any one controller activated.

4. Transfer of control from cab to cab shall be automatic as the individual cabs are activated.

5. Power for the cab control circuits shall be supplied through a dedicated low voltage circuit breaker.

5.3 Windows

5.3.1 Cab End Windshields

5.3.1.1 General

A. Two FRA Type I windshields (one on each side of the body end door) of the same size shall be provided at each cab end of every car.

B. They shall be located at the same height and shall be symmetrically positioned with respect to the longitudinal centerline of the car.

C. Each windshield shall be a flat piece of nominal triple-laminated high impact untinted glass meeting FRA requirements.

D. No curved surfaces are permitted.

E. The windshield dimensions shall permit a maximum field of view for a seated Operator meeting the requirements of TS 5.1.1.1, with a minimum of 200 square inches of see-through area.

F. The design and installation of the windshield shall minimize external glare as well as reflections from inside the car.

G. When the car is operated at night or in tunnels, essentially no reflections shall be visible in the windshield by the Operator.

H. Windows shall be capable of withstanding external and internal pressure differentials requirements of Section 2, Design and Performance Criteria

I. The Contractor shall demonstrate that these requirements have been met through the use of the interior mock-up described in Section 25, Program Management and Commissioning.

5.3.1.2 Heating

A. The windshields used in the Operator's cab on the left and right sides shall be electrically heated using 120 volts 60 Hertz AC single phase power.

B. Heating control shall be as specified in Section 7, HVAC.

C. The electrical wiring connections shall be on the inside of the glazing, preferably at the top.

D. The terminal board for connecting the two leads shall be mechanically mounted on the carbody (not on the window surface) and have the wires secured to prevent damage from installation or during car cleaning.

5.3.2 Cab End Drop Sash Windows

5.3.2.1 General

A. At every cab end of every car, the first side window (at the Operator's cab right side) shall be arranged as drop sash windows for Operator use.

B. Each drop sash window shall be of a two-piece design with an anodized aluminum frame and shall consist of one fixed section and one vertically sliding section.

C. The sash shall be designed to permit an Operator of the dimensions listed in Section 2, Design and Performance Criteria, to easily lean out when either seated or standing and be able to view a station platform or the wayside in either direction.

D. The cab side windows shall slide into watertight stainless steel pockets in the side walls with a stainless steel clean-out basket in the drip pan.

E. When the window slides into the pocket, the minimum clear opening shall be 20 inches wide by 22 inches high. Locks and keepers shall not encroach into this opening.

F. The pockets shall have a minimum of two 1/2-inch diameter drain pipes at the bottom to collect water and drain it to the outside of the car.

G. There shall be an access panel in the carbody interior lining to facilitate cleaning of the pockets and maintenance of the lift assist spring. The mechanism shall be maintained through the access panel. The access panels shall be watertight when the pocket is completely full of water.

H. The drop sash windows shall utilize a stainless steel, spring-loaded, mechanical counterbalance scissor arm, and damper arrangement to facilitate controlled raising and lowering of the window. Rollers used in the mechanism shall have non-detachable connections. The mechanism shall hold the window in any position between and including fully opened and fully closed, except as otherwise Approved. The mechanism shall be designed to operate for the life of the car without replacement.

I. The sash shall be replaceable from inside the car.

J. A drawing shall be submitted **(CDRL 05-07, Cab End Drop Sash Window Drawing)** regarding the adequacy of the proposed arrangement.

K. Each section of the sash shall have a flat piece of FRA Type I clear polycarbonate window glazing, installed in the frame with elastomer sections to form a watertight seal.

L. Easy reglazing of the sash shall be a required design feature.

M. The sash frame shall be constructed of extruded aluminum alloy of type 6061-T6 or T4.

N. Strength and quality requirements shall conform to AIA specifications.

O. The entire drop sash design and installation shall be Approved.

5.3.2.2 Mounting

A. To prevent the accumulation of snow and ice, the vertical sliding section shall have its slides mounted inboard.

B. The design of the drop sash windows shall complement the height and location of the passenger-side windows.

C. The windows shall be free running, effectively weather stripped, free of rattles and drafts, reinforced for hard usage, and designed to eliminate rattles.

D. The design of the window shall be such that the sealing on the outside shall minimize the amount of runoff water that enters the stainless steel pocket.

E. The entire window shall be designed to prevent freezing and still operate freely under all weather conditions.

F. The sash, in its closed position, shall not generate any air noise while the car is operating.

G. The sash shall be operable by a 5^{th} percentile female.

H. All water drainage shall be to the outside of the car. When open or closed, the sash shall prevent water from penetrating into the side frame of the car.

I. The entire sash shall be mounted to the inside and outside of the car in a neat, finished manner without any crevices or gaps and in such a way as to allow easy replacement.

J. The cab side windows shall be glazed to match the passenger compartment side windows in appearance however shall not be tinted.

K. The exposed corners of the window shall have a minimum radius of 2 inches.

5.3.2.3 Sash, Handle, and Latch Design

A. The sliding portion of the sash shall be designed to slide freely in either direction.

B. The sash shall be secured by a rugged latch assembly of an Approved design, easily reached by a seated Operator.

C. The sash design shall be such to allow the sliding portion to maintain any derived opening during normal operating conditions.

D. Positive latching in the closed position is required as well as positive retention in any of the designated open positions.

E. A single, full-width, black anodized handle, as Approved, shall be provided to open and close the window. The handle shall be designed and positioned to provide the best ergonomic condition for closing, locking, latching, and opening movements.

F. The handle shall be securely attached to withstand extraordinary handling.

5.3.2.4 Accessibility and Locking

A. No more than fifteen pounds of force shall be needed to initiate the opening of the sash, and no more than 10 pounds of force shall be needed to move the sash from any other point.

B. Locks and latches shall be designed for operation using only one hand.

C. The standard key shall be required to initially unlock the sash, upon which it shall not require the use of the key to open if the sash was then closed. The sash can be key-locked closed when desired, such as when the Operator leaves the cab. The lock shall be of a highly durable design that is resistant to being picked or forced open.

5.4 Contract Deliverable Requirements List (CDRL)

The following contract deliverables have been identified in this section; however, the Contractor is responsible for providing and submitting anything necessary to fulfill the requirements of this contract, including those not identified by CDRL number.

CDRL 05-01, Cab Design Details 5-1
CDRL 05-02, Interior General Arrangement Drawings 5-4
CDRL 05-03, Final Console Arrangement 5-5
CDRL 05-04, Sample Operator's Seat 5-11
CDRL 05-05, Horn Installation Details 5-13
CDRL 05-06, Master Controller Details 5-27
CDRL 05-07, Cab End Drop Sash Window Drawing 5-30

5.5 CDRL Details

This section lists the expected content for each CDRL required above. The lists provided for each CDRL are an outline only and should not be considered exhaustive, all CDRLs are subject to SEPTA review and Approval.

CDRL 05-01 Cab Design Details:

1. Provide during all design review phases (CDR, PDR, FDR)

2. Include details of the cab design.

3. Include the arrangement of the cab.

4. Include details and the arrangement of the locomotive controls.

CDRL 05-02 Interior General Arrangement Drawings:

1. Provide during all design review phases (CDR, PDR, FDR)

2. Include details of the location of all features and appointments.

3. Include general arrangement diagrams of the Operator's control consoles.

4. Include the location of all features, appointments, controls, switches, gauges, meters, and indicators.

5. Include all device types and cycle life.

6. Include all aspects of the cab design.

7. Include all required plans to convert the full width cab to increase passenger seating capacity at a future date.

CDRL 05-03 Final Console Arrangement

1. Provide during Final Design Review (FDR)

2. Include final details of the location of all features and appointments.

3. Include final general arrangement diagrams of the Operator's control consoles.

4. Include the final location of all features, appointments, controls, switches, gauges, meters, and indicators.

5. Include the cab compartment arrangement and all controls.

CDRL 05-04 Sample Operator's Seat

1. Provide during Preliminary Design Review (PDR).

2. Include one complete fully functional cab Operator's seat.

CDRL 05-05 Horn Installation Details

1. Provide during Preliminary and Final Design Reviews (PDR and FDR)

2. Include details of the mounting arrangement and location.

3. Include details on the anti-vibration pad.

4. Include details on the stainless steel metal screen or deflector and choke.

CDRL 05-06 Master Controller Details

1. Submittal will be reviewed at the Preliminary Design Review.
2. Include size of the handle's spring load, the force required to move, the amount of handle travel between positions, the force required to forestall the deadman feature, and other ergonomic aspects and operational features.

CDRL 05-07 Cab End Drop Sash Window Drawing

1. Provide during Preliminary and Final Design Reviews (PDR and FDR)
2. Include details showing that an Operator of the dimensions listed in Section 2, Design and Performance Criteria, can easily lean out when either seated or standing.
3. Include details showing that an Operator is able to view a station platform or the wayside in either direction.
4. Show that the minimum clear opening is 20 inches wide by 22 inches high.
5. Include details showing that locks and keepers do not encroach into the opening.

5.6 Referenced Standards

49 CFR 227	Occupational Noise Exposure
49 CFR 229.121	Locomotive Cab Noise
49 CFR Part 229.119	Cabs, floors, and passageways
49 CFR Part 229.129	Locomotive Horn
49 CFR Part 229.23	Periodic inspection: general
49 CFR Part 238.233	Interior Fittings and Surfaces
49 CFR Part 238.439	Doors
APTA PR-CS-S-011-99	Standard for Cab Crew Seating Design and Performance

SECTION 6
PASSENGER DOORS

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6.1 General

A. The passenger doors shall be sliding pocket side doors with a single panel for passenger boarding or exit from both high-level and low-level station platforms. Plug doors may be proposed if all clearance and ADA requirements, as well as the requirements of this section, can be met. In addition, body end doors shall be provided for each car at each end.

1. All doors and the door control system shall comply, unless otherwise specified, with the latest requirements of the CFR and APTA.

2. All doors shall be solidly mounted, of lightweight construction, vibration free, open and close positively, and not rattle or make noise in service.

3. The door panels and their hardware shall be of a design related to prior successful rail passenger service.

4. A minimum number of door panel types shall be used. All side doors shall be the same width, regardless of high level or low level entry.

5. The free clear opening of the body end doors shall be 30 inches minimum, and the free clear opening at passenger doorways between handrails shall be 34 inches minimum and may be increased to 36 inches if the number of passenger seats is not impacted. In case of any conflict, ADA requirements take priority.

6. All door panel sheaths shall match the carbody exterior material and finish, with reinforcements bonded to an aluminum honeycomb core.

7. The door panel designs shall match the carbody profile.

8. The minimum thickness of the exterior sheathing shall be 0.030 inch for the side passenger doors and 0.050 inch for the carbody end doors unless otherwise Approved.

9. The side passenger and carbody end door panels shall incorporate window glazing that is flush as possible to the face of the door and within the door thickness maximum dimensions.

10. Doors, including windows, shall be capable of withstanding external and internal pressure differentials requirements of Section 2, Design and Performance Criteria

11. The joints and edges of the door panels shall be thoroughly sealed against moisture and drain holes shall be located in the bottom of the doors to allow the escape of condensed moisture.

12. All doors and their associated hardware such as operators, hangers, tracks, thresholds, etc. shall be jig-drilled to allow interchangeability between similar types.

13. All hardware mounting points shall be reinforced.

14. All doors shall be provided with suitable weather stripping and tight sealing edges, including the bottom, so that when closed they will positively prevent the entrance of outside weather, winds, drafts, and wind whistles to the interior of the car at the maximum operating speed.

    a. All weatherstripping and nosing edges shall be removable to allow for maintenance and replacement without door removal.

    b. All parts of any latches or locks shall be nickel bronze or stainless steel and be designed for long wear.

15. The door operators, panels, tracks, hangers, linkages, obstruction sensing, and electrical controls shall be manufactured or supplied by one subcontractor.

16. The Contractor shall give special consideration to access and maintainability of all door tracks, operators, panels, peripherals, hangers, and controls. Details of the door system accessibility and maintainability shall be submitted. **(CDRL 06-01, Accessibility and Maintainability)**

17. All doors shall be arranged to prevent elastomer abrasion against other surfaces to avoid wear.

18. The numbering sequence used for side doors, door operators and associated components shall be as The numbering sequence used for side doors, door operators and associated components shall be as follows:

    a. Starting at the F-end Cab doors on the right side, are numbered 1 (low level) 5 (high level) 7 (high level) 3 (low level).

    b. Starting at the F-end Cab, doors on the left side, are numbered 2 (low level) 6 (high level) 8 (high level) 4 (low level).

19. Door adjustments shall be simple to accomplish.

20. A detailed system functional description including dimensions and layout drawings shall be submitted. **(CDRL 06-02, System Functional Description)**

6.2 Exterior Side Doors

6.2.1 General

A. The sliding pocket exterior side doors shall be designed to match the specific configuration of high-level and low-level platform boarding. However, provisions for the future conversion of the fixed low-level boarding passenger side doors and doorways to high-level boarding shall be included in the design.

1. The side passenger doors for high-level boarding shall be located at approximately quarter points inwards of the trucks.

2. The side passenger doors for low-level boarding shall be located either at the end of each car, with only one side door at the Cab end (F-end), or at approximate quarter points inward of the trucks, adjacent to the high level doors.

3. The side door leaves on each doorway shall be of a single panel construction configured for each respective low-level or high-level loading.

4. The side passenger door leaves at the door location with steps shall be operating only during low-level boarding, with the high-level doors remaining closed.

5. Likewise, when the door opening is set to high station platform, the door panel for low level boarding shall remain closed.

6. The details or other proposed configurations shall be submitted. **(CDRL 06-02)**

B. The side doors shall be supported at the top and guided at or near the bottom. The hanger shall be of a type in which there is no change in magnitude or direction of load path through the bearing when a misalignment occurs.

C. All door hangers and tracks shall be of heavy duty construction and protected from the weather, but shall be accessible for inspection, adjustment, and removal by access through interior panels above the door openings.

D. Each side door panel shall be equipped with a full height neoprene elastomer nosing which shall interlock with the nosing on the door post, to provide a tight seal against the passage of air, water, or sound to the vehicle interior.

1. The nosing shall prevent injury to human extremities if caught in the path of the closing door and will permit the withdrawal of objects trapped by the closing door, as per the requirements of TS 6.4.10.6.

2. The nosing design shall be easily removable to allow for maintenance and replacement.

3. Weather seals are required at the top of each door leaf, and the bottom of each door leaf against the thresholds.

4. The trailing and inboard edge of each door leaf shall be provided with suitable weather stripping to completely seal the door pocket, both inside and outside the car, when the door is closed.

5. The doors shall be constructed so that all hardware, operating mechanism, and window glazing shall be within the door thickness maximum dimension to allow the doors to operate freely without obstruction.

6. All fasteners used to attach any hardware to the doors (for example, door nosing or weatherstripping) shall be countersunk to prevent premature wear of door frame weatherstripping.

E. There shall be minimum projections along the car side which could accumulate snow or debris.

F. Door operation shall be unaffected by snow, ice, or freezing rain and protective heaters shall be utilized accordingly.

G. The interior of the pocket shall be designed to prevent accumulation of water and shall be easy to clean from the interior for the high level door, and from the exterior for the full length low level door.

H. A trap door shall be provided to cover the steps only on the low-level boarding door located on the opposite side of the Cab. The trap door is intended to be lowered only when the cab is occupied in order to provide a level full-width cab space to the operator.

I. The Contractor shall propose for approval a suitable design arrangement for the low-level and high-level door configuration. The design shall blend into the vehicle interior and be coordinated with the Industrial Designer. **(CDRL 06-03, Exterior Side Door Design)**

6.2.2 Side Door Threshold

A. Each side door shall have a painted high visibility yellow stainless steel threshold with anti-skid surface that shall not project above the surface of the step tread or floor and shall completely seal the door bottom edge when the door is in the closed position.

B. The design of the threshold shall be with adequate drainage to the outside of the vehicle to prevent the accumulation of snow, water, and debris in the track.

C. The sliding pocket doors bottom guides shall be arranged so that accumulation of dirt, debris, salt, sand, or ice shall not cause erroneous closing obstruction detection and shall also provide drainage outside the vehicle.

D. The threshold and pocket door guides shall be heated in accordance with Section 7, HVAC.

6.3 Carbody End Doors

6.3.1 General

A. The carbody end doors will be used frequently by the train crew in the performance of their duties, and shall be designed for ease of use.

1. The cab end of each car shall be equipped with a single leaf, full length, inward swinging door panel.

2. The exterior surface finish of the door at the cab end shall match the profile and finish of the carbody and shall be mounted flush with the car end profile.

3. The door frame shall suitably match the door profile and shall fully support the door when closed.

4. The door design shall be coordinated with the end threshold, buffers, and foot plate per Section 3 Carbody.

B. The carbody end doors shall be equipped with an Approved weather seal which shall be applied to all four edges (top, bottom, and both sides) of the doors.

1. The weather seal shall prevent air, rain, snow, and noise from entering the car body at the interface of the end door and door frame of a lead car traveling at the maximum operating speed.

2. A secondary weather seal shall be used at the interface of the bottom door edge to threshold plate if necessary to meet this requirement.

3. The weather seal joints at the four corners of the door shall be vulcanized to ensure continuity of the seal.

4. Once the door is closed and latched, the weather seal shall not obstruct the end door drain.

C. A full length, heavy duty stainless steel hinge shall be provided for each door.

1. The ends of the hinge shall be closed to preclude the hinge pin from sliding out of the hinge barrel.

2. Hinges shall be bolted, not welded, and shall ensure that each door closes smoothly, without binding or sagging.

3. Where the handle could contact an interior surface, a mechanically attached elastomer door stop shall be provided.

D. An Approved lock of standard commuter railroad quality shall be provided to hold each door securely latched or locked in the closed position and be operated on both sides of the door with the standard key.

1. The lock shall have an exterior keyhole cover and the lock plunger shall have an integral stainless steel or other approved roller at its tip.

2. The door handle shall be horizontal and have a return towards the panel to prevent snagging.

3. The key shall not be required to open the door, except when the door has been key locked.

4. The doors shall be opened manually and have a heavy-duty door-closer mechanism.

5. The swing arm and cover for each door closer shall be either stainless steel or Approved alternative .

6. The covers shall have smooth rounded corners and edges, and shall have a finish to match the body end door finish.

7. The door-closer shall be adjusted to provide the minimum resistance to opening, with an adjustable damped accelerating device which will cause the door to close and latch in a safe and secure manner when released.

8. Elastomer stops shall be provided to limit the door to maximum swing when opened, located in the ceiling and as far from the hinge as practical.

9. The end door shall be equipped with a hold open latch to keep the door in the open position when needed and release the end door automatically when the train is in motion.

6.3.2 End Door Thresholds

A. The end door opening of each end of the car shall have a stainless steel threshold with an integral anti-skid surface and color stripe, similar to the side door threshold material.

1. Suitable drainage beneath the end door shall be provided to prevent any accumulation of water at the door threshold or inside the vehicle. Care shall be taken that the drain water does not contact any coupler equipment.

B. The threshold shall overlap the floor covering.

C. All attachments shall be made with flush mounted stainless steel hardware, suitably protected for dielectric material use.

D. Details of the end door and threshold shall be submitted. **(CDRL 06-04, Body End Door Design)**

6.4 Door Controls

A. The doors shall be zero speed interlocked except as specified herein, and also be interlocked with the propulsion control on a trainline basis.

B. The logic and circuitry of the control system shall use techniques that are fail-safe to the maximum degree using components that are service proven at North American commuter railroads.

C. It shall be understood that the requirement for self-detection of failures, such as welded contacts, open contacts, mechanical failure, shorted components, open components, failure to change state, etc. may require additional system components as well as suitable system design.

D. Doors shall otherwise remain in its last commanded position. After any power loss if the door is not closed and locked, it will close and lock but shall detect any obstacle in the doorway until the closed and locked position is reached. However, during any abnormal command sequence or similar situation, the door leaves shall not move. This specifically applies during times of train activation and storage and shall be considered a design fundamental. Doors leaves shall respond to rapidly changing commands as may arise if the crew attempts to jog doors during opening or closing. A door leaf shall instantly respond to a crew open command if closing, and likewise shall instantly respond to a crew close command if opening.

E. All door system components shall comply with the requirements of Section 16, Materials and Workmanship, and maintenance capability shall be in accordance with Section 27, Special Tools and Test Equipment.

F. Details of the entire door control system shall be submitted. **(CDRL 06-05, Door Control System)**

6.4.1 Door Control Station

6.4.1.1 Doorway Control Panels

A. Each right-side doorway within a car shall be provided with an identical trainlined high-level or low-level door control panel, to control all respective high-level or low-level doors on the right side of the train.

B. The same shall be provided for the doors on the left side of the train.

C. Each low-level door control panel shall include a faceplate mask that is removable when low-level boarding doors are converted to high-level boarding, and a permanent stairwell cover is installed.

D. All door control panels shall have a brushed stainless steel finish, recess mounted and positioned for convenient use by a train crew member standing in the doorway.

E. All panels shall be identical and be hinged along the outboard vertical side and held secure on the opposite side with fasteners of an Approved type.

F. The faceplate mask for all controls and indicators shall be labeled with engraved and black paint filled lettering and borders, or Approved equal durable labeling.

G. All controls shall accommodate the size range and ergonomics of crew members while allowing for boarding and alighting passenger flow at that doorway.

H. The doorway control panel controlling the high platform door trainlines shall be identified as "High Level" and doorway control panel controlling the low platform door trainlines shall be identified as "Low Level."

I. Each doorway control panel shall consist of a key switch, utilizing the standard key identified in Section 2, Design and Performance Criteria, and a series of identified pushbuttons and indicator lights. The key switch shall contain a vertical keyway to insert the key in the "Off" position.

J. Rotating the key 90 degrees clockwise shall energize the door control panel, with the key captive in this position.

K. The key switch shall be located on the lower center of the door control panel, and the tumbler shall be set back at least 0.5 inch from the face and protected by a fixed keyway spacer to prevent operation by a screwdriver or similar device.

L. Each panel shall be identically arranged, as far as possible, with seven individual two-pole, spring loaded momentary contact pushbuttons for door control, arranged in two vertical rows.

1. Door control switches shall be of the momentary contact type and circuitry shall be arranged so that once the button is pressed the operation cycle shall be completed even if the button is immediately released.

2. All door pushbutton switches shall:

a. Be of heavy-duty commuter railroad quality with 1 million cycle life.

b. Provide tactile indications of operation.

3. Each door control panel shall have the following arrangement unless otherwise Approved:

a. Top row

(1) Left: Open Forward pushbutton

(2) Right: Open Rearward pushbutton

b. Second row

(1) Left: Close All Doors pushbutton

(2) Right: Communicating Signal Buzzer pushbutton

c. Third row

(1) Left: Open Local Door pushbutton

(2) Right: Close Local Door pushbutton

d. Fourth Row

(1) Left: Lamp Test pushbutton

(2) Right: All Doors Closed and Locked indicator

e. Bottom Row

(1) Key Switch

(2) Door Control Panel Activated Indicator (green)

M. Incorporated either within each door control panel, or immediately adjacent to it, shall be:

1. A "Push to Talk" pushbutton control for the doorway area public address microphone.

2. A similar control for the crew intercom.

3. A crew intercom speaker and the microphone, per Section 13, Communications.

4. If these devices are mounted separate from the door control panel, they shall be activated whenever the door control panel is activated by use of the key switch.

N. Each panel shall require the insertion of the standard key to make either the "Open" buttons or the "Close" buttons operative.

1. It shall be possible to remove the key after the doors have been opened, and have the doors remain open provided that the train is stopped; and to close the doors using a different door control panel from which they were opened, with the zoning being reestablished at the panel being used for closing doors.

2. The door circuitry shall be arranged that when the local side door at any control station is opened by a member of the train crew, the door closed and locked signal for that door shall be automatically bypassed below 20 mph, allowing the engineer to move the train with that door open.

3. If the key is removed when the local door is open and the train is moving, the local doors shall automatically close.

O. Details of the cab control and doorway control panels shall be submitted. **(CDRL 06-06)**

6.4.2 High/Low Level Boarding

A. The low-level door design must include provisions for future conversion to high-level boarding. This shall include changing the height of the door control panels and moving or adding safety appliances as required.

1. An Approved means for SEPTA to modify converted doors to respond to high-level door commands instead of low-level door commands shall be provided.

B. Details for the step well are defined in Section 14, Interior and Exterior Appointments.

C. The configuration of the high-level and low-level boarding doors shall be submitted. **(CDRL 6-07, Configuration of High-Level and Low-Level Boarding Doors)**

6.4.3 Trainline Control Circuits

6.4.3.1 General

A. All door control signals and trainlines shall be two wire circuits fed from two pole double break switches energizing both the positive and the negative sides.

1. These circuits shall be fully isolated from all other car wiring and shall be fed by an isolated power supply.

2. These trainline circuits shall not mate with any car door control trainlines.

B. Door leaves shall respond to rapidly changing commands as may arise if the crew attempts to jog doors during opening or closing. A door leaf shall promptly respond to a crew open command if closing, and likewise shall promptly respond to a crew close command if opening.

C. Crew access switches shall function at all times, except when the associated door is mechanically locked out.

1. Any door which is open when a train is stored and all door control stations are deactivated, shall remain open until a crew access switch is used to individually

close that door, or a door control station is activated and the "doors close" command given.

D. To enhance safety, the doors closed and locked indication function shall be configured such that the closed and locked indication can be obtained only when no stored open signal is present in any local door leaf control apparatus and when all doors are closed and locked.

E. Door controls shall be interlocked so that no trainline door open signal can be initiated or executed when the car is above its zero speed threshold.

1. Loss of the zero speed signal shall terminate a door open trainline command and initiate a door close command.

6.4.3.2 Trainline Circuits

A. Separate trainlined high-level and low-level door control circuits shall be provided for each side of the cars in a train.

1. The trainline wiring through the couplers shall be configured so that the left side and the right side doors of a train are properly controlled regardless of individual pair orientation within the train, such as if a married pair is turned.

B. If the trap door at the cab end is lowered and latched, that door's local control panel shall not allow any trainline or local door open commands (high or low level).

C. The trainline circuits shall provide for door control of the whole train by a single crew person.

1. The door controls shall permit independent control of doors forward from and rearward from the activated control station. This direction independence is to allow the crew person to observe all the doors under the person's control during the total door closing sequence.

6.4.3.3 Zoning

A. The activation of a door control panel shall establish a door control zone.

1. Multiple door control panels that have been activated or the combination of active door control panel(s) shall create multiple door control zones.

2. Trainlined door commands shall not be transmitted beyond an active control panel.

3. In the event that there are conflicting commands within a zone, such as between two activated control panels, the door closing command shall take precedence in order to provide the safest mode of operation.

6.4.4 Local Door Control Circuits

A. At each doorway, the door controls shall also be zero speed interlocked for trainline door commands so that non-local doors can only be commanded open only at zero speed.

1. Loss of the local zero speed signal shall cancel any stored open command and initiate door closing, except at the local door which has a keyed up active doorway control panel.

B. For crew observation purposes at stations, means shall be provided to open and close the local door at any time at speeds up to 20 mph using a crew key. That local door shall not respond to door open/close trainline commands, but shall automatically close once a speed of 20mph is reached.

C. If the key is removed once the train is underway prior to all door leaves being closed, they shall immediately close under the command of the zero speed interlock.

6.4.5 Door Safety

A. Passenger safety is highly dependent upon safe operation of the door controls. The door systems shall be designed, and manufactured with an emphasis on addressing the following areas of concern:

1. Each door leaf shall be provided with vital sensing means to continuously verify that the leaf is fully closed and securely locked, which shall be based upon the position of the door leaf and not the door operator.

a. Individual leaf closed and locked sensing signals shall be collected by a vital door summary circuit on each car, using vital (non-welding) relays or vital microprocessor logic.

b. The local closed and locked status of the door leaves at each doorway shall be indicated by inconspicuous means so that the train crew can quickly ascertain the status of each leaf while looking down the car aisle.

2. The status of the door summary circuit on each car shall be utilized in a trainline safety circuit for traction interlocking functions.

a. The status of the train door summary circuit shall be indicated inside the car on each door control panel.

b. The status of the door summary circuit of each car shall be indicated externally on each side of the car by door status indicating lights that are conspicuous when viewed along a train.

3. Each door leaf shall be provided with motion obstruction sensing.

a. Motion obstruction sensing and reaction during door closing shall prevent passenger injury if struck by a closing door per APTA PR-CS-S-012-02.

(1) As a deviation from APTA PR-CS-S-012-02, powered leaf reopening in response to a closing obstruction is not to be implemented. Motor power shall be removed for an adjustable time and then attempt to resume closing.

(2) Mechanical leaf push-back shall be used to aid in extraction.

(3) Motion obstruction sensing during opening shall be provided to prevent serious passenger injury arising from door leaf surface discontinuities moving into the door pockets.

4. The Contractor shall establish a logic table listing every possible combination of door control station and crew switch status within a train, and door obstruction response, and the resulting status of door control to ensure positive understanding of the design of the door system.

a. Controlling logic shall be supplied such that no single door operator or control failure shall disable the door leaf.

b. Regardless of the method of door control used on a train, information on door closed status shall always be communicated to the active door control station and to the active cab.

5. The door control system shall be linked on a car basis to the control logic of the propulsion system to prevent the doors from opening unless the train is at zero speed (see Section 10, Propulsion and High Voltage System).

a. Interlocking on a train basis shall prevent the train from developing propulsion power unless all doors are closed and locked and all door control switches and relays are in their proper (i.e., doors closed) position, both in the cabs and in the door system itself, except for the local door activation.

b. Door status information shall also be communicated to the destination sign and stop announcement system (see Section 13, Communications).

6.4.6 Exterior Crew Access

A. To allow the train crew to have ease of access to the car from high level platforms, low level platforms, and track bed, the side doorways shall be provided with four crew switches per car at doors 1, 2, 5, and 6 (1 per door).

B. The high-level crew switch shall be mounted approximately 3 feet, 2 inches above the floor line and the low-level crew switch shall be located above platform height, easily accessible from the side of the car.

C. The exterior keyholes shall be recessed and covered with gasketed top-hinged stainless steel snap covers to ensure weather tightness and attached to the carbody with stainless steel fasteners for ease of replacement.

D. All exterior portions of the crew switch shall be of a non-corrosive material.

E. Each crew switch shall operate the adjacent door leaf whenever sufficient battery power is available on the car.

F. The switch contacts and terminals shall be guarded, and located above the keyway so that any leakage of moisture that may occur will not reach them.

G. The crew switch assemblies shall be attached to the vehicle wiring with an electrical connector and design shall ensure that the integrity of the door system will not be jeopardized.

H. The switches shall be key operated using the standard key, momentary contact type, of heavy duty commuter railroad quality and spring-loaded to the center position. The key shall be inserted or removed only when the switch is in the neutral center position.

    1. Rotating clockwise shall close the door, and rotating counterclockwise shall open the door.

    2. Operating positions shall be suitably labeled by engraving or other durable process.

I. When a door has been opened by operation of a crew switch, it shall be possible to close it by means of any interior door control panel or the door control switches in a cab, and thereafter the door shall operate normally. Likewise, when a door has been opened by an interior door control panel, it shall be possible to close it by means of the crew switch at that door.

J. The crew switch shall be located to ensure that an exiting crew person is clear of the door when it is commanded to close by that switch.

K. The crew switch shall be interlocked with the "no-motion" circuitry so this switch shall be inoperative when the vehicle is in motion.

    1. The interlocking shall be negated during periods of car storage with propulsion shutdown to permit crew access when the "no-motion" logic is unavailable.

L. The overall crew switch arrangement shall be submitted. **(CDRL 06-08, Exterior Crew Switches)**

6.4.7 Door Actuators

6.4.7.1 General

A. Door operators and their controls shall be commuter railroad service-proven, shall have been used with a door panel of comparable weight, and are subject to SEPTA Approval.

B. All leaf position and locking sensing shall be incorporated into this unit and arranged for complete functional adjustment on the car.

C. The door operators shall be mounted above the door in the header area and shall be securely mounted to the structure of the car.

D. Each operator shall be arranged to be easily accessible for maintenance through a ceiling access panel and shall be protected from wind-driven rain, snow or car washing spray.

E. Each door leaf shall be arranged so that it can be manually opened for emergency exit.

1. When the emergency manual release is operated, no more than 20 pounds force shall be necessary to manually open each door leaf.

F. The same door operator and all related parts shall be used for high and low door leaves so that future conversion to high level boarding requires minimal part replacement.

6.4.7.2 Actuator Power

A. The door actuators shall be powered from the car battery voltage system and shall be classed as a critical load.

1. The system shall provide normal and uniform operation at the nominal battery voltage of 37.5 VDC +/- 10%. At lower voltages, the opening and closing time may be slightly above the specified range but must function sequentially and properly.

2. Voltages below 25 VDC shall not damage the door system.

6.4.7.3 Door Opening

A. The door actuator opening times shall be independently adjustable by PTU and shall be initially set at:

1. For sliding pocket doors: 3 (± 0.5) seconds – Adjustable by SEPTA from 2.0 to 4.0 (± 0.5) seconds.

B. Door opening motion shall include a leaf acceleration interval, a constant speed motion interval, and a cushioned deceleration interval ending in a smooth and bump-free stop with the door leaf in its fully open position.

6.4.7.4 Door Closing

A. The door actuator closing times shall be independently adjustable by PTU and shall be initially set at:

1. For sliding pocket doors: 3 (± 0.5) seconds – Adjustable by SEPTA from 2.5 to 4.0 (± 0.5) seconds.

B. Door closing motion shall include a leaf acceleration interval, a constant speed motion interval, and a cushioned deceleration interval ending in a smooth and bump-free stop with the door leaf in its fully closed position.

C. Confirmation of the door leaf being closed and locked shall be sensed, and the leaf closed signal shall be used by the door controls and the car summary circuit.

6.4.7.5 Software Adjustments

A. Temporary software parameter adjustments of all the local control units on a car shall be possible from a single location and a single action sequence using the network. Software subsystem parameter adjustability shall meet the requirements of Section 19, Software Engineering.

B. Software uploading to a new control software version shall similarly be possible from a single location by using a password-protected loading sequence.

C. The Contractor and its supplier shall submit a list of the adjustable parameters and their ranges. (**CDRL 06-09, Adjustable Parameters for Door Control System**) .

6.4.7.6 Door Operator Motors

A. The door operator motors (including brushes and position encoders) and gear units for each leaf shall not require maintenance attention or lubrication for 15 years or 450,000 door cycles of normal service.

B. Door drive motors and controls shall be capable of repetitive cycling between "open" and "closed and locked" conditions under the full range of ambient temperature conditions without damage or degradation.

C. The motors shall be sufficiently sized to enable an open door to close against the maximum acceleration of the train.

D. All door operator motors shall be interchangeable from one door position to another, no matter if it is a high-level or low-level door.

E. Automatically resetting overload protection devices shall be used, except as Approved.

F. The motors shall accept stall currents indefinitely without degradation and a thermal cutout switch shall not be required.

6.4.7.7 Door Locking

A. The door support and drive unit shall positively mechanically lock its door leaf in the fully closed position.

1. Locking may be achieved by inherent over-center motion of a direct connected leaf drive element or by provision of an independent lock mechanism on the leaf.

2. The mechanical method used shall keep all doors closed (when so commanded) without the need for continuous application of electrical power so that door leaves cannot be manually moved farther than the distance allowed by the push-back feature.

B. If inherent locking is provided, no control failure sequence shall be capable of causing a door motor to operate in the open direction thereby unlocking that door leaf.

1. Also, no mechanical failure shall permit the leaf to move enough to permit exit.

C. If independent supplemental locking is provided, the lock shall be either capable of unlocking under the worst case of leaf preload or the door operator shall include a power close before unlock function to eliminate the lock pre-load during unlocking.

D. Confirmation of the door leaf being closed and locked shall be sensed. The leaf closed and locked signals shall be used by the door controls and the car summary circuit as part of the determination of door leaf position safety status.

6.4.7.8 Door Mounting and Support

A. The Contractor shall ensure that the carbody mounting interface with the door operator system, and the door operator and door hanger system, is suitably robust and immune from distortion from the worse-case conditions of car loads and track geometry and condition.

B. The door drive and door support mechanism shall not require lubrication more frequently than every three years in normal service.

C. The drive and support shall prevent door leaf skew movement and maintain the door edges parallel and in alignment.

D. The mounting of each door leaf to its unitized support track and drive unit shall provide all necessary installation adjustments to obtain a good fit of the door leaf in the doorway when closed.

1. The term "good fit" covers providing a weathertight closure that excludes noise, prevents water entry, minimizes interior to exterior air flow, prevents door leaf rattling, but does not introduce friction and does not detract from smooth leaf motion.

2. The weatherstrip shall be designed to seal the gap between the door leaf and the edge of the door opening, on both sides of the door leaf.

E. All mechanism adjustments shall be by positive means, such as interlocking serrated flat clamped surfaces or axial adjustment of threaded items with locking nuts, locking tabs, or similar securement that cannot drift or loosen. Reliance only on friction between clamped surfaces will not be accepted.

F. All limit switches and/or proximity sensors shall be precision units that are positively and precisely located so that they may be replaced without the need for mechanism readjustment.

1. Switch and sensor mounting shall be immune to normal variations in installation workmanship.

2. All limit switch and/or proximity sensor adjustments shall be by positive means, such as interlocking serrated flat clamped surfaces or axial adjustment of threaded items with locking nuts, locking tabs, or similar securement that cannot drift or loosen. Reliance only on friction between clamped surfaces will not be accepted.

G. Contacts used in the door operator for limit switches, signal light circuit switches, etc., shall be commuter railroad quality replaceable unit type. **(CDRL 06-10)**

1. The design and installation of these switches shall be such that they require no periodic adjustment and the adjustment screws be held with a breakable thread locking compound.

2. Signal light circuit contacts shall be arranged to directly verify the locking of each door.

3. Switch design and orientation shall be such as to prevent ingress of dirt and moisture.

6.4.7.9 Door Operator Cutout

A. Each door operator shall be provided with a combination of a door mechanical lock assembly and a cutout switch that effectively disables the door operator, control

relays and obstruction sensing system from the propulsion/doors trainline interlock circuit, on an individual door leaf basis, and locks the door leaf in the closed position.

1. When this assembly is used, the interior door status indicator for the door leaf shall flash, and power shall be removed from the door operator. The exterior door status indicator shall not be illuminated.

2. The lock assembly shall be made of stainless steel, and shall mechanically lock the door leaf in the closed position, independent of the door operator lock mechanism.

3. The switch and locking device shall not be visible to passengers and shall be accessible with minimum disturbance. A location as high as practical from the interior floor through a wall mounted keyed access panel is required.

    a. This panel covering shall be unobtrusive and made of the same material as its surroundings and require the standard key to operate.

    b. Operating positions shall be identified as "Normal" and "Cutout."

    c. The design of this device shall be submitted for approval. **(CDRL 06-10)**

    d. Use of an emergency manual release for a side door shall also unlock this device and allow the door leaf to be opened.

B. Details of the door actuators and motors shall be submitted. **(CDRL 06-10, Door Actuator and Motor Details)**

6.4.8 Door Interlocks

6.4.8.1 Propulsion/Doors Interlock

A. Each car shall have a traction interlock to prevent a train from developing propulsion power unless every door in each car of a train (except the local door panel kept open for train crew observation) is:

1. In its closed and locked position

2. All door control relays including those interfacing with the door control signal trainlines are in a "close door" position.

B. The interlock circuit shall operate on a local car basis but shall be part of a trainline circuit with the active cab of the train.

1. This function shall use a dedicated trainline, and not a data bus system, and shall also be used to operate the cab console and doorway control panel door status and exterior indicators. Use of the propulsion/doors interlock bypass switch shall not affect the operation of this indicator.

6.4.9 Door Bypass Switches

6.4.9.1 Propulsion/Doors Interlock Bypass Switch

A. To allow a train to be moved in the event of an insoluble problem in the doors or their circuits, sealed local car propulsion/doors interlock bypass switch shall be provided in the cab.

B. Use of this switch shall functionally remove the propulsion/doors interlock on a local car basis and the door circuits feeding it, i.e., failure of the door circuits shall be overcome.

C. Use of the bypass switch shall not modify the operation of the cab console door open indicator LEDs in any way, i.e., it shall still accurately indicate door status of the rest of the train. In addition, the use of this switch shall result in the doors of the car not responding to the door control trainlines.

D. The switch shall be labeled and sealed in the "Normal" position. In addition, the use of this switch shall be indicated on the TOD in the active cab in the train and be logged in the propulsion event recorder of Section 10, Propulsion and High Voltage System

E. A failure message shall be displayed and logged in the Diagnostic system.

F. Details of the door interlocks and bypass operations shall be submitted. **(CDRL 06-11, Door Interlock and Bypass Details)**

6.4.10 Door Status Indicators

A. Door status indicators shall be provided on the cab console and the doorway control panels and in the exterior and interior of each car. Details of indicators are defined in Section 8, Lighting.

6.4.10.1 Exterior Indicators

A. Exterior indicators shall illuminate to indicate that one or more door leaves on either side of the car are not fully closed and locked and not locally cut out.

B. See Section 8, Lighting for details.

6.4.10.2 Interior Indicators

A. The indicators shall be arranged to be easily visible to the train crew looking down the aisle of the car.

B. Each indicator shall be illuminated when its respective door leaf is unlocked or open.

C. If the respective door leaf has been cutout and mechanically locked, this indicator shall flash.

6.4.10.3 Door Closing Indicators

A. Each side doorways shall be equipped with an audible warning device and visible warning lights to alert passengers of closing doors.

1. This warning signal shall only be given at a doorway when it receives a trainline command to close from another location on the train. It shall not function to local door control panel operation or crew switch closing commands.

B. Each side doorway shall be equipped with one LED warning lamp fixture with a low-profile amber beehive lens, located in the center of the overhead doorway header.

1. The light shall be visible from outside of the car from high or low platforms) when the door leaves are open but shall maintain the required vertical clearance of the doorway.

2. Also located in each doorway header shall be a solid state beeper with a minimum audio output range of 75 to 95 dB(A) at 2 feet having a tone of 2,900 Hertz with 0.25 second duration produced two times a second, with a volume control shutter.

C. The operation of the audible and visible warning signals shall be fully adjustable by software settings which are password protected, and a range of SEPTA-adjustable timings and features shall be provided.

D. The cars shall be initially arranged so that when the door close trainline command is received at a doorway, the warning lamp shall flash at a 0.5 second on and off rate, and the beeper shall sound, until the door is fully closed.

1. The warning sequence time delay shall be adjustable by SEPTA from 0.5 to 4.0 seconds prior to the door closing movement so that the warning signals will provide an advanced warning of the door movement.

E. The circuitry shall be so arranged that if a door is commanded to open during a closing cycle, the warning signals shall immediately stop, and the door leaves immediately start to open.

1. If the door closing button is pressed before the doors are fully open, the doors shall immediately close with warning signals, without delay and going through the signal and timing cycle.

2. Once the doors are fully open, the signal and timing cycle shall be restored to its starting points.

F. Details of the door status indicators shall be submitted. **(CDRL 06-12, Door Status Indicator Details)**

6.4.10.4 Movement Obstruction Sensing

A. The door control unit for each door leaf shall monitor the door operator motor electrical input (voltage and current), and from known motor characteristics, door mass, position, and friction, compare the expected door dynamics to the actual door leaf movement.

1. This dynamics comparison shall be gauged against appropriate detection thresholds to detect obstructed door leaf movement.

6.4.10.5 Closing Obstruction Response

A. The local control unit for each door leaf shall include SEPTA-programmable response schemes.

1. For obstructions during door closing, the response scheme shall include an initial relaxing and various combinations of timing, sequencing, and repetitions of leaf reclosing attempts.

2. Upon sensing of an obstruction, the local door controls shall cause the door operator on the obstructed door leaf to stop with no power applied to the motor.

3. After a controlled elapsed time of no motor current, the door shall attempt to close again.

4. The initial setting shall be 1.0 second with a 0.5 to 2.5 adjustment range.

5. If the obstruction remains, the door will continue to pause and then retry closing until an upper limit of cycles is reached.

6. The system shall be capable of unlimited retries but shall be initially set to 3 cycles.

7. Once the limit of retries has been reached, the door shall remain at the point of obstruction and power removed until the train crew intervenes. If a new open and close command is received, the control shall be reset.

B. Setup and adjustment of this response shall be provided at a single location on each car through the PTU interface and network as outlined in Section 19, Software Engineering and Section 27, Special Tools and Test Equipment.

6.4.10.6 Detection Sensitivity

A. The sensitivity of the obstruction detection system at the point of door leaf interlocking elastomer nosing engagement shall be as follows:

1. Doors Closed and Locked

a. The system shall detect a flat bar, 0.25 inch wide and 3 inches high, held rigidly between and perpendicular to the door leaves. This sensitivity shall be required along the entire height of the nosing.

b. The system shall also detect a 0.75 inch diameter round object, held rigidly between and perpendicular to the door leaves at all locations along the entire height of the nosing.

c. The force applied on the obstruction shall not exceed 36 pounds.

2. During Door Closing

a. The force applied on the obstruction shall not exceed 36 pounds.

b. Power to the motor shall be removed within 0.5 second of encountering an obstruction.

c. Lateral passenger loading of up to 60 pounds shall not activate the obstruction detection system.

B. The obstruction sensitivity shall be future adjustable to profiles other than the above setting within Contractor authorized limits by SEPTA through the PTU interface, with suitable password protection.

C. Details of the door obstruction and sensing system shall be submitted. **(CDRL 06-13, Door Obstruction Sensing System Details)**

6.4.10.7 Opening Obstruction Response

A. For obstructions during door opening the response scheme shall include the door leaf recycling partly closed, relaxing, and combinations of these with timing and repetitions adjustable.

1. Setup and adjustment of this response shall be provided at a single location on each car through the PTU interface as outlined in Section 27, Special Tools and Test Equipment.

2. The initial settings shall be discussed and agreed upon during design review.

6.4.11 Door Control Unit

A. The door control unit shall be a programmable microprocessor based controller. The controller shall utilize relay-based logic devices for safety-related functions as appropriate and shall protect against all logic faults which may cause unintended operations. The Contractor shall propose a fail-safe scheme. **(CDRL 06-14)**

6.4.12 Door Diagnostics and Self-Test

A. The door controllers shall have an Approved self-diagnostic routine that is initiated automatically each time the subsystem is powered-up and that can also be initiated by the door control unit, VMDS, and PTU.

1. The subsystem shall initiate a self-test upon startup.

2. The door controllers shall contain all necessary LEDs and system status information to be able to alert maintenance personnel of a failure/problem without the need of a PTU.

3. These local control indicating LEDs may be located to be viewable through door clearance gaps when the door leaf is open, or in a similar inconspicuous place.

4. The self-diagnostic routine shall verify that all subsystem components are working normally within predefined limits, and to check and troubleshoot the integrity of the subsystem.

5. Failure conditions from the electronics' self-tests shall be communicated to the VMDS and shall be downloadable as part of the fault log by the PTU.

B. The Contractor shall submit documentation of the door control unit including its capabilities. **(CDRL 06-14, Door Control Unit Documentation)**

6.4.13 Emergency Door Release

A. All side doors shall be designed to be manually opened from both inside and outside the car for emergency egress rescue personnel access, and train crew access in accordance with the latest requirements of 49 CFR Part 238.112, APTA-PR-M-S-18-10, and APTA PR-PS-S-002-98.

1. These emergency door releases shall be located adjacent to each door and protected so as to minimize their misuse by passengers and crew.

2. The location of these emergency devices shall be clearly indicated for any approaching rescue personnel.

3. Interior emergency devices shall be protected by a hinged cover. The arrangement shall allow passengers to lift the cover and then operate the emergency door release.

4. The exterior emergency cover shall be hinged, flush mounted, and openable using the standard key, to permit SEPTA to periodically test the mechanism without damage.

5. The exterior emergency handle shall be protected by an opaque frangible cover which will allow access without any special tools yet discourage unwanted vandalism.

    a. The cover shall be capable of removal by any size range of a person as defined in Section 2, Design and Performance Criteria, without requiring the use of a tool.

    b. If the method of removing the protective cover or screen entails breaking or shattering it, the cover or screen shall be scored, perforated, or otherwise weakened.

6. Activation of any emergency door release shall interrupt the doors/propulsion interlock and indicate an open door condition at that location.

7. One release mechanism shall be provided per door and shall unlock the adjacent door only.

8. The release control location and method of operation shall be similar for each door position.

9. Such a device shall be simple for passengers to understand and operate, especially under stressful conditions of accident, fire, smoke, etc. and adequate signage and operating information shall be provided.

10. Use of this device shall release any mechanical door locks, disable the door operator, and shall not be inhibited by the prior engagement of any cutouts, locks, etc.

11. The door system shall provide no active resistance to the door that would inhibit pushback under emergency release.

12. A fault message shall be displayed in the active cab.

13. All details, including signage, shall be submitted. **(CDRL 06-15, Emergency Door Release**)

6.5 Contract Deliverable Requirements List (CDRL)

The following contract deliverables have been identified in this section; however, the Contractor is responsible for providing and submitting anything necessary to fulfill the requirements of this contract, including those not identified by CDRL number.

CDRL 06-01, Accessibility and Maintainability 6-2

CDRL 06-02, System Functional Description 6-2
CDRL 06-03, Exterior Side Door Design 6-4
CDRL 06-04, Body End Door Design 6-7
CDRL 06-05, Door Controls 6-7
CDRL 06-07, Configuration of High-Level and Low-Level Boarding Doors 6-10
CDRL 06-08, Exterior Crew Switches 6-14
CDRL 06-09, Adjustable Parameters for Door Control System 6-16
CDRL 06-10, Door Actuator and Motor Details 6-19
CDRL 06-11, Door Interlock and Bypass Details 6-20
CDRL 06-12, Door Status Indicator Details 6-22
CDRL 06-13, Door Obstruction Sensing System Details 6-23
CDRL 06-14, Door Control Unit Documentation 6-24
CDRL 06-15, Emergency Door Release 6-25

6.6 CDRL Details

This section lists the expected content for each CDRL required above. The lists provided for each CDRL are an outline only and should not be considered exhaustive, all CDRLs are subject to SEPTA review and approval.

CDRL 06-01 Accessibility and Maintainability

1. Provide during Preliminary and Final Design Reviews (PDR and FDR)
2. The Contractor shall provide details of the accessibility and maintainability of the door system, showing how all components shall be easily accessed or removed.
3. Details shall include, at minimum, access and maintainability of the following door system components: all door tracks, operators, panels, peripherals, hangers, and controls.

CDRL 06-02 System Functional Description

1. Provide during all Design Review Phases (CDR, PDR and FDR)
2. The Contractor shall describe the complete and detailed system functionality of the door system.

CDRL 06-03 Exterior Side Door Design

1. The Contractor shall provide during all Design Review Phases (CDR, PDR and FDR) the following details:
   a. Construction of the side door panels
   b. Threshold, weather sealing, and drainage system
   c. Window glazing

d. Door panel thermal and acoustic insulation

e. Trap door design, including all locking hardware if low level doors are located at the cab end

CDRL 06-04 Body End Door Design

1. The Contractor shall provide during all Design Review Phases (CDR, PDR and FDR) the following details:

   a. Construction of the body end door panel

   b. Threshold, weather sealing, and drainage system

   c. Window glazing

   d. Door panel thermal and acoustic insulation

   e. End door lock and hold open latch design

CDRL 06-05 Door Control System

1. The Contractor shall provide during all Design Review Phases (CDR, PDR and FDR) the following details:

   a. System schematic diagrams

   b. The control scheme of the high level and low level doors

   c. Trainline and local door control circuits

2. The Contractor shall provide a sample of each switch, and pushbuttons which shall be returned to the Contractor.

CDRL 06-06 Door Control Panel and Indicator Arrangement

1. The Contractor shall provide during all Design Review Phases (CDR, PDR and FDR) details for the following:

   a. Doorway control panel

CDRL 06-07 Configuration of High-Level and Low-Level Boarding Doors

1. The Contractor shall provide during all Design Review Phases (CDR, PDR and FDR) the following details:

   a. High level and low level boarding doors

b. Future design conversion of the low-level boarding doors to high-level boarding doors

c. The trap door located on the opposite side of the cab, if applicable.

CDRL 06-08 Exterior Crew Switches

1. The Contractor shall during all Design Review Phases (CDR, PDR and FDR) provide the following details:

   a. Design details of the low level and high level crew switch panel

   b. Location of each crew switch

   c. The control scheme of the crew switch

CDRL 06-09 Adjustable Parameters for Door Control System

1. The Contractor shall provide during Preliminary and Final Design Review the following details:

   a. Door speed for closing and opening

   b. Obstruction detection impact and peak force

   c. Obstruction cycles

   d. Obstruction reopening distance and response time

CDRL 06-10 Door Actuator and Motor Details

1. The Contractor shall provide during Preliminary and Final Design Review the following details.

   a. Drawings of the door operator

   b. Datasheet of the actuator

   c. Door lock and mechanical cutout design

   d. List of software adjustable parameters

   e. Door Operator interface to the carbody

CDRL 06-11 Door Interlock and Bypass Details

1. The Contractor shall provide during Preliminary and Final Design Review the following details:

a. System schematic diagrams

b. Zero speed and ≤20mph speed interlock

c. Propulsion and door interlock bypass

d. Door status interlocks and door position sensing switches

e. Critical circuit relays

CDRL 06-12 Door Status Indicator Details

1. The Contractor shall provide during Preliminary and Final Design Review the following details:

   a. Visual and audible warning

   b. Location

   c. Drawings and data sheets

2. The Contractor shall provide a sample of each visual and audible warning indicator which shall be returned to the Contractor

CDRL 06-13 Door Obstruction Sensing System Details

1. The Contractor shall provide details for door obstruction detection.

2. The Contractor shall demonstrate compliance with the requirements of APTA PR-M-S-018-10.

CDRL 06-14 Door Control Unit Documentation

1. The Contractor shall define during Preliminary and Final Design Review the capabilities of self-test functions and diagnostic systems including the following:

   a. Perform a complete health check and pinpoint failure down to the lowest line replaceable unit

   b. Provide the functional description of its fault logic

   c. Provide a fault list

   d. Functional description of the trace recording subsystem.

2. The Contractor shall provide the DCU hardware and software specifications.

   a. Compliance to EN 50155.

CDRL 06-15 Emergency Door Release

1. The Contractor shall provide during Preliminary and Final Design Review the following details:

    a. Design drawings of the interior and exterior emergency door releases.

    b. Compliance with APTA PR-CS-S-012-02, APTA PR-M-S-018-10, APTA PR-PS-S-002-98, 49 CFR Part 239, and 49 CFR Part 38.

6.7 Reference Standards

The following standards are referenced in this Section:

49 CFR Part 38	Americans with Disabilities Act (ADA) Accessibility Specifications for Transportation Vehicles
49 CFR Part 238	Passenger Equipment Safety Standards
49 CFR Part 239	Passenger Train Emergency Preparedness
APTA PR-CS-S-012-02	Standard for Door Systems for New and Rebuilt Passenger Cars
APTA PR-M-S-018-10	Standard for Powered Exterior Side Door System Design for New Passenger Cars
APTA PR-PS-S-002-98	Standard for Emergency Signage for Egress/Access of Passenger Rail Equipment

SECTION 7
HEATING, VENTILATING, AND AIR CONDITIONING

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7.1 General

7.1.1 Performance Requirements

A. The Heating, Ventilating, and Air Conditioning (HVAC) system shall automatically maintain the specified interior temperatures and humidity level over the full range of ambient temperatures, passenger loads, solar loads, fresh air loads, and operating speeds as described in the following sections.

B. Load Calculations shall be submitted for all operating modes. **(CDRL 07-01, HVAC Load Calculations)**

7.1.1.1 Heating Performance and Design Conditions

A. Each car shall have sufficient heating capacity under normal train operating conditions to maintain the car interior temperature (measured at the return air temperature sensors) at a steady state of 70 degrees F ± 2 degrees F (21.1 degrees C ± 1.1 degrees C) under the following conditions:

Ambient Temperature:	-7 degrees F (-21.7 degrees C) with wind speed of 10 miles/hour (16 kilometers/hour)
Internal Heat Gains:	AW0 (empty) passenger load, with interior lights, blowers, and all equipment heat loads included and carbody transmission losses.
Fresh Air	Maximum fresh air volume.
Solar Load:	None
Door Operation:	Doors cycled open for 20 seconds, then closed for 2 minutes.

7.1.1.2 Air Conditioning Performance and Design Conditions

A. Each car shall have sufficient air conditioning capacity under normal train operating conditions to maintain the car interior temperature (measured at the return air temperature sensors) at a steady state of 72 degrees F ± 2 degrees F under the following conditions:

Ambient Temperature:	100 degrees F DB / 81 degrees F WB (37.8 degrees C DB / 27.2 degrees C WB) with a wind speed of 10 miles/hour (16 kilometers/hour) with 125 degrees F (51.7 degrees C) air entering the condensers. Above 125

	degrees F the HVAC must still operate, but the interior temperature range may be exceeded.
Fresh Air	7.5 CFM (12.7 M3/hr) per passenger at AW2 loading.
Internal Heat Gains:	AW2 passenger load plus Operator at 450 BTU per hour (131.8 W) per person, 55 percent heat ratio.
Additional Loads	Interior lights, blowers, all equipment heat loads and carbody transmission losses.
Solar Load:	Per ASHRAE Fundamentals Handbook, including cooling load temperature differential heat gain due to exposure of the carbody to solar loading.
Door Operation:	Doors cycled open for 20 seconds, then closed for 2 minutes.

B. The air conditioning system shall be designed to continue operating at reduced performance, if necessary, under the design condition specified in the preceding criteria, but with 135 degrees F (57.2 degrees C) air entering the condensers.

1. Under these conditions, the system may utilize bypass switches or shut down one refrigerant circuit per unit but shall be capable of continuous operation without shutdown due to high pressure, circuit breaker trip, compressor motor overload or device failure.

7.1.1.3 Relative Humidity Performance and Design Conditions

A. The relative humidity of the car interior shall not exceed 60 percent at any ambient temperature higher than 45 degrees F (7.2 degrees C).

7.1.1.4 Layover Mode

A. Performance

1. The car interior shall be maintained at the following approximate temperatures in layover mode:

a. Layover Heating: 40 degrees F (4.4 degrees C)

b. Layover Cooling: 85 degrees F (29 degrees C)

2. The Contractor may propose alternate setpoints for Approval.

3. Fans shall be turned off when no layover cooling is active.

4. Layover cooling shall be a feature that can be enabled or disabled through the PTU.

B. Layover Mode (Heating and Cooling)

1. Layover cooling shall operate a single refrigeration circuit from each HVAC unit.

2. Any required pump down shall be performed at the end of the layover mode initiation time delay.

3. Reference Section 5, Operator's Cab, for additional information on layover operation activation.

C. One of the sidewall heater circuits shall also be used for layover heating. The circuit shall overcome carbody heat loss which shall be tested to ensure a maximum of 700 BTU/hour-degree F (370 W/degree K) per Section 14, Interior and Exterior Appointments.

D. See Section 5, Operator Cab.

7.1.1.5 Temperature Variation Limits (Stratification)

A. The HVAC System shall meet the temperature variation limits (stratification) of ASHRAE Guideline 23, Table 4.2. for intercity cars:

1. Following a door opening of 20 seconds duration on one side of the car, the interior temperature anywhere inside the car must recover within 1 degree F (0.55 degree C) of the required specified value within two minutes.

7.1.1.6 Required Heating and Cooling Capacity

Cooling:	No less than 84,000 BTU/hr (24.6 kW) for each of the two overhead unitized HVAC units per car.
Overhead Heating:	As required to meet the testing requirements of Section 15, Test Program, but not less than 15 kW per unit.
Baseboard Heating:	No less than 15kW.
Cab Heaters:	No less than 2 kW for each of the two cab heaters per cab
Heated Windshield:	No less than 0.5 W per square inch (0.08 W per square centimeter)
Protective Heaters:	As required for the proper operation of the protected systems, as specified.

Layover Cooling and Heating:	As required to provide pull-down and pull-up from layover in 20 minutes or less. Pull-down and pull-up will be reached when the return air sensors of both units reach the interior setpoint ±2 degrees F (±1.1 degrees C).

7.1.2 HVAC Unit Physical Characteristics

A. Two identical roof-mounted unitized HVAC units shall be provided per car. The HVAC units shall be roof mounted at the ends of each car, or towards the center of the car if the pantograph limitations make this necessary.

B. HVAC units shall be mounted on a sealed pan with supply and return air openings sealed by roof flanges. Continuous bulb-type clamp on seals shall provide a water-tight seal when the unit is lowered into position. Flat foam strips shall not be used.

C. The clearance dimensions and high voltage catenary clearance requirements shall be respected (Section 2, Design and Performance Criteria).

D. The HVAC unit housing, including frame, brackets, exterior and interior covers, shall be constructed from stainless steel or aluminum except where otherwise specified. Captive-type cover fasteners shall be provided. Hardware shall be stainless steel.

E. The roof covers shall be hinged and utilize gas struts to hold the cover in a vertical position once the safety catch is disengaged. High-voltage warning signs shall be installed on all covers.

F. The units shall be fitted with lifting points and shall allow removal in a vertical orientation without the need to tip the unit. Guide pins attached to the carbody roof shall be provided to assist in installation.

G. If units are mounted on rails welded to the rooftop, pins will be installed to stop the unit from sliding during a collision.

H. The top of the HVAC unit shall serve as a walkway for the maintenance personnel to access captive cover fasteners. The designated walkway shall be at least 24 inches (610 mm) wide and shall be clearly marked with anti-slip material with STEP-HERE labels or Approved equal. The walkway shall support the weight of an operator with tools, no less than 300 lb (136 kg) over any 6 inch by 6 inch (12mm x 152mm) surface area without permanent deformation.

I. Due to the existence of 11,500 Volt, 25 Hertz overhead energized catenary wires in SEPTA's maintenance yards and shops, rooftop maintenance of the HVAC system shall be minimized to the maximum extent practical. Under no circumstances shall electrical controls be roof accessed.

    1. Fresh and return air filters shall be easily replaceable from the vehicle interior.

J. The units shall utilize connectors for all wiring in accordance with Section 16, Materials and Workmanship. Connectors and unit grounding points shall be accessible from the return air opening.

K. Equipment grounding is of utmost importance on this contract. All components, including HVAC unit covers shall be grounded in accordance with the ground connection requirements of Section 16, Materials and Workmanship, as well as the requirements of IEEE Standard 16, including creepage distances with respect to the nominal and low heights of the catenary wire.

L. Rating of the equipment shall meet the requirements of ASHRAE Standard 37-78, "Methods of Testing for Rating Unitary Air Conditioning and Heat Pumps."

M. All components within the HVAC system shall be compatible with synthetic lubricants.

N. Data sheets for the compressor and all motors shall be submitted. **(CDRL 07-02, Major Component Details)**

O. Contractor's approach to HVAC units shall be submitted for review and Approval. Details, including condensate drainage, and removal/replacement steps shall be provided. **(CDRL 07-03, HVAC Unit Mounting Arrangement)**

7.1.3 Controls

A. The evaporator fan motors and condenser fan motors shall allow for a high and low speed. Low speed may be used at stations and when conditions are mild. The controls will limit cycling between speeds and incorporate low and high speed ventilation.

B. Protective heat shall be available at all times, regardless of control key position.

C. When a cab control key is used to activate the train, the heating, air conditioning or reheating (dehumidification) system shall automatically energize. Pre-cooling or pre-heating shall be used to more quickly reach the setpoint. Supply air temperatures will not be limited (maximum heating or maximum cooling will be provided), and fresh air dampers shall be closed. During pre-heating all heat sources shall be in operation. When the setpoint is reached, the system shall revert to normal operation. Pre-conditioning shall not be used during normal operation.

D. When the train is shut down from the controlling cab, layover heating and cooling shall be automatically enabled after a 30 minute time delay (PTU adjustable between 5 and 60 minutes)

E. Operation of the cab heater and heated windshield shall be controlled manually by the Operator.

F. If DC/DC converters are required, they shall be proposed for Approval. Heat sinks will be utilized for solid state relays.

G. Stagger starting of the motors shall be performed to prevent any two compressors on semi-permanently coupled cars from starting at the same time. Supply air shall be immediately available from all HVAC units after start-up or power interruption.

H. The system shall be capable of operating without fault or lockout when subjected to frequent (up to 150 per hour) interruptions of auxiliary power inverter output.

I. When the vehicle carwash mode is initiated, the HVAC units shall close the fresh air dampers and shut down the evaporator blower fans. The system will immediately return to normal operation when the vehicle mode is switched out of carwash.

J. Cut-out switches shall be provided for each HVAC unit in the married pair and each car's floor heat system. HVAC specific circuit breakers may be utilized for this purpose. Contractor may propose alternative arrangements for Approval.

7.1.4 Microprocessor Control

A. A solid state microprocessor-based temperature control system shall be used, with temperature detection by solid-state temperature sensors.

B. The microprocessor shall monitor operation of all LRUs, including circuit breakers and contactors. Fault logging shall detect failures down to the LRU level. A list of faults shall be provided for Approval.

C. The HVAC controller shall have a comprehensive diagnostic function capable of diagnosing failed components. The level of fault reporting shall be sufficiently detailed to allow operating and maintenance personnel to uniquely identify faults.

D. The HVAC controller shall provide a 48-hour interior car temperature profile. Interior temperature shall be logged no less than once every 15 seconds.

E. The control system shall monitor the input and output signals from each device within the HVAC subsystem, together with the equipment's power supply voltage, and transmit to the VMDS via the train network (TCDN).

F. A functional block diagram of the subsystem and its equipment shall be provided to show all signals that will be transmitted to the VMDS.

G. The microprocessor design shall be submitted. **(CDRL 07-04, Microprocessor Control)**

H. See Section 16, Materials and Workmanship, for additional Microprocessors Controller requirements.

7.1.5 Temperature Sensors

A. Temperature sensors shall be mounted in the fresh air inlet, supply air outlet and return air openings.

B. Sensor readings shall be shared by HVAC units such that a failure of a fresh or return air sensor shall have no impact on system operation.

C. Layover sensors shall be located to measure the average temperature in the vehicle. More than one sensor shall be used. The layover thermostat shall be mounted within a stainless steel guard and be enclosed in an Approved concealed location, such as under passenger seats at each end of the car. Layover temperature sensors shall be protected by a rugged stainless steel housing when exposed to passengers.

D. All sensors shall be functionally and physically identical and thus totally interchangeable.

E. Each temperature sensor shall be encapsulated in a protective stainless steel tube.

F. The thermistors shall withstand mechanical vibration of at least 10 g's.

G. The return air sensor readings shall not be biased by fresh air intake.

H. Ambient sensor(s) shall be placed to detect the accurate outdoor temperature in all operating modes, including layover.

7.1.6 Humidity Sensors

A. A humidity sensor shall be incorporated into the return air stream of both units to achieve the required humidity levels.

1. Humidity sensors shall be of rugged type and designed for railcar service. The sensors shall be accurate ±2% R.H and be proposed for Approval.

2. Humidity values shall be averaged across both sensors and a failure of one sensor shall not impact controlled dehumidification from both units.

3. Pulsed Width Modulation (PWM) overhead heat output shall be arranged to maintain supply air at the interior temperature setpoint when interior conditions call for dehumidification (reheat). No less than one compressor per unit shall remain operational until the relative humidity limits are reached.

7.1.7 Additional Control Requirements

A. The overhead heater and the refrigerant compressor shall not operate unless the ventilation blower is operating, as determined by a differential pressure airflow switch.

B. The control system shall be protected against electrical faults and transients, and shall be of a rugged design, proven in electric self-propelled transit vehicle service with high reliability.

C. The total operation time of each refrigerant compressor shall be monitored by an hour meter or through the microprocessor software.

D. A means shall be provided to SEPTA to allow adjustment of all temperature setpoints for the control system at no additional cost, both on a temporary and a permanent nature. Changes shall be accomplished through the PTU.

1. Methods shall be provided to identify such changes by means of a revision level or similar approach to permit ease of identification of revisions to the system software.

2. This capability shall be demonstrated as part of the supplier First Article Inspection, and later verified at the climate room test of the completed car.

7.2 Ventilation System

7.2.1 General

A. An overhead forced air ventilation system shall be integrated into the carbody and the two HVAC units.

B. The supply air fans shall operate whenever the car has been activated, but not at any time during layover mode when cooling is not required. The fresh air dampers shall be closed in both cooling and heating layover modes.

C. Fresh air from the car exterior shall pass through a water eliminator, a fresh air damper and a fresh air filter and be mixed with filtered recirculated air from the car interior and distributed to all portions of the car interior. Water elimination shall include a stainless steel screen or Approved alternate.

D. The air shall be distributed to the passenger compartment by continuous, flush, double-slot type air diffusers on both sides of the car ceiling. The Contractor may propose alternative arrangements for Approval, so long as cold air is provided from the ceiling area.

E. The ducting shall be arranged so that the duct on one side of the ceiling is connected to the HVAC unit at one end of the car, and likewise for the other duct, so that in the event of a failure of one HVAC unit, ventilation shall be continued from the other unit for the entire length of the car. A diagonal splitter in the main air distribution duct may be used to meet this requirement. Conditioned air shall also be provided under the HVAC unit.

F. Ventilation to the Operator's cab shall be provided through individual diffuser(s) at the front of the cab ceiling per the requirements of TS 7.2.4.

G. All ventilation system components, flexible ducting and gasketing must be capable of withstanding the ambient temperature range and the maximum temperatures developed by the overhead electric heating elements up to the maximum temperature reached when the second stage over-temperature device trips.

H. Insulation and acoustic damping shall be provided as required to control heat loss and objectionable noise. Insulation shall be protected by a vapor barrier.

I. The system shall prevent wind driven snow, rain, or carwash liquids from entering the unit. A water eliminator shall be installed that will prevent water from reaching the air filter. The fresh air inlet(s) shall provide the required quantity of fresh air, including

under the environmental conditions of Section 2, Design and Performance Criteria. Closure of the fresh air damper shall not be used to pass any of these requirements.

J. A fresh air damper shall be provided at each fresh air inlet. The damper will spring to the closed position when unpowered.

K. The fresh air damper shall automatically adjust when Service Load Weighing increases or decreases by approximately 25 passengers. Per passenger fresh airflow shall be maintained at 7.5 CFM (12.7 M^3/hr). The proposed arrangement shall be submitted. **(CDRL 07-05, Fresh Air Damper Control/Adjustment and Fresh Air Supply)**

1. The fresh air load may be reduced to 5 CFM (8.5 M^3/hr) per passenger under extreme ambient temperatures above 100 degrees F (37.8 degrees C) or below 5 degrees F or lower (-15.0 degrees C).

L. All equipment shall be capable of handling maximum volume at a velocity not to exceed 1,200 feet/minute (6.1 meters/sec).

M. The air velocity at any seated or standing passenger position shall not exceed 40 feet/minute (0.20 meters/sec).

7.2.2 CFD Analysis

A. The Contractor shall submit a Computational Fluid Dynamics (CFD) model and analysis. The analysis shall show conformance to the specification requirements including airflow uniformity down the length of the car and temperature variation limits (stratification) allowable. **(CDRL 07-06, Computational Fluid Dynamics (CFD) Model and Analysis)**

7.2.3 Ventilation System Prototype

A. Before final acceptance of the HVAC subsystem design, the Contractor and HVAC subsystem manufacturer shall construct and test a full-scale functional prototype of the air duct subsystem for an entire car.

B. The test article shall include complete car ductwork and diffusers, as well as fresh, recirculated (return), and supply-air duct subsystems with design supply-air distribution duct static pressure.

C. The subsystem shall include complete evaporator blower sections including evaporator and overhead heater coils, and return/mixed air sections including air filters, water elimination devices, and any other items in the air path through the units.

D. The test of the prototype shall confirm the following:

1. The capability of the evaporator blower section to supply the design wet and dry coil airflows.

2. Fresh airflow and return airflow.

3. Cab airflow.

4. Main air duct velocity.

5. Diffuser discharge velocity and mixing capability specified.

6. Blower total static pressure.

7. Available duct static pressure.

8. Electrical power requirements of the blower motors.

9. Blower speed. Create a blower performance curve and verify against the HVAC supplier design data.

10. The ability of the fresh air intake to preclude the entrance of moisture into the HVAC unit or carbody (worst-case rain and snow simulation at the air inlets).

11. Air baffling requirements necessary to balance the specified ratio of fresh and recirculated air.

12. Accessibility for maintenance of the air filters.

13. Absence of potential problems, such as excessive noise, pure tones, air turbulence, and blower instability.

7.2.4 Cab Requirements

A. Minimum airflow in the cab with the Operator controlled diffusers wide open shall be 400 cubic feet/minute (680 m^3/hr), with higher air velocity permitted. Volume and direction adjustment shall be included in the outlet grilles.

B. The Operator's cab diffuser(s) shall have a knob or other means to adjust the air volume which can easily be changed from fully open to fully closed.

7.2.5 Pressurization

A. The ventilation system shall produce a minimum car interior pressurization at rest of 0.06 - 0.10 inch water column (15 – 25 Pa) when all doors and cab window are closed.

B. At all operating speed some level of positive interior pressurization shall be maintained.

7.2.6 Exhaust Venting

A. Stainless steel exhaust grilles shall be provided, one at each end of the car. The grilles will allow the passive exhaust of air. The grilles shall include a device for adjusting airflow to meet the pressurization requirements. Airflow setting shall be fixed in place after the setting is determined in the climate room test.

B. The exterior grilles on the carbody shall be designed to prevent the intrusion of rain or snow under all conditions including car washing.

C. Alternate exhaust arrangements may be proposed for Approval.

7.2.7 Carbody Air Ducts

A. The sides and top of the ceiling air distribution duct shall be constructed of stainless steel or aluminum and shall be thermally and acoustically insulated to minimize heat transfer by conduction and provide maximum noise control. Condensation shall not form on the outside of the duct under any humidity levels. No insulation shall be installed inside the duct.

B. The duct system shall be designed to permit each of the two HVAC systems to provide ventilation airflow for the entire length of the car, to permit redundant cooling in the event of failure of one of the HVAC units.

C. Each duct shall maintain proper duct pressurization for its entire length, incorporating any required change in geometry to accomplish this.

D. Each cab shall have ventilation provided by the adjacent HVAC system. Curved baffles shall be used if necessary to redirect the airflow at turns. Seals shall be used to prevent air leakage from the ceiling panels and from other joints. Connections to the HVAC system shall be by means of a flexible transition duct, or alternate Approved approach.

E. Uniform air shall be provided. Each 3 foot (914.4 mm) section of diffuser down the length of the car shall receive the average airflow volume ±15%.

7.2.8 Fresh Air System

A. The fresh air intake system shall be passive, and not use motor driven blowers.

B. Fresh air intake ducts shall be provided on the side of the carbody roof, positioned for the best possible operation with bi-directional car movement. They shall be suitable placed so that supplemental shrouds or exterior ducting is not required to gain specified pressurization levels.

C. The exterior portions of the fresh air ducts shall be built of stainless steel, and shall use all stainless steel hardware. Their exterior appearance shall match adjacent areas of the carbody.

D. The air intake shall face downward to minimize rain, snow, and dirt collection, and shall have a perforated stainless steel intake screen with a multiple vee cross section, similar to the clean air system intake screen used on the SEPTA Silverliner V cars.

E. The vee section shall be parallel to car movement, and the intake screen shall be sized for a face velocity not to exceed 300 feet/minute.

F. A water exclusion baffle and a fresh air filter (easily replaceable from the interior of the car) shall be included in each air intake duct. The ducts shall prevent the carryover of liquids or snow into the air distribution system and the entrance screen shall not plug with ice or snow. Any ingested water shall drain from the duct to the outside.

G. The fresh air shall be properly mixed with recirculated air, such that there is no temperature difference in the airstream across the face of the evaporator or overhead heater.

H. Fixed baffle plates developed during the initial air balance qualification tests shall be used to adjust the volumes of fresh and recirculated air (if required). Baffle plates shall be located far enough upstream of the filters and thermostats such that the necessary uniformity of air flow through filters and air flow velocity over thermostats is achieved.

I. Alternate arrangements that eliminate all rain and car wash liquids from entering the vehicle may be proposed for Approval.

7.2.9 Air Filtration

A. The air filtration system for both fresh air and recirculated air shall be designed to use MERV 8 or better, 4 inch (101.6 mm) thick pleated media, disposable panel type filters. Filters shall be Farr/Camfil or Approved equivalent.

B. All filters must meet the requirements Underwriters Laboratories as a Class 2 product.

C. The air filtration system shall be designed such that maximum face velocity does not exceed 300 feet/minute (1.52 meters/sec) and shall have a minimum service life to the manufacturer's recommended replacement condition of 92 days.

D. Each air filter assembly shall slide without binding into a retaining frame with dimensions as recommended by the filter supplier, and be retained by a hinged latch, or other Approved means.

E. Each filter shall be adequately secured and supported to prevent air bypass.

F. Any clips used for retaining filters shall not require use of any tools for filter removal.

G. A nameplate shall be provided at each filter location which is readily visible during filter changing, which shall indicate airflow direction with an arrow and give nominal filter media dimensions in both English and metric units.

H. Access covers shall be secured by removable panel fastenings in accordance with Section 16, Materials and Workmanship. Fasteners shall be captive on all access panels.

I. Off-The-Shelf catalog size shall be proposed, subject to Approval.

J. The fresh air intake design and water/snow elimination devices and filter size, removal and replacement arrangement shall be provided. **(CDRL 07-07, Fresh Air Water/Snow Elimination and Filter Replacement)**

7.2.10 Air Diffusers

A. The passenger area of the car interior high ceiling shall have two continuous rows of double slot type air diffusers designed to provide uniform distribution of air.

B. Diffusers shall be connected to the main air distribution duct, including the low ceiling area.

C. The Contractor shall provide instructions for the proper airflow adjustment for each unit to allow for future field replacement and adjustment of a diffuser unit without the need for airflow testing.

D. All air diffusers shall be flush mounted ceiling units and shall have exposed surfaces of unpainted satin finished stainless steel or anodized aluminum.

E. Their appearance shall compliment adjacent areas of the car interior.

7.2.11 Return Air Grille

A. The recirculating air return duct shall have a return air grille applied to the car interior ceiling.

B. It shall be flush mounted, and its exterior appearance shall complement adjacent areas of the car interior.

C. The grille shall be constructed of stainless steel or anodized aluminum, with a satin finished frame, and shall be hinged on one of its sides parallel to the car side using a continuous piano-type hinge.

D. A safety catch will be provided to prevent inadvertent opening of the grille. Safety chains shall not be used.

E. All hardware shall be stainless steel.

F. The face velocity of the grille shall not exceed 300 feet/minute (1.52 meters/sec), and it shall not produce any objectionable noise in service.

G. Appropriate means shall be provided so that conditioned cab air can exit a closed cab door and combine with the normal interior return air flow.

H. The return air grill and the filter installation shall not allow any unfiltered air to enter the ceiling or reach any components.

7.2.12 Ventilation Blower

A. The ventilation blower (supply air fan) shall be a motor-centrifugal blower design, which shall direct air through each evaporator coil assembly and the overhead heater, and then into the carbody air ducts.

B. The system shall deliver the required airflow against all resistances in the ventilation system, including pressurization, and shall operate with maximum efficiency and minimum of noise.

C. Each ventilation blower system shall have two blower wheels.

D. The blower motor shall be a NEMA double shaft TEFC, motor of the highest efficiency available meeting the requirements of Section 16, Materials and Workmanship.

E. The motor shall operate on 230 volts, 60 Hertz, 3-phase AC power from the auxiliary power supply. The motor's frame shall be separately grounded to the carbody.

F. Air blower wheels shall be directly connected to the motor using a piloted connection.

1. If mounting bolts are used, the bolts shall be permanently attached, and the connection shall be designed to prevent out of round mounting.

2. Each blower wheel shall be individually two-plane dynamically balanced to a limit of 0.06 ounce-inch (0.42 millinewton-meter) in each plane.

G. The motor and blower assembly shall not exceed a vertical displacement perpendicular to the motor shaft of 0.003 inch (.076 mm) when checked at the motor frame while operating at normal speed.

H. The ventilation blower system shall not vibrate or cause objectionable noise when operating.

7.3 Heating System

7.3.1 General

A. Each car shall be electrically heated by a thermostatically controlled system using a combination of forced air overhead heat and side wall baseboard heat (see TS 7.1.1 for performance requirements).

B. Separate Operator's cab heaters, doorway threshold and protective heaters shall also be provided.

C. All heaters will operate on 230 Volt 3 phase, with the exception of the floor heat, which may operate on 600 VAC provided by the tertiary winding of the transformer,

and the threshold heaters, which operate on 120 VAC. Contractor shall verify proper functionality and safety of this approach and test the maximum voltage and frequency variations possible from the Transformer. See Section 10, Propulsion and High Voltage System, for additional details on the tertiary winding.

D. No exposed surface shall exceed a temperature of 125 degrees F (51.7 degrees C).

E. The overhead heaters shall be used for normal car heating, and to provide reheat during the operation of the air conditioning system for proper humidity control. The overhead heater shall prevent cold air from entering the cab under any heating conditions.

F. The static sidewall baseboard heaters shall provide additional heating in the passenger compartment, Operator's cab, and for layover heat.

G. Each car shall be heated by a combination of two stages of overhead electric heat and two stages of floor electric heat. Overhead heat shall be provided in passenger areas and the Operator's cab by a multi-stage electric heating element furnished as part of each HVAC unit.

1. The overhead heating elements shall be pulse width modulated (PWM) to provide the optimal heat output to maintain the supply air temperature at setpoint during the reheat cycle. Heat output shall prevent compressor from dropping out or raising/lowering the interior temperature.

2. Panel type electric baseboard floor heaters shall be provided. They shall be mounted behind stainless steel guards along both side walls, as well as in the Operator's cab. Alternate means to maintain layover heating conditions in the cab may be proposed for Approval.

3. The Operator's cab shall have two forced-air electric heaters under the Operator's control. One heater will be located on the Observer's side and one on the Operator's side. Heaters shall provide a thermostatically controlled 2 kW maximum output.

7.3.2 Overhead Heaters

A. Electric resistance type heaters shall be supplied within the overhead evaporator units to provide tempering of fresh air intake and for reheat to maintain humidity control under partial cooling operation of the air conditioning apparatus.

1. The heaters in each evaporator unit shall be arranged in two separate circuits sized to provide adequate air tempering during pre-heating, heating and reheat. Pulsed Width Modulation shall be used to provide the required heat without excessive cycling. PWM control shall allow the system to remain in reheat continuously until the relative humidity requirements are met.

2. The heaters shall provide even heat over the face of the heating unit and uniform outlet temperatures avoiding hot and cold streams of air and designed to provide the best possible operation during regular heating and reheat.

B. The heater coils shall be located downstream from the cooling and designed to minimize dust build up within the unit.

C. The heater elements shall consist of a stainless steel-finned, corrosion-resistant sheath surrounding a nickel-chromium resistance wire, embedded in a compressed and baked refractory material.

1. Silicone rubber shall be used to insulate the electrical terminals from the sheath.

2. The maximum surface temperature of the sheath shall not exceed 572 degrees F (300 degrees C).

3. Alternate heater elements with lower thermal inertia may be proposed for Approval.

D. Direct electrical connections to the heating elements shall utilize high temperature, solderless ring-lug terminals and bolted connections, utilizing tinned, flexible-stranded, copper cable with a maximum strand size of 24 AWG, and Teflon insulation with UL certification for continuous service at a minimum of 302 degrees F (150 degrees C) or greater, if required.

E. Wire terminations shall be resistant to thermal cycling and utilize insulated supports.

1. High temperature clear heat-shrink tubing shall be used to protect terminations.

F. There shall not be any exposed, uninsulated, or unprotected electrical components, wiring or terminations, except for the heating elements themselves.

G. Each overhead heater shall be hard wire interlocked with the blower contactor auxiliary contacts. The differential pressure airflow switch will serve as additional protection from heater operation without airflow.

1. A self-resetting overtemperature thermostat shall be provided. The switch will be designed to cycle indefinitely under any air flow conditions or voltage variations without tripping the second stage device. The thermostat shall not trip under normal system shutdown and shall not require airflow to prevent a trip.

2. The second stage device shall only operate after a failure of the first stage protection. The device shall open the heater circuit by shunt trip or other Approved technique that does not require replacement after a trip. Under any possible airflow conditions and voltage variations, no smoke, odor, or damage shall be detectable after tripping of the device.

7.3.3 Static Sidewall Heaters

A. Passenger compartment, Operator's cab and Layover heat shall be provided using electric strip heaters mounted behind stainless steel heater guards along the side walls at the floor and at the doorways. **(CDRL 07-08, Static Sidewall Heaters)**

1. Sidewall heaters may also be provided in Approved underseat areas of the entrance doors, car ends and locker areas as necessary to meet the requirements of this Specification.

B. The heaters shall be uniformly distributed and arranged in two stages of heat output by natural convection or other Approved arrangement.

C. The sidewall heater circuits shall be electrically arranged predominantly in parallel, so that a full stage of heat is not lost upon a single point failure. Each circuit shall be controlled by a separate control signal from the microprocessor and each HVAC unit shall control one circuit. Redundancy will be provided in the case of a failure of one HVAC unit.

D. A Ground Fault Detection System shall be provided to remove power to the heaters in the event of a fault. Each circuit shall be separately protected.

E. The heater housing shall also be used for attachment of the passenger seating, per Section 3, Carbody.

F. The sidewall heating elements shall be high grade nickel-chromium resistance wire and sealed within a high-heat transfer corrosion resistant sheath.

G. The heater elements shall be mounted utilizing ceramic or Teflon insulators to the carbody with suitable provisions to allow for thermal expansion and contraction of the heater strip as well as provide full electrical insulation between the heating element sheath and the carbody.

1. Heating element terminals shall consist of minimum 0.25 inch (6.35 mm) diameter ring connectors, covered with insulated guards or boots to prevent objects, such as a screwdriver or wire, inserted through the heater guard holes from contacting electrically live portions.

2. High temperature clear heat-shrink tubing and silicone boots shall be used to further protect high voltage terminations.

H. The heater elements shall be enclosed in a stainless steel heater guard, which shall be recessed into the side wall to minimize its intrusion into the floor area.

1. The heater guard shall extend from the sidewall no more than 4 inches (101 mm).

2. The heater guard front panel shall be constructed so that sections are removable for replacement of heating strips, without dismantling seats.

3. The heater guard shall be secured in place with stainless steel fasteners with tamperproof heads.

4. The top of the heater guard shall be sloped with a minimum 3 degree angle to prevent collection of dirt and debris, and shall overhang the vertical face with a smoothly rounded surface by at least 0.25 inch (6.35 mm).

5. The heater guard shall be baffled to prevent spilled liquids from contacting the electric heating elements, and the lower section of the heater guard shall be constructed to prevent accumulation of dirt. The design shall be impervious (fault free) when exposed to cleaning fluids and water.

6. Air shall enter the heater guard through holes in the bottom, pass over the strip heaters, rise by convection, and be discharged through holes near the top of the vertical face and through a stainless steel grille located at the bottom of the window masks. Grille conceptual design, including hole size and passenger protection from live terminals shall be subject to Approval.

7. Particular attention shall be given for thermal insulation behind the heaters to minimize heat loss through the sidewall.

7.3.4 Heat Control

A. Each of the two stages of output of the overhead heaters shall be supplied through a circuit breaker and controlled by separate heat contactors.

1. Control of all heaters shall be by heavy duty contactors designed to produce minimum electrical power consumption.

B. While in reheat mode, the overhead heat shall be pulsed to prevent compressors from shutting off while not increasing the interior temperature above the setpoint. The heat output shall utilize the supply air sensor to maintain interior temperature.

C. While in the heating mode, the overhead heat shall be controlled to maintain the duct discharge temperature from setpoint up to a maximum 10 degrees F (5.6 degrees C) above setpoint.

7.3.5 Cab Heating

A. Each cab shall have one independent forced air cab heating unit on each side of the cab under the control of the Operator. Both cab heaters shall be operated independently, based on switches mentioned below. Cab heaters shall only be enabled in an occupied cab (cab active or conductor’s control panel active).

B. The cab heater shall be specifically designed to provide proper heating to the lower legs and feet of an Operator. The heater shall be manually adjustable to direct air to the side windows of the cab to aid in demisting.

C. The heater system shall operate as quietly as possible. It shall be powered from the auxiliary power system and have its own circuit breaker.

D. Cab heaters shall be fitted with a user control. Ventilation shall be provided at the lowest position and maximum heat shall be provided at the highest position. The dial shall have a color coded label that indicates warmer and cooler direction of rotation. An OFF position shall remove power from the heater and blower motor. Alternate control proposals may be submitted for Approval.

E. The heater guard shall be baffled to prevent spilled liquids from contacting the electric heating elements, and the lower section of the heater guard shall be constructed to prevent accumulation of dirt. The design shall be impervious (fault free) when exposed to cleaning fluids and water.

F. Heat output at maximum shall be 2 kW per unit.

G. The heater shall be constructed of heat resistant material and contain stainless steel heater elements. The design shall be impervious to rain, dust, and wind.

H. A heavy duty 3-speed induction motor-blower shall distribute heat through screened outlets. Airflow per cab heater shall be no less than 150 CFM (255 m^3/hr) at the maximum speed. A rotary switch for the motor speeds shall be provided adjacent to the thermostatic control. The motor shall meet the requirements of Section 16, Materials and Workmanship.

I. The heater circuitry shall be interlocked to prevent heating elements from energizing when the fan is not operable.

J. All cab heater components shall be installed to provide ease of access for maintenance.

K. The motor-blower assembly shall be easily removable with the heater unit installed in the cab.

L. The cab heater design shall be submitted. **(CDRL 07-09, Cab Heater Design)**

7.3.6 Heated Windshield

A. Electrically heated windshields shall be provided on both sides of cab. Section 5, Operator's Cab, includes additional windshield requirements.

1. The windshield heaters shall be controlled by the adjacent cab console, pushbutton switch, and an amber LED to indicate the energized state.

2. Energizing the heated windshields shall turn on the unoccupied cab windshields at the end of the consist. The windshield heaters shall be designed to regulate power and surface temperature to remain activated continuously.

3. Windshield over-temperature protection shall be provided.

4. Windshield heater thermostats must be placed in the most convenient location for maintenance, operation, and Operator field of view.

7.3.7 Threshold Heaters

A. The door panel door thresholds for each exterior side doorway, including the low level boarding doors, shall be equipped with a protective heating system designed to prevent freezing in the threshold area, whenever the exterior ambient air temperature is below 40 degrees F (4.4 degrees C).

1. The system shall consist of 120 Volt AC self-regulating heating cable mounted in the area of the door guideways in the threshold plate.

2. The heating cable shall be secured by metallic clips; adhesive tapes shall not be used.

3. All cable and electrical terminations shall be environmentally sealed to withstand exposure to cleaning chemicals, deicing salts, brine, etc., present in the door area.

4. The system shall operate whenever a cab control key is used to activate the train, and a control signal from the HVAC control system indicates that the ambient temperature is below 40 degrees F (4.4 degrees C).

   a. It shall also operate whenever the layover heating system is in operation.

5. Access shall be provided to all electrical terminations for maintenance.

6. The design of threshold heaters shall be submitted. **(CDRL 07-10, Threshold Heater Design)**

7.3.8 Protective Heaters

A. Protective heating elements using Approved power sources and control methodology shall be provided at the air compressor automatic drain valves, the coupler, and as required for the proper operation of other vehicle systems as recommended by the equipment supplier.

1. An ambient air temperature sensor shall be mounted under the car in a location shielded from direct sunlight. This sensor shall power all protective heat and threshold heaters. Sensor shall be located such that heat generating equipment shall not impact the ambient measurement.

2. Heaters shall be provided in a manner which facilitates maintenance, shall be protected from accumulations of moisture and salt, and shall use environmentally sealed electrical connections.

3. Protective heaters shall be sufficiently isolated from other systems so that failure of any protective heater shall not cause shutdown of any other devices, including other protective heaters.

7.4 Air Conditioning System

7.4.1 General

A. Redundancy

1. Each HVAC unit shall include dual refrigerant circuits. The arrangement shall allow cooling to be provided after a failure of a compressor or a refrigerant leak.

B. The air conditioning system shall be able to start and operate without damage under all exterior ambient temperatures, as required to meet comfort requirements. A minimum ambient temperature cooling lockout shall be provided to prevent equipment damage outside the required ambient range, if required to prevent damage.

C. Resilient mounts shall be used to prevent noise and vibration being transmitted to the carbody.

D. Each compressor shall be hard wire interlocked with the blower contactor auxiliary contacts to prevent compressor operation when airflow is not present.

E. The air conditioning system shall be protected by a high pressure transducer and a backup high pressure switch. The transducer shall shut the compressor down when the condenser air is raised beyond 140 degrees F (60 degrees C).

1. The system shall include a minimum 3 minute delay between start attempts. If less than 5 trips occur in a 30 minute period, the trip counter will be reset to zero.

2. If more than 5 trips occur during a 30 minute period, the system shall lock out and require an easily accomplished reset without the need for the PTU.

7.4.2 Evaporator Coils

A. Evaporator coils shall be copper tube copper fin or aluminum fins with an Approved corrosion resistant coating. Any proposal shall detail the materials proposed, pre-cleaning and application method, along with the details of the fins proposed.

B. The evaporator coils shall perform cooling and dehumidification of the fresh and recirculated air handled by the system.

1. The fins shall have a nominal fin thickness of 0.0065 inch to 0.008 inch (0.165 mm to 0.203 mm), and a minimum fin spacing of 0.14 inch (3.6 mm). The tubes shall be rifled. The coil assembly shall be housed in a rigid stainless steel frame.

2. The tube support interface with the tube sheet shall be as recommended by the coil supplier for high vibration applications.

3. The tube expansion collars within the fins shall be firmly secured to the tubes and shall be free of metal edge splits.

C. The spot velocity at any location shall be within 10 percent of the average face velocity.

D. Condensate shall not spill from the drain pan under any condition of car operation, acceleration, deceleration, track condition or track geometry. No condensation shall form on any surface that does not drain into the pan. No outside surface shall condense under any environmental condition listed in Section 2, Design and Performance Criteria.

E. Each evaporator coil shall be proof pressure tested to a minimum of 600 psig (41.4 bar), which shall be performed prior to the application of solenoid and expansion valves. If coil pressure testing shows a consistent leak-free result, a sampling rate may be proposed by the Contractor for Approval.

F. The design of the evaporator unit shall incorporate a space of not less than 2.75 inches (69.8 mm) between the coil and heater fins to clean the coil by back-blowing or washing.

7.4.3 Condensate Drain Pan

A. A condensate drain pan shall be provided beneath the evaporator coil, the thermal expansion valves and the coil return elbows to collect condensation from the coil and suction line.

B. The condensate pan shall be made of stainless steel with stainless steel fittings.

1. It shall be suitably baffled, arranged and sloped for gravity drainage in a manner which prevents water from spilling over into the ceiling area under any operating conditions including maximum acceleration or deceleration and the maximum grade and superelevation listed in Section 2, Design and Performance Criteria.

C. Carbody condensate drain lines installed in the side walls shall be of copper or stainless steel tubing, sloped to provide positive drainage to the underside of the car outboard of the running rails clear of any underfloor equipment.

1. The amount of bends in the piping shall be minimized, and radii shall be as large as practical.

2. An elastomer flapper valve "Kazoo" shall be attached to each drain line termination under the car to prevent backflow.

3. The exit of the condensate drain lines under the car shall be arranged in a manner to be readily accessible for maintenance.

4. Drain systems shall be readily accessible for cleaning without removing components.

D. The condensate drain lines shall be thermally insulated with closed cell foam pipe insulation to prevent condensation.

E. All cold surfaces, including the coil housing and condensate pan, shall be insulated to prevent sweating due to condensation, with sheets of a closed cell foam insulation material bonded to the surfaces with a waterproof, fire-resistant cement.

F. All pipe wrap and drain pan insulation shall meet the flammability and smoke emission requirements described in Section 16, Materials and Workmanship.

7.4.4 Additional Major Components

A. Each evaporator unit shall include:

1. The overhead heater electrical connections,

2. Two liquid line solenoid valves,

3. Two nonadjustable thermal expansion valves with external equalizers,

4. Two liquid line sight glass/moisture indicators.

5. Two filter/driers.

B. Complete maintenance access by means of low ceiling access covers shall be provided.

1. Component selection and installation shall provide a semi-hermetic system by eliminating cutout valves and threaded fittings as much as possible.

2. Schrader-type valve test fittings with chained, metallic caps shall be provided in the liquid line and suction line. Evacuation and charging shall utilize the fittings.

3. All tubing shall be purged with dry nitrogen during brazing. Vacuum shall be 150 microns or less prior to charging.

4. The test units shall also have special testing oil sight glasses for unit qualification testing and climate room testing.

7.4.5 Refrigerant Compressors

A. Two scroll compressors shall be supplied for each unit:

1. They shall be of the highest efficiency available, lightweight, supplied from an Approved U.S. manufacturer, and have previous successful North American rail application experience.

2. The compressors shall be operated on 230 volts, 60 Hertz 3-phase AC power from the auxiliary power supply inverter. Voltage variation performance shall be proven in the climate room.

3. The compressors shall not be impacted by number of starts and start attempts shall not be limited. Oil return shall be verified to not require a minimum run time.

4. The application of the compressor shall take into account that auxiliary power interruptions of up to 150 times per hour may frequently occur, and that pump down may not be performed prior to every power interruption, and this shall not have any negative effect on the operation or life of the compressor.

5. Controls shall be arranged to equalize operating time on both compressors within a unit. Compressors shall not equalize except after periods of time when both are OFF.

6. Crankcase heaters shall not be used unless recommended by compressor manufacturer for the application. If proposed, all aspects of the heater shall be detailed, including power interruptions and power usage. At no time shall a crankcase heater prevent operation of the system.

7. The motor shall be equipped with internal overtemperature protection.

8. Check valves and liquid line solenoid valves shall be provided to prevent the liquid refrigerant from entering the compressor. Pump down shall be utilized. Bump starts shall be incorporated if suggested by Contractor and compressor supplier.

9. The compressor shall be dynamically balanced and installed using resilient mounts and safety straps and be electrically grounded*.*

7.4.6 Refrigerant Type

A. HVAC units shall utilize an Approved refrigerant that complies with the United States Environmental Protection Agency (USEPA).

B. The refrigerant shall also be listed in the USEPA Significant New Alternatives Policy (SNAP) Program as a substitute acceptable for HCFC-22 (class II ODS) in MVACs for buses and Passenger Trains.

C. The refrigerant shall be assigned an ASHRAE number, and its safety group (flammability and toxicity) shall be classified as "A1" as defined in ANSI/ASHRAE Standard 34, "Designation and Safety Classification of Refrigerants".

7.4.7 Condenser Coils

A. The condenser coils shall consist of fabricated copper tubing, using high thermal efficiency copper fins. The Contractor may propose alternative arrangements for Approval. Any proposal shall detail the materials proposed, pre-cleaning and application method, along with the details of the fins proposed.

1. The proposed coating shall pass a 2,000 hour salt spray test per ASTM B117.

2. The fins shall have a nominal fin thickness of 0.0065 inch to .008 inch (0.165 mm to 0.203 mm), and a minimum fin spacing of 0.14 inch (3.6 mm). The tubes shall be rifled. The coil assembly shall be housed in a rigid stainless steel frame.

B. The coil assembly shall be housed in a rigid stainless steel.

C. The coils shall be interlaced to allow each refrigerant circuit to utilize the full condenser area when high ambient, single compressor operation is required.

D. The tube support interface with the tube sheet shall be as recommended by the coil supplier for high vibration and thermal stress applications.

E. Each condenser coil shall be proof tested by the manufacturer at 1.5 times the maximum operating pressure or 600 psig (41.4 bar), whichever is greater. If coil pressure testing shows a consistent leak-free result, a sampling rate may be proposed by the Contractor for Approval.

F. The condenser coils shall be protected against damage by a hinged stainless steel mesh screen. The Contractor may propose alternate arrangements to prevent fin damage for Approval.

G. The condenser coil housing shall be arranged to allow full access to the total face area of both sides to facilitate the cleaning of the coil.

H. Condenser impeller fan(s) shall be provided, complete with corrosion resistant shrouding and screening.

I. The assembly shall have sufficient capacity to provide a maximum condensing temperature no greater than 28 degrees F (15.5 degrees C) above the ambient air temperature at rated load.

1. The condenser coil assembly shall be designed to be approximately 5 percent oversize to counter the long-term drop in efficiency from dirt accumulation on the coil.

J. A separate subcooling circuit shall be incorporated into the condenser design.

1. A minimum 10 degrees F (5.6 degrees C) subcooling of the refrigerant shall be provided at rated load and design conditions.

7.4.8 Condenser Fans

A. One or more 2 speed condenser fan motors shall be used, operating from the 230 volts, 60 Hertz, 3-phase AC power from the auxiliary power supply.

1. The fan(s) shall run based on discharge pressure and be in low speed under low load conditions. Controls shall be arranged to equalize operating time on all condenser fans within a unit, if applicable.

2. The fan motor shall be a readily available commercial of the shelf NEMA TEFC induction motor of the highest efficiency available.

3. The motor shaft shall be corrosion resistant, and a weathertight shaft seal shall be used. If the motor shaft is vertical, a slinger shall be used to prevent moisture entry into the motor. The shaft mountings and all hardware shall be stainless steel.

4. Ingress protection rating shall be IP56 or better.

5. The motor frame shall be separately grounded to the carbody.

B. Each multiple blade impeller fan shall be constructed of UV stabilized, long life, high density polypropylene which is die cast to a true airfoil shape or other corrosion resistant style.

C. The design shall prevent the condenser fan exhaust from being recycled through the condenser.

7.4.9 Control Box

A. The control box shall be located within the HVAC. Interior accessibility requirements shall be met and all service and troubleshooting shall be performed from the interior of the car. The conceptual design detailing accessibility shall be submitted. **(CDRL 07-11, Control Box Electrical Component Arrangement and Accessibility)**

1. The control box shall contain various devices for the control and servicing of the unit:

a. A gasketed hinged cover with support shall be included. The IP rating of the box shall be IP64.

b. Electrical components including contactors and circuit breakers shall be located in the control box.

c. Service valves shall be arranged to isolate the Schrader-type suction and discharge access ports which shall be provided with retained caps.

d. High pressure transducers shall be provided to control high pressure cutout, modulation for high ambient conditions, and cycling of the condenser fans (if applicable).

e. Low and high pressure switches and transducers shall be provided in the control box.

(1) The pressure switches shall be of non-adjustable design and have the contacts protected from dust and moisture.

(2) Pressure switch setpoints shall be an adjustable parameter.

(3) The switches and transducers shall be fitted with Schrader valves to allow replacement with a minimum loss of refrigerant.

7.5 Valves and Piping Components

A. Refrigerant piping shall be in accordance with ASTM B280 or Approved alternate. Piping which shall also meet the requirements of Section 16, Materials and Workmanship. The following items shall be provided for each refrigeration circuit.

1. Vibration eliminators shall be used where any piping is connected to the compressor or to a resiliently mounted assembly and shall be installed in accordance with the manufacturer's criteria.

2. All piping shall be adequately supported to prevent vibration, chafing, fatigue or stress.

3. The compressor discharge line shall have a check valve.

4. All refrigeration system service valve and Schrader valve caps shall be metal and shall be safety-chained to the valve to retain them when the caps are removed.

5. A fusible plug shall be provided to safely evacuate system in case of fire.

6. A liquid line sight glass/moisture indicator shall be provided with a captive, protective snap-on plastic cover.

7. A brazed filter drier shall be provided.

8. A hot gas bypass valve shall be provided. An energy efficient arrangement of the valve shall be proposed for Approval. Bypass operation to fine tune supply air temperature is not preferred.

9. Solenoid valves shall be provided for the liquid line.

10. High and low pressure lines shall be equipped with pressure transducers and pressure switches. Data sheets shall be provided for Approval.

7.6 Insulation

A. All portions of the air conditioning system which may at any time be reduced in temperature to the ambient air dew point, such as the condensate drain pan,

refrigerant suction lines and all concealed condensate piping, shall be insulated with a fire-retardant closed cell foam insulation, installed with a fire retardant, water resistant adhesive.

1. All insulation corners shall be mitered and sealed.

2. Insulation shall have sufficient thickness to keep the outer insulation skin temperature above the dew point at all times.

3. The insulation system must meet the smoke and flammability requirements of Section 16, Materials and Workmanship.

7.7 Fire Detection System

A. An ionization type smoke detector sensor shall be provided in the mixed air compartment of each HVAC unit. Photo-electric smoke detector may be proposed for Approval.

1. It shall be designed to resist sensitivity changes due to dust collection and shall not require cleaning.

2. Upon detection of the products of combustion in a car which has been activated for operation, it shall shut down the HVAC system, close the fresh air dampers and be announced on the TOD.

3. Methods shall be provided to easily test the smoke detector on a periodic basis.

4. The smoke detector shall be accessible from the return air grille.

7.8 Test Functions

A. The following indicators and controls shall be provided at each control panel:

1. Return air temperature for HVAC system.

2. Fresh air temperature for HVAC system.

3. Power ON and fault indicators for HVAC system.

4. A series of indicators showing the status and fault conditions of the various parts of the HVAC system.

5. Fault reset pushbutton for HVAC system.

6. The Contractor may propose alternative arrangements for Approval.

7.9 Portable Test Units

A. Portable test units shall be provided as required by Section 27, Special Tools and Test Equipment, for use by maintenance personnel to check the correct operation of all control system components and to isolate control problems in the temperature control system unit and ground fault detection units, for HVAC systems on the car.

1. The PTU's shall be designed to allow simulation of sensor readings to perform a complete functional test of the HVAC system.

2. The PTU shall also have diagnostic capabilities to isolate faults to the LRU level. Diagnostic information shall be transmitted to the VMDS.

3. PTU Screens and Functionality shall be submitted. **(CDRL 07-12, PTU Functionality and Screens)**

7.10 Maintenance Requirements

A. Air filters shall not require maintenance more often than once every 92 days.

B. The HVAC equipment shall not require maintenance more often than every 184 days. The motor bearings shall have a minimum life of 8 years.

C. All ceiling-mounted equipment accessed through access panels shall be fitted with captive fasteners, hinges, and safety catches. Safety chains shall not be used.

D. Any component requiring periodic servicing shall be maintainable from inside the car.

E. Special emphasis shall be given to the condenser coils to prevent dirt fouling and to aid in cleaning. The system shall be designed to allow full access for condenser back washing.

F. Rotating equipment shall be guarded for personal safety and shall comply with OSHA requirements.

G. It shall be possible to initiate a self-test using the VMDS or PTU. Failures down to the LRU level shall be communicated to the VMDS.

H. Maintenance shall be in accordance with Section 21, Reliability, Availability and Maintainability.

7.11 Contract Deliverable Requirements List (CDRL)

The following contract deliverables have been identified in this section; however, the Contractor is responsible for providing and submitting anything necessary to fulfill the requirements of this contract, including those not identified by CDRL number.

CDRL 07-01, HVAC Load Calculations..... 7-1
CDRL 07-02, Major Component Details 7-5

CDRL 07-03, HVAC Unit Mounting Arrangement 7-5
CDRL 07-04, Microprocessor Control 7-6
CDRL 07-05, Fresh Air Damper Control/Adjustment and Fresh Air Supply 7-9
CDRL 07-06, Computational Fluid Dynamics (CFD) Model and Analysis 7-9
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CDRL 07-08, Static Sidewall Heaters 7-17
CDRL 07-09, Cab Heater Design 7-19
CDRL 07-10, Threshold Heater Design 7-20
CDRL 07-11, Control Box Electrical Component Arrangement and Accessibility 7-26
CDRL 07-12, PTU Functionality and Screens 7-29

7.12 CDRL Details

This section lists the expected content for each CDRL required above. The lists provided for each CDRL are an outline only and should not be considered exhaustive, all CDRLs are subject to SEPTA review and approval.

CDRL 07-01 HVAC Load Calculations

1. Cooling and heating load calculations in accordance with the Design Conditions section of the specification shall be provided during all Design Reviews.

    a. Capacity requirement calculations of the HVAC system shall include all operating modes and shall include worst case passenger loading, solar loading on the carbody, maximum fresh air volumes and worst case ambient temperatures with corresponding humidity.

CDRL 07-02 Major Component Details

1. The Contractor shall provide data sheets during all Design Reviews on all major components, including motors, compressors, blowers, operating conditions, fan curves and compressor manufacturers safety and operating guidelines. The use of bump-start, pump-down and crankcase heaters (if applicable) shall be as recommended by compressor manufacturer.

CDRL 07-03 HVAC Unit Mounting Arrangement

1. HVAC Unit Installation conceptual details including sealing of supply and return air openings, clearance dimensions, drain line approach, location of units on roof and removal/replacement steps shall be provided during all Design Reviews.

    a. Proposed location of the units on the roof shall be conveyed.

    b. Proposed materials proposed for the HVAC unit shall be justified. Walkway areas shall be defined.

    c. Connector type and location, as well as unit grounding shall be detailed.

CDRL 07-04 Microprocessor Control

1. Microprocessor design details, including inputs and output signals to the microprocessor, transient protection, diagnostic capabilities, recording capabilities, the proposed fault list and the VMDS communication arrangement shall be provided during Preliminary and Final Design Reviews.

CDRL 07-05 Fresh Air Damper Control/Adjustment and Fresh Air Supply

1. Fresh air volume under all operating modes shall be provided during all Design Reviews. Damper type and spring close details, damper motor details. Damper design, including vane type and material used. Damper positions and verification methods.

CDRL 07-06 Computational Fluid Dynamics (CFD) model and analysis

1. CFD to be submitted during Preliminary and Final Design Reviews detailing conformance to the speciation requirements including airflow uniformity down the length of the car and temperature variation limits. Contractor to detail previous experience with CFD modelling and analysis.

CDRL 07-07 Fresh Air Water/Snow Elimination and Filter Replacement

1. Fresh air intake design including water elimination devices, filter size, replacement interval and maintenance steps for removal and replacement from inside the vehicle shall be provided during all Design Reviews.

    a. Contractor to detail the approach to car wash operation and provide details of the water test arrangement proposed.

CDRL 07-08 Static Sidewall Heaters

1. Sidewall heater design shall be provided during all Design Reviews, including heater guard arrangement, watt density, element details, ground fault detection and temperature limit results of a stand-alone temperature test. Contractor to detail the circuit arrangement that provides parallel connections that limit heat loss upon failures. Layover mode Operation and Performance.

CDRL 07-09 Cab Heater Design

1. Cab heater design shall be provided during all Design Reviews, including air diffuser outlets, installation location, heating elements, controls, and airflow volume. Contractor shall convey a design that includes manual adjustment of airflow and demisting of side windows.

CDRL 07-10 Threshold Heater Design

1. The threshold heater design details that ensure specification compliance shall be provided during all Design Reviews, including installation details, heater wattage,

overtemperature protection and electrical controls. Contractor shall detail the steps taken to prevent snow buildup in the areas around the door panels.

CDRL 07-11 Control Box Electrical Component Arrangement and Accessibility

1. Layout of components and ease of removal/replacement shall be provided during Preliminary and Final Design Reviews. Data sheets of all proposed devices shall be provided. Corrosion protection shall be detailed.

CDRL 07-12 PTU Functionality and Screens

1. PTU screen shots and overall arrangement details to be provided during Preliminary and Final Design Reviews. A list of Faults shall be provided. Hot Car and Cold Car faults shall be included. Fault data shall include diagnostic details that indicate failures down to the LRU level. Interface details to the VMDS shall be provided.

7.13 Referenced Standards

EPA SNAP	Environmental Protection Agency's (EPA) Significant New Alternatives Policy
ASHRAE Guideline 23	Guideline for the Design and Application of Heating, Ventilation, and Air-Conditioning Equipment for Rail Passenger Vehicles
ANSI/ASHRAE Standard 34	Designation and Safety Classification of Refrigerants
ASHRAE Standard 37	Methods of Testing for Rating Unitary Air Conditioning and Heat Pumps
ASHRAE Handbook	Fundamentals
ASTM B117	Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B280	Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service

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LIGHTING

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8.1 Lighting General

8.1.1 General

A. Comply with the following:

1. All light fixtures shall use LED lighting operated from the low voltage power supply. Light intensity shall remain constant when operating anywhere within the entire low voltage power supply limits. See Section 9, Auxiliary Power for additional information.

2. Emergency lighting is considered an essential load and shall not be load shed. See Section 9, Auxiliary Power for additional information.

3. The general interior lighting arrangement shall be coordinated with the ceiling arrangement and shall be submitted for Preliminary Design Review. **(CDRL 08-01, Lighting Interior General Arrangement)**

4. The doorway areas shall have lighting fixtures arranged to provide sufficient light on all boarding steps and on station platforms when the side doors are opened.

5. Cab lights shall be provided in each cab for reading use by the Operator.

6. Lighting in all locations shall be arranged to minimize shadows, avoid glare and excessive brightness ratios.

7. Fixtures shall be arranged to allow for easy cleaning and replacement of lights and drivers.

8. There shall be no LED hotspots visible within the car interior. Lenses shall evenly distribute light.

9. Each lowest replaceable unit (LRU) shall be maintainable by a single maintainer.

10. Each lowest replaceable unit (LRU) shall be replaceable in less than 30 minutes.

11. The number of different fixture types used on the car shall be kept to a minimum.

12. Unless otherwise specified, interior lighting shall be based on the requirements and guidelines of:

    a. Illuminating Engineering Society of North America (IESNA), LM-79-08 Electrical and Photometric Measurements of Solid-State Lighting Products

b. 49 CFR 238.115

c. APTA standard PR-E-RP-012-99 Normal Lighting System Design for Passenger Cars

d. APTA standard PR-E-S-013-99 Emergency Lighting System Design for Passenger Cars, and

e. APTA PR-PS-S-006-23 Emergency Egress/Access Signage and Low-Location Exit Path Markings for Passenger Rail Equipment identified for a commuter coach.

13. All lighting components shall comply with EN 50121 Railway Applications – Electromagnetic Compatibility and EN 50155 Railway Applications – Electronic Equipment Used on Rolling Stock, including all referenced supplemental standards.

14. Fixtures installed in the interior within 3 feet of a doorway that can be exposed to weather when the door is open, shall be watertight to IP55 or higher according to IEC 60529, Degrees of protection provided by enclosures (IP Code).

15. All lighting system consumables shall be readily available in the U.S. either from the OEM or multiple sources of supply.

8.1.2 LED Luminaires and Driver

A. All lighting components shall have prior experience in North American transit, commuter rail or intercity passenger rail application.

B. LEDs shall comply with the Illuminating Engineering Society of North America (IESNA) standard LM-79-08, Electrical and Photometric Measurements of Solid-State Lighting Products.

C. The lighting color for all white interior luminaires throughout the car shall have a Correlated Color Temperature (CCT) range of 4000°K to 4500°K. Lighting color shall be included in the mockup reviews as described in Section 25, Program Management and Commissioning, and Approved. LEDs shall be from a single CCT/Color bin.

D. LEDs shall have a color rendering index (CRI) of at least 80, with the same color consistency and color stability.

E. An LED driver designed to ensure proper operation of the LEDs shall comply with IEEE 1789, Recommended Practices for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to Viewers.

F. The LED driver shall be mounted on the LED assembly.

G. LED driver shall have an end-of-life function to indicate a warning level when upcoming replacement is required. **(CDRL 08-02, LED Driver End of Life Function Description)**

H. LED assemblies shall be removable without special hardware.

I. LED assemblies shall be connected via interlocking, self-polarizing and modular connectors accessible when the light fixture is opened. Connectors shall be white in color to blend in with the reflector housing.

J. Using common LED and drivers is preferred whenever possible. The number of different boards shall be minimized.

K. LED assembly shall have lumen maintenance of 70 percent (L70) for 120,000 hours.

L. All minimum lighting levels per Section 8.1.3 Intensity, shall be maintained at the end of the 120,000-hour period.

M. LED luminaires shall be provided with sufficient heat sinks capable of keeping LED junctions and associated electronics below 125°F, regardless of summer ambient temperature and continuous operation.

8.1.3 Intensity

8.1.3.1 Passenger Interior and Exterior Intensity

A. All light intensities shall be met using the LED L70 end-of-life light output.

B. Interior light intensity levels for Normal Lighting Mode shall comply with APTA PR-RP-012-99, Normal Lighting System Design for Passenger Cars, unless otherwise specified in this section.

C. The lighting system shall provide a minimum of 5 foot-candles of illumination on both high level and low level station platform surfaces when the side door is opened, for a distance of 3 feet from each step landing at low level doors, and at door threshold at high level doors. This level is greater than the minimum requirements of APTA PR-E-RP-012-99, Normal Lighting System Design for Passenger Cars.

D. Outside the A-end door, in the diaphragm area, the lighting levels at floor level shall reach 5 foot-candles to allow safe passage between cars.

E. Lighting intensity under emergency lighting conditions shall also comply with the requirements of 49 CFR Part 238.115 and APTA PR-E-S-013-99, Emergency Lighting System Design for Passenger Cars.

F. The emergency lighting system shall provide a minimum of 2 foot-candles of illumination at floor level for all potential evacuation routes, greater than the

minimum requirements of APTA PR-E-S-013-99, Emergency Lighting System Design for Passenger Cars.

G. Special attention shall be given to the avoidance of passenger interior stray light entering into the cab area during night operations.

H. See TS 8.2 for additional information for exterior light intensity requirements.

I. See TS 8.4.2 for additional information for HPPL material input charging light requirements.

8.1.3.2 Cab Interior Intensity

A. The cab area white reading light, when in use by the Operator, shall produce a minimum of 25 foot-candles at an elevation of 2 feet, 9 inches above the floor in the Operator's work area, or on the cab console desk.

B. The cab area red nighttime light, when in use by the Operator, shall produce a minimum of 2-foot candles at an elevation of 2 feet, 9 inches above the floor in the Operator's work area, or on the cab console desk.

C. All backlighting for cab switches and controls shall provide sufficient lighting to illuminate controls without the use of the ceiling lights. See Section 5, Operator’s Cab for additional details.

D. Attention shall be given to the elimination of glare into the cab during night operation, which shall be tested in the cab mock-up. See Section 25, Program Management and Commissioning for additional mockup details.

8.1.3.3 Layover Interior Light Intensity

A. When the car is in layover mode as defined in TS 8.5, the interior light intensity shall be reduced for energy savings.

B. Layover light intensity shall be adjustable by parameter files as specified in the software subsystem adjustability requirements of Section 19, Software Engineering.

C. Minimum average light intensity shall be 5 foot-candles measured at the floor for all emergency exit path locations.

D. Maximum average light intensity shall be 10 foot-candles measured at the floor for all emergency exit path locations.

8.1.4 Interior Ceiling Light Fixture Housings

A. The interior ceiling lighting fixtures shall be arranged as follows:

1. The interior lighting fixtures shall be mounted in two continuous rows, one on each side of the aisle, each row approximately centered over the seats.

2. The fixtures may be integrated with the air diffusers.

3. The fixtures shall be arranged so that the centerline of the light projects below the centerline of the ceiling and edge of the lens, so that the car ceiling and upper side walls are evenly illuminated.

4. Fixtures shall be resistant to entry of dust, moisture, and insects.

5. Fixtures shall be free of rattles and other noises under all conditions.

6. Fixtures shall be designed to permit easy cleaning and replacement of LED and driver.

B. All interior ceiling lighting fixtures shall be arranged for maintenance from below, by means of a hinged door which shall contain the lens.

1. Each lighting fixture and its door shall be sufficiently rugged to maintain their alignments and resist distortion during the life of the car.

2. The door frame shall be a full perimeter frame with replaceable lens, using welded or screw/rivet joined corner joints, and have a length matching that of the light used.

3. Alignment pins, where required, shall be used between adjacent fixtures.

4. A concealed hinge or links shall be on the long side of the fixture.

5. The door shall be removable when desired and be held closed on the side opposite the hinge by a spring latch and Approved panel fasteners.

6. The frame shall be constructed of anodized aluminum with a glass-beaded satin finish. Any surfaces visible from the passenger interior shall be reviewed and coordinated with the passenger interior. See Section 14, Interior and Exterior Appointments.

7. Exposed portions of reflectors shall be finished in gloss white.

8. Connectors and wiring within the reflector area shall also be white in color to avoid contrasting shadows behind the light lenses.

9. Fasteners exposed to the passenger interior shall be tamper-proof. See Section 14, Interior and Exterior Appointments for additional information.

C. Lenses shall be a one-piece ultraviolet-stabilized polycarbonate lens.

1. Lenses shall be uniform in color, smooth on the exposed side, and provide the specified intensity of illumination on the reading plane while diffusing the light to illuminate adjacent wall and ceiling surfaces, increasing the overall brightness level in the interior of the car.

2. There shall be no LED hotspots visible within the car interior. Lenses shall evenly distribute light.

8.1.5 Cab Area Lighting

A. Cab lighting arrangement shall be submitted for Conceptual Design Review. **(CDRL 08-03, Cab Lighting Arrangement)**

B. Each cab area shall have the following lights to comply with the requirements of 49 CFR 229.127 and 49 CFR 238.115:

1. One red ceiling nighttime light shall be used for illumination of cab controls during periods of darkness. The red ceiling light shall be recessed.

2. One white ceiling light shall provide sufficient illumination for the reading of printed material on the cab desk according to TS 8.1.3. The white ceiling light shall be a recessed, focused, gimbal-type reading light.

3. The “Left Cab Area”, including the aisleway leading to the carbody end door, shall be illuminated by ceiling lighting separate from cab desk and reading lights.

   a. The “Left Cab Area” lighting shall be included in the emergency lighting circuit.

   b. The “Left Cab Area” lighting shall be interlocked with cab activation so that when the cab is activated, the left cab area lighting is turned off. When the cab is not activated, the left cab area lighting shall be on. See Section 5, Operator’s Cab for additional information.

   c. There shall be a momentary switch that will override the “Left Cab Area” lights on/off. This switch shall only function when the local cab is activated.

4. There shall be backlighting provided to illuminate all cab switches and controls without the use of the ceiling lights.

   a. All backlighting shall be controlled by a single dimming switch.

   b. Backlighting shall be a red-orange color to be proposed at CDR and demonstrated on the cab mockup for further evaluation. See Section 25, Program Management and Commissioning for additional mockup details.

5. Cab area emergency lighting shall be provided to illuminate the aisleway according to:

    a. 49 CFR 238.115 and

    b. APTA standard PR-E-S-013-99, Emergency Lighting System Design for Passenger Cars, Section 3.5.3.11 Crew area of MU/cab car.

6. There shall be no lights that reflect onto the windshield or interfere with outside observation during night operation.

8.1.6 Interior Equipment Locker Lighting

A. Light fixtures shall be provided for all potential maintenance activities in equipment lockers or cabinets.

B. Lights shall only turn on when the magnetic proximity switch detects the door or access panel is open. The lights shall turn on if there is a proximity switch failure.

C. General lighting shall measure 20 foot-candles at the floor.

D. Sufficient lighting shall be provided to illuminate all signage to 20 foot-candles.

8.1.7 Stepwell Lighting

A. Light fixtures having a cover lens shall be provided in the stepwell areas to achieve the lighting levels specified in TS 8.1.3.

B. The lights shall be mounted below the floor level and shielded to protect the eyes of entering or exiting passengers.

C. The stepwell light shall be watertight to IP56 or higher.

8.1.8 Interior Door Open Lighting

A. Each side door leaf shall have an unobtrusive red LED indicator light installed in the doorway area, one near each door leaf, for a total of seven per car.

B. The indicators shall be arranged to be easily visible to the train crew looking down the aisle of the car.

C. Each indicator shall be illuminated when its respective door leaf is unlocked or open.

D. If the respective door leaf has been cutout and mechanically locked, this indicator shall flash.

E. If the Operator’s cab is active, the door indicator light in the left cab area of the local car shall turn off.

8.2 Exterior Lights

8.2.1 General

A. The exterior of the cab end of each car shall have lighting fixtures installed which comply with the requirements of 49 CFR Parts 221.14, 229.125 and 229.133.

B. All lights shall be designed for ease of replacement from the car interior by access hatches, unless otherwise Approved. Exterior lights that can be accessed at ground level without the use of a ladder may be proposed to be maintained from the exterior.

C. Each lowest replaceable unit (LRU) shall be replaceable in less than 30 minutes.

D. All lighting fixtures shall be flush mounted into the carbody to prevent accumulation of snow, ice, or other debris.

E. Materials surrounding and facing any exterior lights, including a coupled car, shall be capable of withstanding the heat caused by leaving these lights on indefinitely on a clear summer day with maximum ambient temperature.

F. Fixtures installed on the vehicle exterior shall be watertight to IP56 or higher. They shall use a one-piece elastomer gasket. Multiple piece gaskets and bonding are prohibited.

G. Exterior lighting equipment arrangement shall be submitted for Preliminary Design Review. **(CDRL 08-04, Exterior Lighting Equipment Arrangement)**

8.2.2 Headlights and Auxiliary Lights

A. Two round headlights (located above the body end door) and two round auxiliary lights (located approximately at the bottom of the end sheet, one toward each outboard edge) shall be provided at each cab end of a car, using Approved fixtures, located such that they produce a triangular lighting appearance.

1. They shall use LED headlights and auxiliary lights that are FRA Approved to 49 CFR 229.125.

2. Headlights and auxiliary lights shall have integrated thermostat-controlled heating elements to protect against frosting, or shall be recessed behind heated cover with FRA Type II glazing.

3. Failure of a single light shall not cause the other lights to be subjected to increased voltage.

4. Bezel design shall feature locating tabs to ensure the light can only be installed in one correct position that aligns the reflector housing appropriately.

5. The headlight and auxiliary light fixtures shall be easily adjustable for horizontal and vertical alignment, and shall be provided with a locking device.

6. Replacement of lights shall not require re-aiming or adjustment of the horizontal and vertical alignment.

7. Lights shall be controlled per TS 8.5. The headlight and auxiliary light controller shall have a set of red and green diagnostic LEDs on its enclosure.

8.2.3 Marker Lights

A. Two red marker light fixtures wired in parallel utilizing LED clusters shall be provided on the cab end of each car, and shall be located above the top of the windshields, at the outboard edges of the end sheet.

1. The marker lights shall be FRA Approved to 49 CFR 221.14.

2. Marker lights shall have integrated thermostat-controlled heating elements to protect against frosting, or be recessed behind heated cover with FRA Type II glazing.

3. Failure of a single light shall not cause the other light to be subjected to increased voltage.

4. Bezel design shall feature locating tabs to ensure the light can only be installed in one correct position that aligns the reflector housing appropriately.

8.2.4 Low Level Station Platform Lighting

A. To illuminate low level station platforms, weather resistant lighting fixtures shall be provided in Approved locations adjacent to the stepwell areas to achieve the lighting levels specified above.

B. The lights shall be mounted below the floor level and shielded to protect the eyes of entering or exiting passengers.

8.2.5 Exterior Signal Light Fixtures

8.2.5.1 General

A. The following requirements shall apply to the exterior brake signal light assembly and door open indicator light assembly:

1. One located on each side of the car in an approved location, and

2. Installed within the clearance line and visible to an Operator leaning out of a cab side window or to train crew on the station platform in bright sunlight.

a. Signal lights shall be visible from both ends of the train up to a twelve-car train length.

b. Signal lights shall not be directly in line with the cab side window or any side mirrors to avoid blinding an Operator.

3. Each assembly shall consist of a watertight low profile stainless steel or a finished aluminum housing.

4. Electrical connections shall be made with carbody wiring by use of an in-line connector.

5. Maintenance shall be performed from the car interior.

6. The indicators on both sides of the car shall be wired in parallel so that both shall illuminate when required whenever the car is in active status.

8.2.5.2 Exterior Brake Signal Light

A. The Exterior Brake Signal Light shall have three LED lights, each illuminating a recessed colored (amber, green and blue) lens at each end of the fixture so as to be visible from either end of a twelve-car train.

B. The signal lights shall be similar in operation to the cab console indicators described in Section 5, Operator's Cab, but shall function on a local car basis only.

C. The amber signal lights shall be illuminated whenever the friction brakes on both trucks are applied,

D. The green signal lights shall be illuminated whenever the friction brakes on both trucks are released, and

E. The blue signal lights shall be illuminated whenever the parking brake is applied.

8.2.5.3 Exterior Door Open Light

A. Each car shall be equipped with one exterior red indicator light on each side. The light shall be located near the center of the car and above the door height.

B. Both shall illuminate to indicate that one or more door leaves on either side of the car are not fully closed and locked and not locally cut out. See Section 6, Passenger Doors for additional information.

8.3 Blue Flag Signal Protection Light

A. There shall be a blue flag light installed in the operator cab area to be used during maintenance activity only as described in Section 5, Operator's Cab. The blue flag light

shall be used to for visual indication of blue flag protection according to 49 CFR 218 Subpart B – Blue Signal Protection of Workers.

1. The blue flag light shall be visible to a minimum of 500 feet ahead of the windshield, when no sun glare is present. The blue light shall be readily identifiable regardless of cab interior lights being on or off.

2. There shall be a keyed on/off switch to control the blue flag light. See Section 5, Operator's Cab for additional information.

8.4 Emergency Lighting

8.4.1 General

A. Emergency lighting shall be provided in the event of failure of the normal lighting supply power, and shall comply with the requirements of 49 CFR Part 238.115 and APTA PR-E-S-013-99 Emergency Lighting System Design for Passenger Cars.

B. Emergency lighting shall automatically be activated after the loss of the low voltage power supply.

C. Emergency lighting shall be powered by the main car storage battery, as specified in Section 9, Auxiliary Power, as long as it is available.

D. When main car storage battery is unavailable, emergency lighting shall be powered by supercapacitor-based independent power sources.

E. The emergency lighting system shall have a reserve capacity of at least 180 minutes from each independent power source.

F. Emergency lighting control shall be hardware based. Any software control within the emergency light functionality is prohibited.

G. Emergency lighting system shall report independent power source operating status, voltage, current, charge levels, warnings, faults, and other diagnostic information to the VMDS. See Section 18, Monitoring and Diagnostics, for additional information.

H. The arrangement and control of the emergency lighting system shall be submitted for Preliminary Design Review. **(CDRL 08-05, Emergency Lighting Arrangement and Control)**

8.4.2 Emergency Independent Power Source

A. Independent Power Sources

1. Independent Power Sources shall comply with the requirements in APTA PR-E-S-013-99 Emergency Lighting System Design for Passenger Cars.

2. There shall be two independent power sources on each car, protected by separate circuit breakers, to provide maximum emergency lighting availability on each car.

3. Each power source shall be at least 20 feet apart from each other to avoid a single point failure, in case of a catastrophic accident that could disable all emergency lighting on the car.

4. Lighting fixtures shall alternate power sources over the entire length of the car to maximize availability of emergency lighting according to 49 CFR 238.115(b)(1) equivalent level of safety.

5. Independent Power Sources shall have their own dedicated equipment enclosure for improved maintainability.

6. Independent Power Source risks must be included in the hazard analysis specified in Section 23, System Safety and Security, at Preliminary Design Phase.

7. Power source charge level shall be reported on the lighting power source enclosure with status LEDs.

8. Self-test functions of the independent power sources shall consider time required to function test the controller, validate power source capacity, and display to the maintainer estimated time for self-test completion.

9. It shall be possible to self-test power sources either one at a time, or both simultaneously to minimize test duration for maintenance personnel.

B. Capacitor-Based Power Source

1. The required emergency lighting that has an alternate back-up to the car storage batteries shall be supplied by maintenance-free capacitor-based lighting.

2. The capacitors must be rated for a minimum of 500,000 charge cycles.

3. Capacitor terminals shall be covered to protect shorting and shall be connected to fixtures through connectors.

4. The capacitor-based power source for emergency lighting shall have a label located on the side of the unit exposed for service that includes the following information:

   a. OEM name and address

   b. OEM part number — revision/modification level and date

c. Date of manufacture

d. Unit serial number

e. Voltage and capacity rating

8.4.3 High Performance Photoluminescent (HPPL) Marking for Emergency Signage and Low-Location Exit Path Markings (LLEPM)

A. Emergency signage and a low-location exit path marking (LLEPM) system shall be installed in the car in compliance with APTA standard APTA PR-PS-S-006-23 Emergency Egress/Access Signage and Low-Location Exit Path Markings for Passenger Rail Equipment. See Section 14, Interior and Exterior Appointments, for additional arrangement information.

B. Light intensity for emergency lighting levels, specified in TS 8.1.3, shall take color temperature into consideration to allow HPPL material to be sufficiently charged by emergency light levels.

8.5 Lighting Control

A. When the low voltage power supply fails, the emergency lighting circuit shall function as described in TS 8-4. The changeover shall be automatic in both directions.

B. Layover Lighting Mode shall be controlled by Operator's Cab Activation. See Section 5, Operator's Cab for additional information on Cab Activation.

1. When the Operator's Cab is deactivated, all interior lights on all cars on the train shall follow layover light intensity. See Section 5, Operator's Cab for additional information for Cab Control Key. See TS 8.1.3.3 for additional information.

2. Layover light intensity shall remain on for 90 minutes.

3. At the end of 90 minutes, all lights on the car shall turn off for energy savings.

C. Cleaning Mode shall be controlled by Conductor Key Switch Activation. See Section 5, Operator's Cab for additional information on Key Switch Activation.

1. When the Conductor Key Switch is activated, all interior lights on the train shall turn on to normal lighting levels.

2. When the Conductor Key Switch is deactivated, all lights on the train shall turn off after 10 minutes for energy savings.

D. The low-level passenger doorway step well lights and outside low platform door area lights shall be controlled on a doorway basis whenever the adjacent door panel is open (not closed and not locked).

E. The headlights shall be under the control of an easily reached Operator's cab console mounted three position rocker switch (Bright, Off, Dim).

1. A blue or amber indicator light identified as "High Beam" located on the cab console annunciator panel shall be illuminated when the headlight switch is set to "Bright".

F. The auxiliary lights shall be under the control of a second easily reached Operator's cab console mounted three position rocker switch (On, Auto, Flash), which shall be functional in the cab where headlight control is functional.

1. In all three operating modes the sounding of the horn shall cause the auxiliary lights to immediately flash alternately for 30 seconds, then resume their previous state.

2. Activation of the horn again within 30 seconds shall immediately restart the 30 second timing.

3. In the On position, the auxiliary lights shall be on continuously.

4. In the Auto position, the auxiliary lights shall be on continuously when the headlights are set to Bright, and not illuminated when the headlights are set to Dim or Off.

5. In the Flash position, the auxiliary lights will flash alternately at a rate of 80 flashes per minute (40 flashes per minute per bulb) in accordance with 49 CFR Part 229.133.

G. A set of 4 green indicator LEDs in an Approved arrangement shall be provided in the cab to indicate the functional status of each headlight and auxiliary light bulb.

H. Passenger Lighting System Controllers shall report operating mode status, warnings, faults, and other diagnostic information to the VMDS. See Section 18, Monitoring and Diagnostics for additional information.

I. Passenger Lighting Controller System Function Description shall be submitted for Preliminary Design Review**. (CDRL 08-06, Passenger Lighting Controller System Function Description)**

8.6 Contract Deliverable Requirements List (CDRL)

The following contract deliverables have been identified in this section; however, the Contractor is responsible for providing and submitting anything necessary to fulfill the requirements of this contract, including those not identified by CDRL number.

CDRL 08-01, Lighting Interior General Arrangement 8-2
CDRL 08-02, LED Driver End of Life Function Description 8-4
CDRL 08-03, Cab Lighting Arrangement 8-7
CDRL 08-04, Exterior Lighting Equipment Arrangement 8-9
CDRL 08-05, Emergency Lighting Arrangement and Control 8-12
CDRL 08-06, Passenger Lighting Controller System Function Description 8-15

8.7 CDRL Details

This section lists the expected content for each CDRL required above. The lists provided for each CDRL are an outline only and should not be considered exhaustive, all CDRLs are subject to SEPTA review and approval.

CDRL 08-01 Lighting Interior General Arrangement

1. Submit at Preliminary Design Review.
2. Submit a dimensioned general interior lighting arrangement. Include the general arrangement of the interior ceiling with air diffusers (if applicable). Identify all lighting fixtures, including the cab area, left cab area, stepwells, and general passenger interior.
3. For each lighting fixture, identify if it is an emergency light.
4. For each lighting fixture, identify the IP rating.
5. Include a legend that identifies the number of different light fixture lowest replaceable units LRUs.

CDRL 08-02 LED End of Life Function Description

1. Submit at Preliminary Design Review.
2. Describe functionality of LED driver circuitry to monitor service life and determine when the LED and driver assembly have reached end of life. Include warning setpoints to allow maintenance activities to be scheduled in advance.
3. Describe the method of annunciation for maintenance workers.

CDRL 08-03 Cab Lighting Arrangement

1. Submit at Conceptual Design Review.
2. Submit a dimensioned cab lighting arrangement including the left cab area lighting and Operator's cab lighting.
3. Show a separate view when the cab is active which light fixtures are powered.
4. Show a separate view when the cab is not active which light fixtures are powered.
5. Identify all dimmable lightings in the Operator's cab area. If subcomponents have their own dimmers and are not controlled by the lighting system, include a note in the arrangement layout.
6. Include a description of light reflection and glare risks and mitigation methods.

CDRL 08-04 Exterior Lighting Equipment Arrangement

1. Submit at Preliminary Design Review.
2. Submit a dimensioned exterior lighting arrangement. Include plan and side views with key dimensions for maintainability access.
3. Identify all metallic materials and surface finishes. Call out areas with dissimilar metal mitigation and include notes where gasket seals are used for isolation.

CDRL 08-05 Emergency Lighting Arrangement and Control

1. Submit at Preliminary Design Review.
2. Describe how the emergency lighting arrangement comply with the requirements of 49 CFR Part 238.115 and APTA PR-E-S-013-99 Emergency Lighting System Design for Passenger Cars.
3. Submit arrangement layout showing each capacitive-based independent power source location and each emergency light fixture location. For each lighting fixture identify which independent power source provides power.
4. Describe functionality of the emergency lighting control circuit, including failure mode operation if one independent power source fails. Include description of the changeover from normal lighting to emergency lighting is activated. Include description of the changeover back from emergency lighting to normal lighting is activated.
5. For each changeover scenario, include a flow diagram identifying each step of the process and indicate the operating status of the auxiliary power system, low voltage

power supply, main car battery, capacitor-based independent power source. Identify in each state if the capacitor-based independent power source is charging or discharging.

6. Describe how the emergency lighting controller detects and reports information described in TS 8.4.G.

CDRL 08-06 Passenger Lighting Controller System Function Description

1. Submit at Preliminary Design Review.
2. Describe functionality of the lighting controller, including degraded mode and failure mode operation. Include LED and driver control as described in TS 8.1.2
3. Describe the lighting controller inputs and outputs for system integration.
4. Describe the light fixture car wiring and how the normal lighting circuit functions and how the emergency lighting circuit functions.
5. Describe Layover Lighting Mode, and Cleaning Mode functionality and include failure mode priority levels relative to normal lighting mode and emergency lighting mode.
6. Describe how the lighting controller detects and reports information described in TS 8.5.I.

8.8 Referenced Standards

The following standards are referenced in this section:

49 CFR 218 Subpart B	Blue Signal Protection of Workers
49 CFR 221.14	Marking Devices
49 CFR 229.125	Headlights and Auxiliary Lights
49 CFR 229.127	Cab Lights
49 CFR 229.133	Interim locomotive conspicuity measures—auxiliary external lights
49 CFR 238.115	Emergency Lighting
APTA PR-E-RP-012-99	Normal Lighting System Design for Passenger Cars
APTA PR-E-S-013-99	Emergency Lighting System Design for Passenger Cars

APTA PR-PS-S-006-23	Emergency Egress/Access Signage and Low-Location Exit Path Markings for Passenger Rail Equipment
EN 50121	Railway Applications – Electromagnetic Compatibility
EN 50155	Railway Applications – Electronic Equipment Used on Rolling Stock
IEC 60529	Degrees of protection provided by enclosures (IP Code)
IEEE 1789	Recommended Practices for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to Viewers
LM-79-08	Illuminating Engineering Society of North America (IESNA), Electrical and Photometric Measurements of Solid-State Lighting Products

SECTION 9
AUXILIARY POWER

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9.1 Auxiliary Power General

9.1.1 General

A. The electrical devices on each car, other than the propulsion motors, shall be energized by the car's auxiliary power systems and associated wiring.

B. In addition to any requirements noted in this section, all devices and wiring shall meet the requirements of Section 16, Materials and Workmanship.

C. Apparatus shall be installed to supply each car with auxiliary power having the following nominal characteristics:

230 Volts, 60 Hertz, 3 Phase AC

120 Volts, 60 Hertz, Single Phase AC

37.5 Volts DC

600 (or lower) Volts, 25 Hertz, Single Phase AC, Unregulated (derived from a tertiary winding on the main transformer. (Refer to Section 10, Propulsion and High Voltage System).

D. The auxiliary power apparatus shall use solid state devices for regulation and all frequency and voltage conversion.

1. Inverter power output which is to be used by a motor or an electrical or electronic device shall be suitably conditioned to produce an output waveform which can be used by standard commercially available motors or electronic components without any adverse impacts on reliability, life span or maintenance requirements.

2. All contactors and relays shall be of transit or heavy industrial quality, with prior rail transit history.

3. All systems shall be provided with main and branch circuit breaker protection.

4. All auxiliary power equipment shall be self-protecting and not depend on Operator intervention or removal from service to avoid equipment damage or the occurrence of an unsafe condition.

5. All systems shall comply with the diagnostic test equipment requirements of Section 15, Test Program.

6. Any auxiliary power apparatus powered by the overhead catenary system shall operate whenever the catenary line voltage is between 9,000 Volts and 13,500 Volts at 25 Hertz and as defined in Section 2, Design and Performance Criteria.

7. The auxiliary system shall not be damaged by continuous exposure to catenary line voltages between 0 Volts and 13,500 Volts, or by exposure to higher transient voltages which occur on the catenary. (See Section 2, Design and Performance Criteria).

8. The auxiliary power system shall meet Electromagnetic Interference and Compatibility requirements as defined in Section 2, Design and Performance Criteria.

9.1.2 Configuration

A. A main auxiliary power inverter shall be supplied per car to produce 230 Volts, 60 Hertz, 3 phase alternating current. The inverter shall comply with the requirements of IEC 61287-1 and IEEE 16, including all referenced standards.

B. The loads for this inverter shall include, but not be limited to, the HVAC system (see Section 7, Heating, Ventilation, and Air Conditioning), equipment cooling blowers, and the air compressor, and shall have a minimum of 10% excess power capacity over the maximum combined power draw of the loads. The contractor shall perform and submit a detailed load analysis of the API loads to confirm the inverter rating. As a minimum, the load analysis shall contain the information as detailed in IEEE 1476. **(CDRL 09-01, Auxiliary Power Supply Load Analysis)**

C. A wayside power connector shall be supplied. Refer to TS 9.9.

D. Low voltage at nominal 37.5 Volts DC and battery charging shall be supplied by a controlled converter suitable for float charging the car storage battery.

E. The contractor may propose for Approval to have the low voltage power supply and battery charger installed in the same enclosure as the auxiliary power inverter. Separate cutouts to isolate each unit individually shall be provided.

F. Unregulated single-phase 25 Hertz voltage, not to exceed a nominal 600 Volts shall be obtained from the tertiary winding of the main transformer. This voltage, suitable for use when the transformer cooling is inoperative shall supply layover heat and battery charging.

G. Other space and weight effective configurations for the auxiliary power system and heater system voltage may be proposed to SEPTA for Approval.

H. The entire auxiliary power system shall be designed for minimum power consumption, especially during times of car storage.

I. A cross-feed arrangement shall be proposed whereby if an auxiliary inverter fails on one car of a married pair, the loads on that car will be fed from the remaining operational auxiliary inverter on the other car. Suitable load shedding shall be proposed for approval to optimize the power rating of the auxiliary inverter. Refer to TS 9.3.4 for details of load shedding.

J. The Contractor shall provide a detailed and comprehensive system functional description (SFD) for the auxiliary power system prior to each design review. The SFD shall include detailed descriptions of all major components of the auxiliary power system, how the components function and how they interact. The SFD shall contain all descriptions, block diagrams, schematics, and other features necessary for SEPTA to clearly understand how the auxiliary power system functions and how it meets the requirements of this specification. The SFD shall be updated at each design stage as the system design is refined. **(CDRL 09-02, Functional Description of the Auxiliary Power Supply Equipment)**

9.1.3 Other Considerations

A. The Contractor shall coordinate the design of all circuits and equipment to prevent damage or disturbance to operation caused by electrical noise and transients. Whenever possible, this shall be done by suppression at the source.

B. All circuits and equipment shall be designed and protected so that the sustained presence of any voltage from zero to the maximum, and any specified transients will not cause damage to any part of the car or cause unsafe operation.

C. The Contractor shall be responsible for proper systems interrelation and function of the auxiliary power system and shall provide an auxiliary load supply protection and coordination analysis demonstrating proper sizing and coordination of all auxiliary power circuit protective devices.

D. All associated fuse and circuit breaker curves and data sheets shall be provided.

9.1.4 Control

A. Whenever a car or train is placed in train service, all portions of the auxiliary power inverter system shall operate.

B. When all controls of a car or train are inactive, all portions of the auxiliary system shall transition to layover mode, except for those portions necessary for layover heating/cooling and battery layover charging.

1. Refer to Section 7, Heating, Ventilation, and Air Conditioning, for operational details of the HVAC system in layover mode.

2. Refer to Section 6, Passenger Doors, for operational details of the Passenger Door system in layover mode.

3. Refer to Section 10, Propulsion and High Voltage System, for operational details of the propulsion system in layover mode.

4. Refer to Section 13, Communications, for operational details of the communications system in layover mode.

5. Opening control circuit breakers for these subsystems shall also shut them down during storage conditions.

C. The auxiliary power system design shall ensure the lowest possible power consumption, especially during periods of car storage.

D. Remote reset of overload or other fault conditions shall be possible from the cab; however, to the extent possible and considering equipment safety and except as noted otherwise, all faults shall reset automatically without Operator intervention.

E. If staggered starting of the auxiliary motor loads are necessary, the Contractor shall propose for approval the load starting sequence.

F. The inverter, low voltage power supply, and battery charger shall use a control system containing extensive self-diagnostic logic and incorporate a self-test feature upon start up to verify that all system components are operating within normal limits. Any anomalies found at any time during start up or during operation shall be reported to the VMDS as noted in Section 18, Monitoring and Diagnostics.

G. It shall be possible to initiate a self-test using a PTU. The Contractor shall provide an on-demand self-test function for the auxiliary power system that may be initiated and monitored as part of the train display unit (TOD). Test results shall be stored locally and sent to the vehicle monitoring and diagnostic system (VMDS).

H. Receptacles to allow connections to any necessary test equipment shall be provided in the car interior, as required in Section 15, Test Program.

9.1.5 Layover Mode

A. Provide a primary power layover mode for cars parked in the yard during off-peak or non-revenue hours. The primary power layover mode shall save power by reducing consumption of car non-essential onboard subsystems powered by the LVPS and APS.

B. Layover mode shall begin automatically 30 minutes after the cab control key is removed and parking brake applied. Layover mode shall be initiated for all cars in the train. The VMDS shall command a graceful shutdown of all relevant systems prior to any loads being shed for layover.

C. Layover mode shall remove all LVPS loads except for the following: battery charging, event recorder, HVAC control, door crew access switches, Video Surveillance, VMDS, and TWDT. The removal of overhead lighting shall be performed according to the separate timer specified in Section 8, Lighting.

D. Layover heat and layover cooling shall be provided as specified in Section 7, Heating, Ventilation, and Air Conditioning. The air compressor shall function as specified in Section 12, Friction Brake Subsystem.

E. Layover mode shall terminate when the cab is activated through the cab control key, the conductor control panel is activated, or primary power is lost.

F. VMDS shall log all events and faults information and activate the interior cameras according to Section 13, Communication, during the layover mode.

G. Submit a layover mode functional description document. **(CDRL 9-03, Layover Mode Functional Description)**

9.2 Main Transformer Supply

A. The main transformer, further described in Section 10, Propulsion and High Voltage System, shall supply two sources of power for the auxiliary power system.

9.2.2 Regulated DC Link Source

A. The regulated DC intermediate link that is fed by the line converter from the main transformer propulsion secondary winding shall also supply the auxiliary power inverter.

B. Use of this source will provide for on-board use of some of the regenerative braking energy that the propulsion system will return to the DC intermediate link.

C. Use of this source will also permit continuity of supply of power to car auxiliary loads during power collection interruptions while moving by means of automatic regenerative braking converting kinetic energy to provide auxiliary power.

D. Alternate arrangements may be proposed for approval; however, the features noted above (capture of regenerated energy, and continued operation through short term loss of overhead power) are required features of any alternate arrangement.

9.2.3 Unregulated Secondary Source

A. A tertiary winding of the main transformer shall be provided to feed auxiliary circuits.

B. This winding shall supply the unregulated 600 Volts (or lower) car heating circuits, and the low voltage power supply. Refer to Section 2, Design and Performance Criteria, and Section 10, Propulsion and High Voltage System.

C. A proposal for approval may be made to feed the auxiliary inverter from the tertiary winding through a suitable unity power factor line converter; however, the features noted above (capture of regenerated energy, and continued operation through short term loss of overhead power) are required features of any alternate arrangement. The line converter and filtering circuit shall accommodate all specified input voltages, voltage variations, and frequencies to the car while supplying the auxiliary inverter.

9.3 Auxiliary Power Inverter

9.3.1 General

A. Each car shall have a solid-state auxiliary power inverter package with microprocessor-based control logic.

B. Constant Volts-per-Hertz regulation system shall be provided. Alternate proposals may be submitted for approval. During startup, the API shall ramp up voltage and frequency, maintaining a voltage/frequency ratio of 3.83 Volts per Hertz.

C. The inverter shall control the three-phase AC output voltage to 230 Vac ± 3% at a frequency of 60Hz ± 2 Hz.

D. The Contractor shall carefully consider the actual starting inrush current requirements of all motors and inductive loads in making its system capacity calculations. A stagger start strategy of the car HVAC loads to limit the inrush current to the inverter may be proposed for approval. In any staggered start strategy, the friction brake air compressor shall always have priority.

E. The inverter shall be of robust microprocessor controlled PWM design utilizing reliable service proven switching devices.

1. The inverter shall be of lightweight construction and mounted under the car in enclosures meeting the requirements of Section 3, Carbody.

2. The inverter shall be conveniently located under the car and mounting shall use suitable vibration isolating mountings, if necessary. The inverter shall be designed to meet or exceed the shock and vibration requirements of IEC 61373. Testing shall be conducted to verify compliance.

3. The efficiency of all auxiliary power conversion equipment shall be greater than 90 percent under all load conditions from 10 percent to 100 percent of rated load.

F. The inverter shall have sufficiently low harmonic content and a rate of rise limitation to the voltage waveform in the output to allow the use of standard industrial motors and control devices with no change in their performance, maintenance requirements or life span.

1. When operating under full load, any motors fed by the inverter shall not exceed their nameplate rating.

2. The inverter shall not be affected by rapid interruptions in catenary supply power caused by ice or gaps, nor cause damage to connected loads during these conditions. At full rated load with catenary supply interruption less than 40 milliseconds the auxiliary power supply shall continue to provide normal operating output voltage within normal range.

3. Shop power standby receptacles shall be included.

4. The total harmonic distortion of the inverter 230V output shall be less than 5% and shall contain less than 3% distortion at each individual harmonic.

5. Details for the design of the inverter package and its controls and protection shall be submitted for approval.

9.3.2 Ventilation

A. The auxiliary power inverter system shall be designed to use external non-energized heat sink fins.

B. Methods of forced cooling by fans may be proposed for approval if this would result in the size and the weight of the unit being reduced.

1. If used, the minimum fan service life shall exceed the internal maintenance interval for any other inverter component and be compliant with motor requirements as found in Section 16, Materials and Workmanship.

2. If forced cooling is used, all electrical and electronic parts shall be protected from dust and water and shall include over-temperature protection.

3. If ingress filtering is required for force air cooling the surface area of the filters shall be as large as practicable to minimize filter contamination. The use of media filters shall require approval. Any media filters shall be easily replaceable from the side of the car. The design and location of media filters shall be such that replacement of the filters will be required at intervals of no less than 184 days.

C. Operation and storage shall be possible under the range of ambient and operating temperatures identified in Section 2, Design and Performance Criteria, without degraded performance.

9.3.3 Voltage Regulation

A. Sufficient capacity to repeatedly withstand the most severe combination of starting surges of all equipment is required.

B. The application or removal of any load or combination of loads from any supply voltage shall not result in the nuisance activation of protective devices.

9.3.4 Load Shedding

A. In the event of LVPS failure or the loss of primary power, the battery load shall be shed automatically in stages, each stage triggered using a predetermined combination of voltage level, length of time, or both. The overall load shed scheme shall leave the battery sufficient capacity to meet the requirements of TS 9.7.2. All load shed timers and voltage levels shall be provided as configurable parameters. Parameter adjustment shall be limited to be within defined safe limits as determined by the car builder. Refer to Section 18, Monitoring and Diagnostics for further details concerning adjustable parameters.

B. Battery Load shedding shall be performed according to the following stages:

1. Stage 1: Non-performance critical, non-essential loads such as standby lighting and signs shall be shed 60 seconds after LVPS failure or loss of primary power.

2. Stage 2: Non-essential loads shall be shed when the train is stationary, and the battery voltage has dropped below a Contractor-defined level for 15 seconds.

3. Stage 3: Essential loads shall be shed when the train is stationary, and the battery voltage has dropped below 25 Vdc for 15 seconds (exact voltage value shall be determined by car builder but shall leave the battery sufficient capacity to meet the requirements of TS 9.7.2).

4. Crew access switches, as specified in Section 6, Passenger Doors, and pantograph and primary circuit breaker control, as specified in Section 10, Propulsion and High Voltage System, shall not be load shed.

C. The following Low Voltage loads shall be considered essential:

1. HVAC controls and cab heater controls

2. Door controls, including crew doors, operators, indicator lights, and voice announcements,

3. Cab signal/ATC systems,

4. ACSES/PTC

5. Exterior lights

6. Emergency lighting, including threshold lights

7. Braking control (including air compressor control)

8. All protective heater circuits

9. Cab Control key and Master Controller signals

10. Fault indicator lights

11. Friction brake

12. Radio

13. VMDS in the lead car

14. Public address and intercom

15. Propulsion control

16. Windshield wiper and horn control

17. APS control

18. Train network

19. Event recorder

20. Video Surveillance System

21. FRA required communication system

22. Any other equipment necessary to maintain the operation of the vehicle shall not be shed.

D. Removal of loads when the cab control key is removed and primary power is available shall follow the sequence specified in TS 9.1.4.

E. When the supply voltage to the auxiliary power inverter system drops below 9,000 Volts, as defined in Section 2, Design and Performance Criteria, loads may be individually shed by the system on a priority basis. The inverter and low voltage power supply/battery charger shall comply with IEEE 16 and IEEE 1476.

F. If reductions in weight or size of the inverter can be demonstrated, the application of load shedding techniques may be proposed when AC power is being cross fed between cars of a married pair due to failure of one inverter. Performance critical loads shall remain fully functional on both cars. Performance critical loads shall include:

1. Air compressor

2. Propulsion inverter cooling fans

3. Cab heaters / windshield defrosters

4. Any other equipment necessary to permit the movement of the vehicle

5. HVAC units shall also be considered as essential loads but may be partially load shed by operating only 1 of 2 HVAC units per car, or by operating only one out of two refrigerant compressors per HVAC. Alternate HVAC load shed control may be proposed for approval.

G. Adaptive load control to maintain operation of the auxiliary inverter in case of a reduction in inverter cooling may be proposed for approval. Such control shall be carefully coordinated with the HVAC supplier and shall be clearly annunciated for maintenance purposes.

H. If the supply voltage drops below the minimum necessary to operate the inverter system on a continuous basis, it shall shut down and automatically start up when the supply voltage recovers to the specified operational range.

I. Hysteresis shall be incorporated into the controls to prevent excessive cycling at low voltage conditions.

J. The Contractor shall submit the details of the DC and AC load shedding systems and load shedding scheme, including the treatment of each individual auxiliary and critical/essential and non-essential loads. **(CDRL 09-04, DC and AC Load Shedding)**

9.3.5 Inverter

A. The power conversion elements of the inverters shall use insulated gate bipolar transistors (IGBTs) and shall be Approved. Alternate devices may be proposed for review and approval.

1. The inverter shall have a nominal output of 230 Volts, 60 Hertz, 3 phase AC. Neutral shall be grounded via a resistor to limit fault current, and permit continuation of service in the event of a ground fault. Proposal for approval to be submitted with details of neutral grounding, and ground fault detection and annunciation.

2. Power devices and switching elements shall be individually rated to perform at the required rated output level. The use of switching or power devices in series or parallel configuration to achieve the functionality and rating of a single element shall not be permitted without approval.

B. The power circuit design must reflect full understanding of circuit induced or out-of-limit failure modes in the power devices, such as out-of-saturation or excess current conditions.

C. The circuit design must include circuits which afford protection and which themselves are resettable.

D. Wave shaping and harmonic suppression strategy shall produce an output line voltage with no significant output current harmonics below the 13th referred to the fundamental.

1. If it can be shown to produce overall reductions in weight for the inverter and loads, then waveforms of higher harmonic content may be proposed for approval provided that:

a. All the driven loads maintain their thermal margins.

b. The audible noise levels of the driven loads do not increase significantly.

c. The additional electrical noise does not produce EMI negatively affecting other car circuits and wayside communication.

d. Refer to Section 2, Design and Performance Criteria, for further details regarding EMC requirements.

E. The Contractor shall provide a load start/stop and sequence analysis for the inverter including:

1. Load starting current levels and durations.

2. Analysis of anticipated inverter output variation with load start-up and shutdown.

3. A description of load start-up methods and sequencing, including output Volts/Hertz ratio variation during start-up.

4. Verification that worst-case load starting is within inverter operational limits and will not trigger any inverter protection device. Sequence time delays shall be a maximum of 3 seconds.

F. Load sequencing and sequence timing, if used, shall be software adjustable and shall be password protected and retained permanently.

G. The Contractor shall provide the power ratings and associated load analysis for the inverter demonstrating correct sizing of the inverter for all normal operating modes. The analysis shall consider all loads, these shall include but not be limited to:

1. Motor loading for each motor type under all normal running conditions,

2. Motor locked rotor (starting) conditions for each motor type,

3. Simultaneous motor starting conditions (where load scheduling permits such events),

4. Air compressor motors under high temperature starting conditions,

5. HVAC compressors under pull-down conditions,

6. Resistive heating loads under cold heater (starting) conditions.

H. Each inverter shall contain sufficient internal diagnostic circuits and annunciation means to permit a maintenance technician to rapidly troubleshoot an inverter internal fault and have maintenance capabilities in accordance with Section 15, Test Program.

I. The auxiliary inverter shall have the ability to transmit a discrete or network health status signal to be used by other systems within a married pair.

J. The design of each inverter shall be submitted. (**CDRL 09-05, Auxiliary Power Inverter Design Details)**

9.3.6 Isolation

A. There shall be galvanic isolation provided between the catenary power and the inverter loads, and also between the propulsion intermediate DC link and the inverter loads. In addition, galvanic isolation shall be required for all equipment where passenger or operator contact is possible. The 120 Volts convenience outlets and any other 120 VAC loads shall be transformer isolated and conform to IEEE Std. 1476.

B. This isolation may be accomplished either upstream or downstream of the auxiliary inverter.

1. If downstream, all inverter output shall be supplied to the loads through a purpose-designed transformer, based on previous designs for the same type of application.

a. It shall be specifically designed and manufactured for use with the solid-state inverter, and the harmonic content of the supply waveform shall not cause it to experience hot spots or generate excessive temperatures from this application.

b. Acoustic noise generated by the transformer shall not cause the noise level to exceed limits for a stationary car.

c. The insulation system shall be comparable to that of the traction motors defined in Section 10, Propulsion and High Voltage System.

d. Copper windings shall be used.

e. The transformer shall be given a protected environment in which it is not exposed to snow and moisture whipped up by train motion or car washer mist.

2. If upstream, the main transformer shall supply power to the inverter by means of a dedicated tertiary winding.

a. It shall meet all the above requirements.

9.3.7 Driven Loads

A. The primary loads to be supplied by the auxiliary inverter are:

1. HVAC refrigerant compressors,

2. HVAC Condenser fans,

3. HVAC Evaporator blowers,

4. Main transformer coolant pump and cooling fans,

5. Cab heater fan,

6. Heated windshield,

7. Air compressor,

8. All other 230Vac and 120Vac loads.

9.3.8 Protection

A. Each auxiliary inverter shall have output protection for overvoltage, undervoltage, overcurrent, overtemperature, phase loss, DC imbalance, excessive distortion, switching device failure and ground fault protection.

B. Protective measures shall be self-resetting to the extent possible.

1. Lockout due to repeated occurrences of the same fault may be proposed for approval.

C. The Contractor shall provide a comprehensive description of all auxiliary inverter protective features.

1. This shall include input protection analysis, description of all other protective features, including identification of triggering events and sequence of protection operation, and description of proposed resetting schemes, including automatic and manual resets.

D. The contractor shall submit the Auxiliary Power Supply and Low Voltage Power Supply protection strategy, isolation, and grounding scheme. **(CDRL 09-06, API Protection Strategy, Isolation, and Grounding Scheme)**

9.4 Outlets

A. The power to the 120Vac outlets shall be:

1. Derived from 230Vac, fed via a three-phase circuit breaker protected isolation transformer rated to supply 120 Volts, 60 Hertz single phase AC power. The transformer rating shall be proposed for approval. The transformer shall be able to operate with any combination of phase loading including conditions where one phase is off-load due to a single phase load breaker tripping.

2. Appropriately filtered to allow its use directly in standard recording and other types of instrumentation which require a sine wave input power characteristic without damage to the equipment or errors in the data collection process.

3. Appropriately filtered to allow its use directly for laptop type power supplies.

B. The 120Vac from the isolation transformer shall also be connected to four 20A grounded duplex Ground Fault Circuit Interrupter (GFCI) convenience outlets for maintenance and vehicle cleaning purposes, located in the passenger seating area, and two in each cab of a car.

1. One outlet shall be located near each end of the passenger seating area of the car.

2. Two outlets shall be located approximately one third of the length of the seating area from each end of the car.

3. A common circuit breaker with ground fault interruption protection shall be provided for the 120Vac convenience outlets. The GFCI breaker shall be as specified in IEEE-16 for convenience receptacles. The status of each GFCI breaker shall be communicated to the VMDS. The ground fault interruption protection shall be subject to approval.

4. Convenience outlets shall be 20A Duplex outlets, NEMA WD 6-2016 5–20R configuration, compliant with the requirements for convenience receptacles accessible to vehicle passengers as specified in IEEE-16 and shall have stainless steel cover plates identified as "120 Volts".

C. The location and the design of the 120 Volts system shall be proposed for Approval.

9.5 Low Voltage Power Supply

9.5.1 General

A. Each car shall be equipped with a low voltage auxiliary power supply (LVPS) of adequate capacity to carry all 37.5 Volt DC loads on a married pair as well as safely meet the charging requirements of the main storage battery.

B. The low voltage power supply and battery charger shall comply with the requirements of IEC 61287-1, IEEE 16, and IEEE 1476 and all referenced standards therein.

C. The combined output of the LVPS and battery shall be referred to as the low voltage power supply within this Specification.

D. The LVPS shall supply the propulsion and friction braking system controls, heating and air conditioning system controls, interior lighting, exterior lighting, communications system, door system, cab signal, radio power supply, the coupler control system and such others as may be required.

E. The low voltage power supply shall be a static converter designed to charge the proposed battery technology.

1. The battery and LVPS shall function together as an uninterruptible power supply without changeover switching.

2. The nominal bus voltage shall be 37.5 Volts DC as determined by the battery charging needs.

3. In operation, the battery will be float charged by the LVPS converter.

4. The Contractor shall prepare a load analysis and determine the power rating for the LVPS demonstrating correct sizing.

5. The analysis shall consider all operating modes, including operation with a failed LVPS on a married pair and seasonal variations in operating modes.

6. The LVPS for a married pair train configuration shall have sufficient capacity to carry the entire married pair low voltage DC load without load shedding and under the worst-case ambient conditions.

7. The contractor shall perform and submit a detailed load analysis of the Low Voltage Power Supply to confirm capacity. **(CDRL 09-07, Low Voltage Power Supply Load Analysis)**

F. In addition to the LVPS logic having control of the nominal charging voltage noted above and depending on battery chemistry proposed, there shall also be a temperature-compensated charging feature employing a temperature sensor installed on a battery cell inside the battery box in an approved location or a battery management system providing the battery cells temperature.

1. Temperature-compensated charging shall be the normal operational mode of the LVPS. Temperature compensation of the LVPS output voltage shall be limited to be within a range of 37.5V +/- 5%. Alternate proposals may be submitted for approval.

2. The LVPS control logic shall sense abnormal operation, out of range, or failure of the battery temperature sensor(s), and when such is detected, the logic shall automatically revert to the mode of only maintaining the charging voltage at the nominal level noted above.

3. Simultaneously, this change in operating mode shall be logged as a fault in the VMDS for maintenance personnel.

G. All connected loads shall be protected from switching and other transients on the supply and shall also not be affected by other continuous or discontinuous electrical noise such as ripple and high frequency hash.

1. Voltage range and other requirements will be found in Section 16, Materials and Workmanship, and other related sections.

H. In normal operation, the battery shall be floated across the LVPS output.

1. The LVPS shall be completely solid state and shall contain the transient suppression and protective circuitry necessary to produce reliable performance in the electrical environment existing on the cars.

a. The LVPS shall be automatically self-starting under dead battery conditions (Dead Battery Start feature).

b. The Dead Battery Start feature shall provide sufficient energy to permit the closure of the Main Circuit Breaker (detailed in Section 10,

Propulsion and High Voltage) after the pantograph is manually raised, even when the 37.5V battery is dead.

c. Details for the dead battery start feature shall be submitted. **(CDRL 09-08, Design Details For the LVPS)**

2. The output efficiency shall be a minimum of 80 percent from 20% to 100% of full load.

3. The LVPS shall limit transients to ±10% of nominal voltage as a result of any step load change with the battery connected. The maximum overvoltage shall not exceed 42 Volts.

4. Appropriate fault and operation indicating lights and test switches shall be provided. Location and features of lights and test switches shall be proposed for approval.

5. No external reset on the enclosure shall be provided.

6. Remote reset of overload or other fault conditions shall be possible from the cab. Refer to Section 5, Operator's Cab.

7. In the event of a loss of output from the supply, a signal shall be sent to the fault monitoring system.

I. The output shall be 37.5 Volts DC ± 5% (35.5 VDC to 40.5 VDC) over the range of zero to 100 percent load with a recovery time following load or supply transients no greater than 0.5 second in duration.

1. Proper harmonic filtering shall be provided.

2. Response to turn-on and startup surges shall be sufficient to prevent activation of protective devices on this or other equipment.

3. The Contractor shall ensure that output ripple harmonics are within the acceptable limits of the apparatus connected to the low voltage power supply whenever the main storage battery circuit breaker is tripped.

4. The LVPS shall not, from any cause by any mechanism, subject any connected load to any transient voltage with a peak amplitude more than ± 2500 Volts or an energy content in excess of 80 watt-seconds, and all connected equipment shall be capable of withstanding these transients.

J. The low voltage power supply system shall be designed to provide layover battery charging during times of car storage.

1. This may be accomplished by the main LVPS system, a separate trickle charger, or other approved means.

2. If a trickle charger is used, the trickle charger power supply for car storage shall receive input power from the main transformer tertiary winding and shall otherwise be completely independent.

3. Separate filtering may be utilized if a reduction in weight or volume can be achieved.

4. This power supply shall operate to maintain battery charge and supply the marker lights, layover heating controls and other 37.5 Volt storage loads for the car.

K. Details for the entire low voltage power supply system shall be submitted. **(CDRL 09-08, Design Details for the LVPS)**

9.5.2 Enclosure

A. The LVPS shall be installed in an underfloor enclosure with all components internal to the box, except for certain circuit breakers. The contractor may propose for approval to have the LVPS in the same enclosure with the auxiliary power supply.

B. External non-energized fins mounted to the box walls shall be used to dissipate heat.

C. Forced cooling of externally mounted heat sinks may be proposed for approval. If used, the control electronics and power semiconductors shall be protected from dust and water and shall include over-temperature protection. Operation of any forced cooling (if used) shall not be reliant on the operation of the API.

D. The enclosure shall meet the requirements of Section 3, Carbody. This enclosure may be part of the auxiliary power supply enclosure, if desired.

E. The LVPS shall meet or exceed the shock and vibration requirements of IEC 61373.

9.5.3 Protection

A. Whenever the LVPS output voltage exceeds 40.5 Volts, the low voltage power supply shall shut itself down.

1. The overvoltage circuit shall be immune to activation from externally applied voltages.

2. The time period of the overvoltage detection shall be coordinated with the auxiliary power system design and the transient conditions that occur when loads are switched off or shed, so that nuisance trips do not occur.

3. No automatic resetting of the overvoltage detection shall be used; manual resetting shall be possible from inside the enclosure and from the cab.

B. A main circuit breaker shall protect the power supply from major current overloads or short circuits and shall be inside the enclosure.

C. The voltage regulation controls of the power supply or an approved alternate methodology shall be used to keep the output current within design limits under peak battery charging conditions.

D. Current limit and voltage control algorithms shall be designed in coordination with the battery supplier to ensure that the battery shall not be overcharged and shall not overheat to the point where there is any risk of damage or degradation to any battery cells.

E. Circuit breakers shall protect equipment and wiring from potentially damaging current levels.

F. Each LVPS shall have output protection for overvoltage, undervoltage, overcurrent, overtemperature, excessive distortion, switching device failure and ground fault protection.

1. Protective measures shall be self-resetting to the extent possible.

2. Lockout due to repeated occurrences of the same fault shall be proposed for approval.

3. The LVPS shall detect internal device failures and respond with appropriate protective action.

4. An output short circuit shall not damage the LVPS and shall not result in the need to manually reset any protective device.

    a. Output wiring shall be rated to support the continuous current output of the LVPS under output short circuit current conditions.

5. Circuit breakers' status and faults shall be monitored and reported to the vehicle monitoring and diagnostic systems per Section 18, Monitoring and Diagnostics.

G. The Contractor shall provide a comprehensive description of all LVPS protective features. **(CDRL 09-09, LVPS Protective Features)**

1. This shall include input protection analysis, description of all other protective features, including identification of triggering events and sequence of protection operation, and description of proposed resetting schemes, including automatic and manual resets.

9.5.4 Circuit Arrangement

A. The output of the low voltage auxiliary power supply shall be routed to a low voltage distribution switchboard located in an electric locker located at the rear wall of the "F" end cab.

1. Individual approved circuit breakers shall be used to protect each branch supply required by this Section. The status of all circuit breakers shall be monitored by the VMDS (see Section 18, Monitoring and Diagnostics).

2. The negative return current from each branch shall run individually to an approved single pole switchable terminal block, Weidmuller WSI6 with LED or approved equal, located within an underfloor enclosure meeting the requirements of Section 3, Carbody, and arranged for easy access from the side of the car.

3. Each branch return circuit shall be floated from the carbody.

4. The terminal block shall be arranged to allow rapid tracing of a grounded branch circuit by opening the switched connections in the terminal block.

5. No tools shall be required for this action.

B. The entire circuit arrangement details shall be submitted. (**CDRL 09-10, Low Voltage Distribution)**

9.6 Fault Indicators

A. The failure or loss of output of the inverter, the low voltage power supply, or the trickle charger (if used) in the auxiliary power system shall be annunciated to the Operator by the fault monitor system on a train basis in accordance with Section 18, Monitoring and Diagnostics.

B. In addition, local indicators on the equipment shall confirm the status of the equipment.

1. These shall be visible through the enclosure wall or access cover.

9.7 Storage Battery

9.7.1 General

A. Each car shall have a storage battery and battery compartment, which shall meet the requirements of APTA standard RP-E-007-98R1, Recommended Practice for Storage Batteries and Battery Compartments.

B. Nominal battery voltage of 37.5 VDC shall be provided to the DC power distribution system in each car.

C. The battery system shall be a reliable service proven design that provides the latest available technology in passenger rail and provides the longest life cycle cost effective system. The battery chemistry shall be optimized for SEPTA's rail applications and shall be subject to review and approval.

D. The battery system shall be installed to be accessible from the side of the car.

E. The battery system shall be designed and constructed to be suitable for operation under the environmental conditions as defined in Section 2, Design and Performance Criteria.

F. In conjunction with power supplied through the battery trainlines, the battery shall support normal operation with the low voltage power supply output lost for at least 90 minutes before the voltage at any low voltage apparatus drops below minimum operational voltage limits.

G. In the event that catenary power is lost for any reason, the battery shall have capacity sufficient to maintain critical car functions and essential loads operational for at least 90 minutes. In this instance no power availability from the trainlines shall be assumed, and non-essential loads shall be shed to achieve this objective. Refer to TS 9.3.5.

H. In addition, the battery shall have the capacity to supply all low voltage power loads which exist when the car is shut down to a minimum of 25 volts (measured at the load) a minimum period of 58 hours.

I. The battery system proposal shall include all appropriate rail passenger vehicles standard(s) for battery chemistry and battery sizing.

J. In all analyses, the initial condition shall be assumed to be 85 percent of full charge level for a new battery.

K. The storage battery shall be designed to deliver a minimum of 2,000 deep discharge cycles without a permanent capacity loss greater than 20 percent.

L. An auto-filling feature with a single point filling location shall be provided. Details of the auto-filling feature shall be provided for review and approval. Details for any special equipment required for water filling shall be provided for review and Approval.

M. All battery connectors and connection hardware shall be corrosion resistant.

N. The battery system shall be recharged by the battery charger as specified in this specification.

O. As an option, a single battery per married pair may be proposed for SEPTA review and Approval if it can be demonstrated that it will reliably meet the required loads for both vehicles in a married pair after load shedding and meet the overall married pair emergency loads operational requirements.

P. The contractor shall submit a load analysis, including load profiles, operating conditions, de-rating factors and other parameters for battery sizing. **(CDRL 09-11, Storage Battery Sizing)**

9.7.2 Battery Capacity

A. The battery system shall have the capacity to supply all essential loads for a minimum of 90 minutes and maintain voltage within equipment operating limits in the event no output is available from the LVPS.

B. A discharge rate beyond the rating of the battery shall not reduce the battery capacity.

C. Complete discharge of the battery shall not permanently damage the battery.

D. A load shedding device shall be provided to disconnect all DC loads, so the car battery is not damaged running the battery voltage to 0V. The device shall allow at minimum all emergency and vital loads to remain powered by the battery until rated discharge voltage as specified by the battery manufacturer. When the battery discharge voltage is attained the load shed device shall automatically operate to disconnect all loads from the battery. Upon restoration of power by the LVPS, the load shed device shall automatically re-engage all DC loads without requiring any user interaction. A plan for the essential loads and the loads to be shed shall be submitted for review and approval.

E. The battery system supplied as spare parts, shall be properly configured for long term storage in unheated conditions. Any instructions required for battery preparation prior to use shall be included with each spare battery.

F. Nickel Cadmium Alkaline Batteries shall include clear casing to allow for ease of checking electrolyte level.

9.7.3 Battery Protection

A. A double pole main battery circuit breaker of approved design shall be mounted in an environmentally protected enclosure and as close as possible to the battery. The circuit breaker shall incorporate a shunt trip device and shall disconnect the battery from car wiring when the battery temperature is excessive as defined by the battery supplier. An alternate battery over-temperature protection scheme may be proposed for review and approval.

B. The circuit breaker shall be rated to withstand the short circuit capacity of the battery and shall be connected into the B+ and B- leads from the battery terminals.

C. The battery shall also be connected by a two-pole circuit breaker to a trainline of adequate capacity to permit one car in a train to supply a second car which has an inoperative low voltage power supply and a fully discharged battery, so as to continue normal train operation.

D. The battery trainline and associated coupler contacts shall be suitably sized and suitably protected with circuit breakers to avoid damage in the event of a short circuit at any point on the battery trainline for any length train.

E. Electrical designs shall be in accordance with Section 16, Workmanship and Materials.

9.7.4 Battery Box

A. The battery shall be housed in an approved rattle-proof stainless steel battery box located under the car floor adjacent to the car side in an approved convenient location.

B. Ventilation shall be provided through filtered holes in the box to minimize dust accumulation and avoid any gas build up as required by the battery supplier. Details of the ventilation design shall be standards based and shall be submitted for review and approval. Ventilation shall be designed according to EN 50272-2. Calculations to indicate that hydrogen concentrations will remain within acceptable limits shall be performed and submitted for approval for worst case normal condition with suitable justification, and also for typical failure condition including but not limited to:

   1. One shorted cell

   2. Malfunctioning temperature sensor

C. All cells shall be fully and easily accessible for servicing to permit inspection and maintenance from the side of the car without removing the battery box.

D. The battery box cover shall be hinged and be watertight and permit full access to the battery compartment without requiring cover removal.

E. Means should be provided within the box to prevent lateral and longitudinal movements of the battery cells and crates using approved fire-resistant material.

F. The box floor shall have a drain inboard of the running rail.

G. The battery trays shall be mounted on a locking slide-out tray for ease of servicing.

   1. The rearmost cells shall have vertical line of sight visibility to the filler caps when the tray is extended.

   2. Sufficient slack shall be provided in the battery cables to permit tray movement, and anti-chafing materials shall be applied to prevent damage to the cables.

   3. The tray shall lock in the fully extended and fully retracted positions.

H. Fiberglass or other approved fire resistant easily replaceable filtering media shall be applied to ventilation openings to prevent dust ingress due to car motion.

I. The battery box shall be completely self-draining to allow flushing of the battery with water.

J. Wire terminations shall be both labeled and color coded.

K. The battery and battery enclosure shall meet or exceed the shock and vibration requirements of IEC 61373.

L. The Contractor shall submit details of the battery enclosure, accessibility covers, and pull-out tray. **(CDRL 09-12, Storage Battery Enclosure)**

9.7.5 Battery Marking

A. Each battery cell or each battery unit shall be permanently marked with the following information:

1. Manufacturer's name
2. Battery type
3. Catalog or part number
4. Nominal rated capacity
5. Serial number
6. Date manufactured
7. Warning and safety precautions
8. Blank space where installation date can be written.

B. Markings shall be resistant to the chemical and mechanical environment encountered in service for the design life of the cell.

C. Polarity of the positive cell terminal shall be identified by a red post insulator or bushing and/or a plainly marked P, POS or + symbol. Polarity of the negative post shall be identified with a black post insulator or bushing and/or a plainly marked N, NEG or - symbol.

9.8 Circuit Breaker Panels

9.8.1 General

A. Each electrical subsystem energized from the auxiliary power system shall be protected by a circuit breaker.

B. All circuit breakers shall be arranged and sized commensurate with the wiring which they are intended to protect.

C. All circuit breakers provided shall be extremely rugged and fully suitable for the service intended.

D. Any one wire connected to a circuit breaker shall have sufficient current capacity to trip its breaker during an overload prior to the wire itself being damaged.

1. The Contractor shall have responsibility for the supervision of this effort.

E. Circuit breakers shall be mounted vertically so that the up position is "On".

F. Circuit breaker current rating shall be clearly and permanently marked and shall be completely visible after installation.

G. The ON, OFF, and TRIPPED position of all circuit breakers shall be permanently marked on the handle or the case of the circuit breaker. The circuit breaker, when tripped, shall assume a distinct position between the ON and OFF position to permit determination of the fact that it has been tripped. All circuit breakers labeling and marking shall be subject to Approval.

H. The status of all circuit breakers shall be monitored by the VMDS (Section 18, Monitoring and Diagnostics).

I. No load shall be fed by more than one breaker. Each breaker shall feed only one load. Any proposal for an alternate arrangement shall require specific approval for each instance.

J. Full details of all circuit breakers and fuses, including breaker panel details, rating, curve type, mechanical drawing, labeling, marking, anticipated normal and transient load current (e.g., locked rotor current – include duration), and load distribution wiring size and type shall be submitted. **(CDRL 09-13, Circuit Breakers and Fuses)**

9.8.2 Panel Arrangement

A. Circuit breaker panels shall be built into the car interior electric lockers as described herein.

B. The electric locker enclosures shall be lined with a minimum 0.12-inch thickness of polyester fiberglass mat or approved equal flame-retardant UL recognized material.

C. Each panel shall have an approved "dead front" of laminated phenolic or equal material, be arranged for easy access to all wire connections, and be designed to prevent an Operator from coming in contact with electrically live parts when operating circuit breakers.

D. The design shall be as lightweight as possible.

E. All circuit breakers shall be provided with a nameplate mechanically attached by non-screw fasteners on the "dead front" which clearly identifies the circuit and current rating, as approved. Proposals for approval may be made to provide circuit breakers with amperage rating permanently marked on the switch lever.

F. All wire connections shall be accessible from the front. Alternate arrangements may be proposed for approval.

G. The lists of circuit breakers given below are not necessarily complete; they are intended principally to identify the desired location for the various items listed.

9.8.3 Fuses

A. Circuit breakers shall be used for circuit protection wherever practicable.

B. Fuses may only be used with approval, where the use of circuit breakers is either impractical or inappropriate.

C. Fuses that are used to protect main auxiliary loads and main DC loads shall be clearly identified and permanently marked where possible and shall include a blown fuse indication.

D. See Section 16, Materials and Workmanship for additional details.

9.8.4 High Voltage Circuit Breaker Panel

A. The output circuits of the tertiary winding of the main transformer and the outputs of the auxiliary power supply inverter shall be protected by approved circuit breakers.

B. The 230 Volts circuit breakers may be located in the car interior in their own enclosure.

1. Circuit breakers for higher voltage circuits shall be located under the car, preferably in a centralized enclosure.

C. Circuit breakers shall be supplied to individually protect as a minimum the following circuits:

1. Inverter Input Power
2. Overhead Heat (2)
3. Floor Heat (2)
4. Layover Heat
5. Low Voltage Auxiliary Power
6. Air Compressor
7. Heated Windshields
8. Cab Heater
9. Threshold Heaters
10. Convenience Outlet Supply Transformer
11. Main Transformer Pump
12. Convenience Outlets
13. Main Transformer Fans
14. Traction Motor Ventilation Blowers
15. HVAC Units (Circuit Breakers as necessary to feed individual HVAC loads)
16. Spare (2)

9.8.5 Low Voltage Circuit Breaker Panel

A. The low voltage power supply output shall be controlled by approved circuit breakers.

B. These circuits shall be located in a circuit breaker enclosure with hinged cover located on the rear wall of the cab at the "F" end of the car.

C. Circuit breakers shall be supplied to individually control the following circuits as a minimum:

1. Local Traction Control
2. Friction Brake Control (2)
3. Cab Signal/PTC
4. Trainline Control
5. HVAC Control
6. Interior Lighting 1
7. Interior Lighting 2
8. Data Network System
9. Emergency Lighting
10. Cab Lights
11. Doorway Lights
12. Headlights
13. Auxiliary Lights
14. Marker Lights
15. Destination Sign Lights
16. Console Annunciator Lights
17. Public Address/Intercom
18. Destination Sign System
19. Door Control
20. Door Operators
21. Radio Power Supply
22. Automatic Train Control (ATC)
23. Positive Train Control (PTC)
24. Spare (3)

9.9 Auxiliary Power Inverter Standby Receptacles

A. To permit testing of the auxiliary power loads on the car in a shop environment where catenary power is not available to operate the auxiliary power inverter, standby power receptacles shall be installed to permit 230 Volts, 3 phase wayside shop power to energize the auxiliary power system loads downstream of the inverter, similar to the arrangement used on the SEPTA Silverliner V fleet.

B. Each car shall be equipped with a total of two 230 Volts, 4 pole grounded receptacles, located on each side of the car under the floor line near the center of the car, angled downward and sufficiently recessed and shielded to prevent debris damage.

1. These receptacles shall be connected using an approved transfer switch or similar means to positively interlock the auxiliary power inverter and the receptacles to prevent back feeding of either circuit.

2. Manual changeover controls located on the side of the car near the receptacles shall be provided.

3. An exterior amber LED indicator near each receptacle shall illuminate when the controls are arranged for receptacle power.

4. The receptacles shall have sufficient capacity to carry all 230 Volt, 3 phase loads simultaneously.

5. Shop power outlets are limited to 100A and certain loads, including but not limited to the air compressor, shall automatically be shed to keep the current drawn from the supply to less than 100A. For test purposes, it shall be possible to override any limitation on load operation via the TOD. Details to be discussed during design review.

6. Details for the design and control arrangements shall be coordinated with the existing SEPTA maintenance shop power connectors and shall be submitted. **(CDRL 09-14, Shop Power Receptacle)**

C. The car receptacle shall:

1. Be functionally identical with the present solder contact receptacle used on the SEPTA Silverliner V fleet, Eastern Connector Specialty Corp., New Milford, CT, model ZREP-C24-26S, or Approved equal,

2. Have four AWG 4/0 cable connections (with number 4 connector being grounded), rated at 900 Volts AC, 600 amps RMS circuit breaking.

9.10 Contract Deliverable Requirement List (CDRL)

The following CDRLs are refenced in this section:

CDRL 09-01, Auxiliary Power Supply Load Analysis....9-2
CDRL 09-02, Functional Description of the Auxiliary Power Supply Equipment....9-3
CDRL 09-03, Layover Mode Functional Description....9-5
CDRL 09-04, DC and AC Load Shedding....9-10
CDRL 09-05, Auxiliary Power Inverter Design Details....9-11
CDRL 09-06, API Protection Strategy, Isolation, and Grounding Scheme....9-13
CDRL 09-07, Low Voltage Power Supply Load Analysis....9-15
CDRL 09-08, Design Details for the LVPS....9-17
CDRL 09-09, LVPS Protective Features....9-18
CDRL 09-10, Low Voltage Distribution....9-19
CDRL 09-11, Storage Battery Sizing....9-20
CDRL 09-12, Storage Battery Enclosure....9-23
CDRL 09-13, Circuit Breakers and Fuses....9-24
CDRL 09-14, Shop Power Receptacle....9-27

9.11 CDRL Details

Submit the following in accordance with Section 25, Program Management and Commissioning.

CDRL 09-01 Auxiliary Power Supply Load Analysis

1. Submit during all Design Reviews auxiliary power inverter (API) AC connected loads power ratings to confirm API rating, details on sequence or staggered start of loads approach if required, worst case of normal operating conditions and starting currents, and Initial and final loads calculation.

CDRL 09-02 Functional Description of the Auxiliary Power System Equipment

1. Submit a detailed and comprehensive system functional description (SFD) for auxiliary power system (APS) prior to each design review. The SFD shall include details for:
    a. Operational concept,
    b. APS architecture and block diagram,
    c. Main vehicle interface,
    d. System components overview,
    e. Control functions,
    f. Cooling Method,
    g. APS protections and failure conditions, and APS diagnostic capabilities,
    h. Detailed descriptions of all major components of the auxiliary power system, how the components function and how they interact.
2. The SFD shall contain all descriptions, block diagrams, schematics, and other features necessary for SEPTA to clearly understand how the auxiliary power system functions and how it meets the requirements of this specification. The SFD shall be updated at each design stage as the system design is refined.

CDRL 09-03 Layover Mode Functional Description

1. Provide detailed description of the layover mode functionality during Preliminary and Final Design Reviews. Details shall include at a minimum:
    a. Conditions for transitioning into layover mode and recovery to normal operating mode,
    b. Loads and controls that will be disconnected during layover mode,
    c. Diagnostic and fault annunciation during layover mode if required,

d. Video Surveillance System status during layover mode.

CDRL 09-04 DC and AC Load Shedding

1. Submit during all Design Reviews details for load management of AC loads and DC loads under API and LVPS failure conditions and impact to single vehicle and married pair operation, load shedding and timing, and load shed recovery when failure conditions are removed.

2. The submittal shall contain all descriptions, block diagrams, schematics, and other features necessary for SEPTA to clearly understand how the load shedding functions for AC loads and DC loads and how it meets the requirements of this specification.

CDRL 09-05 Auxiliary Power Inverter Design Details

1. Submit details for the auxiliary power inverter during Preliminary and Final Design Reviews. Details shall include:

   a. Electrical design calculations to show that the selected devices, components, and circuits are fully capable of performing the required functions with adequate margin.

   b. Thermal analysis to show that the cooling system is adequate to keep the temperatures of all devices and components within margins consistent with operation over a 40-year life.

   c. Mechanical details to show that all devices are accessible for maintenance, and that all LRUs are accessible and exchangeable when the API is fitted to the vehicle.

   d. Components layout and Bill of material.

   e. EMI Filtering.

   f. Details for API Output Voltage regulation and tolerance, output maximum current, output voltage ripple, and heat loss.

CDRL 09-06 API Protection Strategy, Isolation, and Grounding Scheme

1. Submit during Preliminary and Final Design Reviews detailed description of protection schemes, triggering of events, lockout conditions, resetting, schemes, equipment grounding schemes, and isolation under failure conditions.

CDRL 09-07 Low Voltage Power Supply Load Analysis

1. Submit during Preliminary and Final Design Reviews analysis and description of all DC loads and worst-case calculation to confirm LVPS capacity.

CDRL 09-08 Design Details for the LVPS

1. Submit details for the LVPS/Battery Charger during Preliminary and Final Design Reviews. Details shall include:

    a. Electrical design calculations to show that the selected devices, components, and circuits are fully capable of performing the required functions with adequate margin.

    b. Thermal analysis to show that the cooling system is adequate to keep the temperatures of all devices and components within margins consistent with operation over a 40-year life.

    c. Mechanical details to show that all devices are accessible for maintenance, and that all LRUs are accessible and exchangeable when the LVPS/Battery Charger is fitted to the vehicle.

    d. Components layout and Bill of material.

    e. EMI Filtering.

    f. Details for LVPS/Battery Charger Output Voltage regulation and tolerance, output maximum current, output voltage ripple, and heat loss.

CDRL 09-09 LVPS Protective Features

1. Submit during Preliminary and Final Design Reviews detailed description of protection schemes, triggering of events, lockout conditions, resetting, schemes, and isolation under failure conditions.

CDRL 09-10 Low Voltage Distribution

1. Submit during all design reviews the detailed description of the low voltage distribution arrangement.

2. The submittal shall contain all descriptions, block diagrams, schematics, and other features necessary for SEPTA to clearly understand how the low voltage distribution functions and how it meets the requirements of this specification.

CDRL 09-11 Storage Battery Sizing

1. Submit during all design reviews the detailed analyses and validation of methods used to size the battery to support all essential and emergency loads and battery discharge curve under environmental conditions.

2. The submittal shall contain all descriptions, analyses, reports, and other features necessary for SEPTA to clearly understand how the battery meets the requirements of this specification.

CDRL 09-12 Storage Battery Enclosure

1. Submit during all design reviews detailed description of the battery enclosure, battery tray, ventilation, accessibility and maintainability, and markings.

CDRL 09-13 Circuit Breakers and Fuses

1. Submit during all design reviews full details of all proposed circuit breakers and fuses. Details shall include, but not be limited to:

    a. Breaker panel details, including drawings, renderings, breaker identification label details, any other panel labeling and marking, wire support,

    b. Manufacturer's datasheets for devices,

    c. Device Ratings,

    d. Device Trip/fuse curves,

    e. Device Mechanical drawings, including mounting and terminal details,

    f. Anticipated normal and transient load current for each device (for example: motor locked rotor current – also include normal motor start duration),

    g. Load distribution wiring size and type for each device.

CDRL 09-14 Shop Power Receptacle

1. Submit during all design reviews full details for the shop power receptacle. Details shall include, but not be limited to:

    a. All component data, including but not limited to connector, switches, and indicators,

    b. Mounting location,

    c. Wiring.

9.12 Standards

The following standards are refenced in this section:

APTA Standard RP-E-007-98R1	Recommended Practice for Storage Batteries and Battery Compartments
IEC 61287-1:	Railway applications - Power converters installed on board rolling stock - Part 1: Characteristics and test methods.
IEEE 16:	IEEE Standard For Electrical And Electronic Control Apparatus On Rail Vehicles

IEEE 1476:	IEEE Standard for Passenger Train Auxiliary Power Systems Interfaces
IEC 61373:	Railway applications - Rolling stock equipment - Shock and vibration tests.

SECTION 10
PROPULSION AND HIGH VOLTAGE SYSTEM

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10.1 Propulsion

10.1.1 General

A. The propulsion system traction motors and converter design shall be service proven in North American commuter railroad service of comparable demand and severity.

B. A separate AC traction motor shall drive each axle through a gear unit.

1. The traction motors shall be controlled by suitably rated variable voltage, variable frequency traction inverters. There shall be one inverter per truck.

2. A system with single inverter per motor may be proposed for Approval provided the system demonstrates superior reliability, availability, and maintainability. A single inverter per car proposal will not be acceptable to SEPTA.

C. Power for the traction inverters shall come from one or more DC links supplied by traction windings of a main transformer through rectifying four quadrant converters.

D. The four-quadrant converter shall be capable of compensating for normal catenary line voltage variations, capable of drawing a unity power factor load, and capable of controlled return of regenerated braking energy to the main transformer and the overhead line within receptivity limits and at unity power factor. Note the requirements defined in Section 2, Design and Performance Criteria, concerning measurements and analysis of the catenary system, and line current limits.

E. Propulsion system controls shall provide for continuously modulated acceleration and dynamic braking in response to trainlined commands.

1. Propulsion system controls shall also provide for wheel slip and slide control to maximize the use of available wheel-to-rail adhesion during acceleration and braking and to minimize wheel tread damage due to sliding.

F. The propulsion system shall provide for operation of auxiliary loads, including auxiliary converters through short interruptions in the overhead line supply, including through phase gaps. Power to auxiliary loads shall be maintained using the traction motors in regenerative brake to use the car kinetic energy. This feature shall be maintained to the lowest speed possible without incurring the risk of the car stopping in a dead section of wire. Details shall be included in the system functional description (SFD). Characteristics of the overhead supply used to determine an appropriate minimum speed should be as detailed in Section 2, Design and Performance Criteria.

G. The contractor shall provide a detailed and comprehensive SFD for the propulsion system prior to each design review, and at propulsion converter FAI. The SFD shall include detailed descriptions of all major components of the propulsion system, how the components function and how they interact. The SFD shall contain all descriptions, block diagrams, schematics, and other features necessary for SEPTA to clearly understand how the propulsion system functions and how it meets the

requirements of this specification. Except where assigned a specific CDRL, all design and equipment details noted as requiring submission shall be included in this CDRL and be clearly identified as such in the submittal. The SFD shall be updated at each design stage as the system design is refined. **(CDRL 10-01, Propulsion System Functional Description)**

10.1.2 Starting and Stopping

A. This section describes apparatus that will start and assist in stopping the train.

1. Whether specifically mentioned or not in this section, any and all hardware and software required to provide a system that meets the requirements of this Technical Specification shall be included by the Contractor.

2. The Contractor is responsible for the careful coordination of the design efforts of the propulsion and friction brake system suppliers to ensure proper interface and Specification compliance.

3. All details of the equipment necessary to establish compliance with the performance requirements of these specifications in accordance with Section 2, Design and Performance Criteria, shall be submitted at the CDR (Conceptual Design Review), and then updated as the design progresses through PDR and FDR. **(CDRL 10-01, Propulsion System Functional Description)**

4. All propulsion equipment shall be self-protecting and not depend on Operator intervention or removal from service to avoid equipment damage or the occurrence of an unsafe condition. As far as is reasonably practicable, all faults that do not require the lockout of equipment shall not require operator intervention to cause the equipment to restart operating on demand when the condition causing the fault has cleared. Where any Operator intervention is required (including, but not limited to a reduction in power demand to zero before reapplication of power), this shall be clearly indicated to the engineer via the TOD.

5. The equipment supplied for each car shall have the following salient features:

    a. A propulsion system.

    b. Separate friction brake blending/wheel slide control for each truck. Refer to Section 12, Friction Brake, for details regarding the friction braking and wheel slide system.

    c. Performance meeting the requirements of Section 2, Design and Performance Criteria.

    d. Design and construction of all motors, gear units and power conditioning apparatus such that a 500,000 mile overhaul cycle will be achieved without intermediate maintenance activity beyond routine inspection and servicing.

(1) Packaging meeting the requirements of Sections 2, Design and Performance Criteria, and Section 16, Materials and Workmanship, and shall withstand the impacts of wayside debris, typical of urban/suburban US railroad transit operation.

6. Silverliner VI trains will be operated manually by an Operator normally from the front cab, but possibly from any cab in the train.

7. The apparatus shall be designed to maximize the probability of completing a trip, particularly regarding detection circuitry and non-critical failure modes. Under partial equipment failure or overload conditions, maintaining operation at reduced performance to complete a trip shall be prioritized over maintaining specified performance where that may present a risk of in-service failure.

8. Normal service braking shall be accomplished electrically, using the traction motors as controlled alternators, supplemented by a coordinated pneumatic friction brake system.

    a. Regenerated braking energy shall be returned to the DC link for use by car auxiliaries, and for return to the overhead line.

    b. A dynamic brake resistor shall be included in the design to absorb and dissipate regenerated energy during periods where the energy regenerated exceeds the auxiliary load capacity and the overhead line receptivity is insufficient.

9. Load weighing shall be provided to meet the requirements as defined in Section 2, Design and Performance Criteria.

10. Automatic compensation for wheel wear shall be provided.

    a. The maintainer shall enter wheel size details for the wheels of axle number 2 after wheel turning.

    b. The propulsion system shall automatically determine the size of other wheels based on relative wheel speed when coasting above a speed consistent with obtaining a reliable value for wheel size.

    c. Details for wheel wear compensation shall be provided. **(CDRL 10-01, Propulsion System Functional Description)**

10.2 Design Parameters

A. The cars shall operate satisfactorily and shall perform in accordance with the requirements of Section 2, Design and Performance Criteria, when in service on the SEPTA Railroad Division, and the Amtrak Northeast Corridor and Harrisburg Line.

10.2.1 Voltage Variations

A. The propulsion system shall operate as defined in Section 2, Design and Performance Criteria, with variations in the overhead supply voltage.

1. Current draw shall be in accordance with Section 2, Design and Performance Criteria requirements.

2. The apparatus shall tolerate intermittent power supply as occurs as a result of pantograph bounce, overhead wire gaps, poor wire tension, snow and ice storms or other inclement weather affecting catenary contact.

a. Operation shall be without damage to any part, or unnecessary activation of any protective circuits or devices; unnecessary being defined as activation when no equipment fault has occurred.

b. Operation of auxiliary loads through short interruptions in the overhead line supply shall be maintained using the traction motors in regenerative brake to use the car kinetic energy.

10.2.2 Jerk Rate

A. The rate of change of acceleration or deceleration shall be in accordance with the requirements of Section 2, Design and Performance Criteria, under all conditions other than emergency braking, Carwash mode, Yard mode, spin/slide correction or loss of power supply.

B. The control logic and its parameters shall be submitted. **(CDRL 10-01, Propulsion System Functional Description)**

C. The suitability of the method shall be demonstrated on the Pilot Cars and any necessary optimization modifications shall be implemented, tested, and Approved.

10.2.3 Response

A. Propulsion system response times shall be as detailed in Section 2, Design and Performance Criteria.

10.2.4 Duty Cycle Rating

A. Duty cycle rating shall be as detailed in Section 2, Design and Performance Criteria.

10.2.5 Towing

A. Towing operating requirements are stated in Section 2, Design and Performance Criteria.

10.2.6 Low Voltage Power Supply Limits

A. The propulsion, dynamic and friction brake apparatus shall function in a normal manner and meet all Specification requirements when the low voltage power supply output is in the range specified in Section 9, Auxiliary Power.

1. Continuous application of any voltage in that range shall not be injurious to the apparatus, shall not adversely affect its operation or cause it to operate in an unsafe manner.

2. Voltages above that range shall be protected against and shall not cause operation in any unsafe manner.

3. Fusing shall not be used to achieve this requirement.

4. Similarly, voltages below that range shall not cause operation in any unsafe manner.

5. Details of the protective methods used to meet these requirements shall be submitted. **(CDRL 10-01, Propulsion System Functional Description)**

10.2.7 Transient Generation and Protection

A. The propulsion and friction brake control systems shall not generate transients or electrical noise injurious to or affecting the satisfactory operation of any other apparatus on the car, as detailed in Section 2, Design and Performance Criteria.

1. If necessary, isolated DC-to-DC power supply techniques shall be used.

2. The Contractor shall coordinate this interface among all suppliers.

B. The electronic components of the apparatus shall have susceptibility and emissions characteristics conforming to IEEE Std 16, and EN 50155 and relevant standards referenced therein.

10.2.8 Wayside Interference

A. The cars will operate with wayside signal systems which utilize power frequency and audio frequency track circuits sharing rail traction return. The signal systems also include Amtrak track circuits and cab signals, with characteristics as defined in Amtrak curve A-60-7659 (latest revision), modified by Amtrak drawing SP 920.

1. The car and all installed equipment shall be electromagnetically compatible with itself, and the wayside as specified in Section 2, Design and Performance Criteria.

2. The propulsion supplier shall perform an analysis of the electrical noise produced by the propulsion system in accordance with Section 2, Design and Performance Criteria.

a. Additionally, the supplier shall conduct a full-scale laboratory test using simulated running rails, and with equipment oriented as it will be installed on the car, to verify the analytical findings.

(1) Throughout this process the propulsion supplier shall communicate the findings to the cab signal/ATC supplier and SEPTA to ensure that the new cars and the existing signal system are fully compatible.

B. The propulsion system shall include a line current interference current monitoring unit (ICMU). The unit shall detect any instance of line current harmonics that appear in the signaling bands, and that exceed safe operating levels.

1. When harmonic current exceedances are detected, the ICMU shall inhibit the operation of the propulsion system in a failsafe manner. When the exceedance is no longer detected, the propulsion system may be restarted.

2. Repeated inhibitions due to harmonic current exceedances shall lead to a lock out of the propulsion system.

3. It shall be possible to inhibit the operation of the ICMU using a PTU.

C. Full details of the ICMU shall be submitted. Submittal shall detail how the ICMU shall operate and interface to the propulsion system. **(CDRL 10-12, Interference Current Monitoring Unit)**

10.3 Propulsion System

10.3.1 Response to Power Commands

A. A DC current loop P-wire trainline shall transmit the tractive effort command. Refer to Section 5, Operator's Cab, and Section 17, Network and Trainline Control, for further details. Propulsion acceleration shall be controlled in response to the P-wire trainline command. This P-wire value shall also be recorded by the FRA Event Recorder. Refer to Section 20, Automatic Train Control and Positive Train Control.

B. Redundant control shall be provided for backup in the event of failure of the P-wire signal consisting of three trainlines fed by the master controller.

1. The power commands shall include the ability to produce initial acceleration rates of 1.0, 2.0 and approximately 3.0 miles/hour/second to the propulsion system's base speed, and then at 1/3, 2/3, and maximum capability respectively at higher speeds.

Master Controller Position	Trainline A	Trainline B	Trainline C
P1	1	0	0

P2	1	1	0
P3	1	1	1

2. Any trainline combination other than these shown shall be detected as fault condition, and the propulsion system shall assume a coast command and indicate a fault.

3. The VMDS shall automatically detect a failure in the P-wire circuit and provide a signal to all relevant systems to fall back to the redundant trainlines. A failure message shall be displayed on the TOD.

C. Propulsion control shall be modified by trainline signals for Yard mode and for Carwash mode. Refer to Section 7, Heating, Ventilation, and Air Conditioning, and Section 17, Network and Trainline Control, for further details.

1. The propulsion system mode shall be according to the relevant trainline signal as detailed in the table below:

Yard Trainline Status	**Carwash Trainline Status**	**Propulsion Mode**
0	0	Normal Mode Fault to be logged in Propulsion Event Recorder and transmitted to VMDS (Vehicle Monitoring and Diagnostics Subsystem) to indicate propulsion mode signal discrepancy.
0	1	Carwash Mode
1	0	Yard Mode
1	1	Normal Mode

2. In Normal mode, between the Minimum Power position and Maximum Power position of the master controller, the Propulsion System shall provide continuously-variable (within the resolution limits of the control, but with a minimum resolution of 0.2 miles/hour/second) propulsion tractive effort.

a. At the minimum power position, the vehicle shall be coasting, applying no traction effort, with exceptions as necessary for rollback control.

b. At the maximum power position, initial acceleration rates shall be approximately 3.0 miles/hour/second, as required to meet the

acceleration requirements as defined in Section 2, Design and Performance Criteria.

3. Yard mode shall be provided for coupling of cars and slow movements.

    a. In Yard mode, tractive effort demand shall be modified so that between the Minimum Power position and Maximum Power position of the master controller, propulsion tractive effort shall be limited between 0% (Coast) and 12% of maximum tractive effort.

    b. When car speed exceeds 5mph, propulsion shall be inhibited and if necessary, braking shall be applied to limit speed. When car speed exceeds 8mph, a penalty brake shall be initiated.

    c. Jerk rate limitation shall be 0.5 mph per second per second.

    d. The speed limit, jerk rate and maximum tractive effort parameters for Yard mode shall be user-configurable within contractor defined limits via the PTU.

4. The Carwash mode shall be provided to enable the Operator to maintain an appropriate speed through the car wash facility.

    a. In Carwash mode, tractive effort demand shall be modified so that propulsion tractive effort shall be limited between 0% (Coast) and 12% of maximum tractive effort.

    b. When the master controller is in the Minimum Power position, the propulsion tractive effort shall be set to 0% (Coast).

    c. When the master controller is in any power position other than the Minimum Power position, the train speed shall be controlled to 3mph +/- 10%, using propulsion and brake control as necessary.

    d. Jerk rate limitation shall be 0.5 mph per second per second.

    e. The speed limit, jerk rate and maximum tractive effort parameters for Carwash mode shall be user-configurable within contractor defined limits via the PTU.

    f. If any part of the propulsion system that is cooled by forced air is not tolerant of the chemicals in the car wash, then the forced air cooling for those parts shall be shut down in Carwash mode and shall restart automatically when Carwash mode is exited.

    g. Any parts of the propulsion system that are normally cooled by forced air and where the force air cooling is required to be shut down in Carwash

mode shall be capable of normal operation at Carwash speeds without forced air cooling.

5. The coast position shall be free running unless otherwise approved.

6. The rates of change of acceleration shall not exceed the jerk limit except where otherwise specified.

7. The propulsion apparatus shall place enough load on the control trainlines to avoid "dry circuit" type problems. Details shall be submitted. **(CDRL 10-01, Propulsion System Functional Description)**

8. A maximum speed limit function shall be contained within the control logic and shall be initially set at maximum operating speed as defined in Section 2, Design and Performance Criteria.

    a. The speed limit shall be user-configurable within contractor defined limits via the PTU.

9. Tractive effort shall be modified under wheel spin conditions during motoring and under wheel slide conditions in dynamic braking in accordance with Section 12, Friction Brake. Details of wheel spin/slide control shall be submitted. **(CDRL 10-01, Propulsion System Functional Description)**

10.3.2 Configuration

A. All power converter parts shall be readily accessed either through the opened covers of the converter or by providing the ability to slide a modular component outward, while not requiring removal from the car.

B. Designs which require a module to be taken to another location for repair are not acceptable unless the module weighs 50 pounds or less.

1. The design shall permit the removal of a module that exceeds 50 lbs. without difficulty.

2. If a module weighs more than 50 lbs., special provisions shall be made for handling without damage.

3. Any item or assembly that requires maintenance, and that exceeds 25 lbs. shall have a heavy item warning label affixed that also indicates the weight of the item or assembly.

C. The DC link shall have a conservatively rated filter capacitor bank.

1. The capacitor bank shall be modular, branch fused, and the failure of any capacitor branch shall be detected, annunciated, and logged on a module basis.

2. The filter rating shall accommodate continued system operation with a single failed capacitor branch.

3. Alternative methods of failure detection and response that enhance operational reliability may be proposed. **(CDRL 10-01, Propulsion System Functional Description)**

D. The inverter design shall use Insulated Gate Bipolar Transistor (IGBT) switching elements to minimize size and weight. Alternative technologies (including, but not limited to the use of SiC devices) may be proposed. **(CDRL 10-01, Propulsion System Functional Description)**

1. They shall have prior electric traction operating experience or shall be a device, or be a member of a family of devices, designed specifically for electric traction applications.

2. To minimize temperature excursions, they shall be mounted such that a low thermal impedance exists between the device and the point of heat exchange with the atmosphere.

3. During design review, the supplier shall present the results of laboratory tests that establish that the temperature excursions experienced by the device will not result in a service life of less than 20 years in service.

4. All power semiconductors shall be housed in watertight, dustproof enclosures and shall not be exposed to any non-captive moving air stream.

5. Immersed fluid bath power semiconductor cooling shall not be used.

E. The point of heat exchange with the atmosphere shall be external to the sealed enclosure.

1. Heat exchange fins may be supplied on one or more walls of the enclosure or may be mounted in an air channel surrounded by the enclosure yet external with respect to the environmentally sealed portion.

2. The heat exchanger may be either a solid metal heat sink or a sealed "heat-pipe" clamped-on liquid filled device in which a captive liquid undergoes changes of state to achieve high thermal transfer capacity while providing a low thermal impedance to the semiconductors.

3. If used, heat-pipes shall be sealed for life and shall be suitable for use under all specified temperature extremes under all car and spare part storage and operational conditions.

4. A combination of the two techniques or an air-to-air heat exchange method in which captive air is circulated internally to transfer heat from the semiconductor heat sink to the heat exchanger may also be employed.

5. Under no circumstances shall there be electrically live surfaces external to the converter/inverter enclosure. All high temperature components shall be shielded from accidental maintenance personnel contact.

F. Air flow across the heat exchanger fins shall be accomplished by motion of the car.

1. The location of the propulsion system enclosures shall be integrated with the car design such that motion of the car will produce sufficient airflow across the heat sinks to produce the heat transfer required for the calculated power semiconductor life.

2. The Contractor may propose an alternate cooling method, using ventilation blowers which move air over the cooling fins. **(CDRL 10-01, Propulsion System Functional Description)** If the air source is from under the car, the blowers shall be of a design which through configuration or chemical coating has a very low level of dirt adherence. The layout of the equipment under the car shall be such as to avoid or minimize to an acceptable level any recirculation of heated air.

G. The propulsion system logic shall contain sufficient checks and safeguards to ensure operation in the commanded direction. The propulsion controls shall continuously monitor the validity of the trainline direction commands and shall inhibit accelerating tractive effort whenever an invalid trainline direction command is received, and train speed is below 3mph.

H. The inverter design shall be integrated with that of the traction motors to hold magnetically induced and mechanical noises from the motors to a practical minimum during the initial acceleration period.

I. The inverter-motor combination shall not produce torque pulsations or transients that might negatively affect the design life of the coupling, gear drive or truck components.

10.3.3 Master Controller

A. The master controller shall function as described in Section 5, Operator's Cab.

10.3.4 Cutout Switches

A. Individual cutout switches shall be provided for each propulsion inverter. The switches shall be located on the cab rear wall in a location readily accessible to the Operator.

B. The switches shall inhibit the propulsion inverters individually and independently.

C. Operation of the cutout switches shall not affect any fault or status indicators.

D. Operation of the cutout switches shall not affect the spin/slide system functionality of inverters that are not cutout.

10.3.5 ATC/PTC Interlocks

A. When the Automatic Train Control and/or Positive Train Control systems initiate a penalty brake application, all propulsion systems on the train shall be inhibited in a

failsafe manner. Details shall be as explained in Section 20, Automatic Train Control and Positive Train Control.

10.3.6 Rollback Protection

A. Measures shall be taken to limit rollback to less than 1.5s and less than 3ft on the worst-case grade and AW3 loading and shall be coordinated with the friction brake. These measures shall limit rollback even if the Operator initially does not request sufficient tractive effort with respect to the grade.

B. If rollback is not controlled to the specified limit, an automatic full service brake application shall be made to stop the rollback movement.

C. Details for rollback protection shall be submitted. **(CDRL 10-01, Propulsion System Functional Description)**

10.4 Dynamic Braking System

10.4.1 General

A. Dynamic braking shall be automatic at all speeds in response to trainline braking commands per Section 12, Friction Brake. Performance shall be as defined in Section 2, Design and Performance Criteria.

B. Regeneration to the main transformer shall not occur when there is no wayside supplied voltage present on the overhead catenary.

C. The dynamic brake and the friction brake shall be coordinated such that the total braking effort requested will be produced by a blending of the dynamic and friction braking.

10.4.2 Response to Braking Commands

A. The dynamic braking control system shall be integral with the propulsion control system and shall receive its commands from the braking control trainlines and the propulsion control trainlines. See Section 17, Network and Trainline Control.

1. It shall not automatically respond to downward changes in cab signal authorized speed, as this will be the responsibility of the train Operator through the mechanism of the master controller.

B. For both dynamic and friction brakes, loss of load weigh signal shall never result in production of braking effort at less than that required for a car weight of AW0 for the brake command in force.

1. Dynamic brake effort shall be modified under slide conditions in accordance with Section 12, Friction Brake.

10.4.3 Configuration

A. Dynamic braking shall be regenerative using the inverters and traction motors in a negative-slip operation.

1. When the preset line voltage limit and link voltage are approached, excess braking energy shall be blended with friction brakes.

2. The operation of the dynamic brake shall be fully independent of transient discontinuities in contact between the car and the overhead catenary.

3. Rapid transitions between dynamic braking and friction braking due to rapid changes in power system voltage or due to intermittent contact between the pantograph and the catenary shall be automatic and undetectable by the Operator or the passengers.

10.4.4 Friction Brake Interface

A. Dynamic braking interface with the friction brake system shall be by means of the friction brake control unit described in Section 12, Friction Brake.

1. Should a propulsion inverter fail to produce the commanded dynamic braking effort, the friction brake shall be applied to a level that will result in no less than the commanded brake rate being produced.

10.4.5 Braking Resistors

A. The requirements of this section apply equally to braking resistors, and if the functionality is not performed by the braking resistors, to transient voltage limiting resistors.

B. All dynamic braking resistors shall be placed on the car roof (see Section 2, Design and Performance Criteria) and their location and shrouding shall be designed to provide an adequate flow of air across them in both directions of car motion.

1. The braking resistors shall comply with the requirements of 49 CFR Part 238.225 (c).

2. They shall be designed for a service life of no less than 20 years in operation.

3. The resistor size and weight shall reflect the nature of their duty cycle and available cooling air and shall be held to the minimum.

4. They shall be manufactured of chrome-steel alloy or approved weight-effective equal.

5. All details of resistor sizing and construction shall be submitted. **(CDRL 10-01, Propulsion System Functional Description)**

6. All resistors and resistor groups shall be adequately insulated from their frames with the frame isolated from the carbody with high temperature insulation.

    a. Insulators shall be of a design that does not require cleaning at less than 5-year intervals.

    b. Provisions shall be made for expansion to prevent warping or distortion by heat.

    c. Cable connections shall be made at a location outside of the heated air flow and cables shall be shielded from radiant energy.

    d. All connection fasteners shall be corrosion resistant.

    e. The connecting cables shall exit the carbody downward in a watertight manner, and each cable shall be provided with a drip loop.

        (1) The cable and sealing materials shall use components designed for maximum service life in a roof top environment with high ambient temperatures.

7. All fasteners and hardware utilized in the mounting and construction of the resistors shall be stainless steel, the screening and the shrouding shall be of stainless steel.

10.4.6 Regeneration Cutout

A. A sealable switch in the cab shall allow regeneration to be minimized on a whole car basis.

    1. The "Normal" position shall allow regeneration.

    2. The "Cutout" position shall inhibit the regenerative braking by blocking the inverter operation of the four-quadrant line converter during the braking cycle.

    3. Placing the switch in the cutout position shall not prevent rheostatic dynamic braking from taking place, nor shall it prevent regeneration of energy to auxiliary loads when power is not available from the overhead line.

10.5 Propulsion Control Unit

10.5.1 General

A. Each converter package shall contain a control unit.

    1. The control unit shall be microprocessor based with peripherals which are necessary to meet all the required functions and performance criteria, and to interface with the vehicle network and propulsion trainlines.

2. The control unit shall function to make the propulsion inverter produce positive or negative tractive effort as commanded by the trainlines, interface with the control of the pneumatic brake control valves to provide the brake blending function, interface with the spin-slide function as detailed in Section 12, Friction Brake, and such additional functions as are necessary to provide a complete design.

3. The control unit shall be contained in the converter package in a location that minimizes the impact of heat and electromagnetic interference from the power converter. The control unit shall be accessible to a maintainer without exposing the maintainer to high voltage.

4. Each propulsion inverter shall be controlled with a maximum degree of independence and the overall design shall be such as to minimize the number of single point failures that can produce loss of tractive effort from any inverter.

5. The control unit shall only accept valid trainline commands, and shall detect, annunciate, and not respond to invalid patterns or commands.

    a. Adequate debounce protection (such as continuation of the invalid pattern for greater than a software-specified time, initially set to 1.0 second) shall be provided as approved to prevent nuisance fault messages.

    b. The response shall be to annunciate detection to the logging system, and to inhibit application of power to the motors fed from that inverter (with appropriate indications to the Operator) until the Operator has taken appropriate action with the cab reset switch.

    c. The invalid signal experienced shall be stored in non-volatile memory.

6. The control unit shall detect software or hardware malfunctions and monitor overall propulsion system operation with respect to the trainline commands.

7. Propulsion control unit shall contain an automatic self-test function which shall execute at start up. Any faults shall be annunciated. Self-test results shall be transmitted to VMDS. It shall be possible to execute the self-test using a PTU.

8. Details for the proposed control unit shall be submitted. **(CDRL 10-01, Propulsion System Functional Description)**

9. The entire unit package shall meet the requirements of Section 16, Materials and Workmanship.

10.5.2 Component Criteria

A. All electrical and electronic components shall meet the requirements of Section 2, Design and Performance Criteria, and Section 16, Materials and Workmanship.

10.5.3 Electrical Protection

A. Each control unit shall be protected against damaging exposure to high voltage power that might become connected to signal lines between the logic box and components which handle, or which are in close proximity to, sources of high voltage power whether due to low level short circuits or catastrophic failures. Examples are contactors, changeover devices, measuring devices, etc.

1. To obtain this protection, it will be acceptable to employ low cost, self-annunciating, easily renewed sacrificial elements.

2. Sensors and their feed wires shall be shielded against EMI/RFI as required for proper operation under all conditions.

10.5.4 Data Recording

A. The propulsion logic shall be equipped with an event recorder (referred to as Propulsion Event Recorder) with a separate non-volatile memory that can store all significant system operating parameters that occur over a period of at least 2 seconds at a frequency appropriate for the signal characteristics as approved, but at a time step of no more than 20 ms.

B. Updating and write-over will be programmed to cease whenever any of the fault flags are set or by manual local command.

C. In addition, whenever the car speed exceeds 5 miles/hour, reduced speed data collection shall be initiated such that principal operating parameters and signal lines during a 40 second period can be stored.

1. The data collection shall cease 5 seconds after the car stops.

2. This data shall be held until the car speed exceeds 5 miles/hour, indicating that normal car operation has resumed, after which normal frequency data collection shall be resumed overwriting the previously recorded data.

3. This data shall be accessible from the PTU.

4. The data shall be stored in the non-volatile memory. The non-volatile memory shall not lose the data in case of a power failure.

5. The Propulsion Event Recorder shall store and update the data regularly in the non-volatile memory.

6. The propulsion system shall annunciate to the maintainer when the non-volatile memory is full.

D. The activation of a manual command shall prevent any overwriting of the data already stored in the non-volatile memory.

1. This command shall be stored in the fault logging system and normal data collection shall not resume until a second, password protected command requests that the data is erased.

E. Provision shall be made on each car for indicating major subsystem states and faults on the TOD.

F. Control logic and signals from the propulsion subsystem shall be transmitted read-only to the VMDS and easily accessed using the PTU User Interface. Refer to Section 18, Monitoring and Diagnostics.

1. Both analog and digital and network data shall be readily accessible. It shall be possible to address significant logic signals for analysis and diagnosis. These signals shall include (but not be limited to) signals to and from contactors, external inputs and outputs, and network data.

2. Unless otherwise specifically Approved, the control unit shall have the capability of supplying analog outputs to a high impedance chart recorder or data logger for real time recording of propulsion data.

a. The control unit for each inverter shall have a minimum of 16 channels available, each channel having the ability to address all analogue and logic signals significant to analysis and diagnosis, including signals to and from contactors and all external inputs and outputs.

b. Scaling shall be integral with the design and require no supplementary effort by the user and shall be logically decoded.

c. There shall also be an addressable output that has an interface that meets resolution requirements. An Ethernet interface would be considered acceptable.

d. Jumper wires to a slave patch panel shall be provided in an approved location in the car interior near the cab for ease of test data collection.

e. Alternate arrangements may be proposed. **(CDRL 10-01, Propulsion System Functional Description)**

3. The PTU for the propulsion subsystem shall comply with the requirements of this Section and the PTU requirements of Section 27, Special Tools and Test Equipment. The interface to the PTU shall be an IP addressable output that uses an RJ45 Ethernet connector.

4. Logic shall be arranged for the connection of a PTU to permit static testing, and running monitoring of propulsion subsystem operation, accessing fault or other memory, and access to analog signals.

G. Details shall be submitted. **(CDRL 10-01, Propulsion System Functional Description)**

10.5.5 Friction Brake Blending

A. The control unit shall interact with the friction brake control unit as described in Section 12, Friction Brake, to provide blended dynamic/friction service braking.

B. There shall be a controlled taper to the fade out of the dynamic brake so as to produce optimal blend-in of the friction brake as a function of the build-up characteristics of the friction brake.

C. The low speed brake blending shall be initiated at the lowest practical car speed as required by the friction brake supplier and as approved. See Section 2, Design and Performance Criteria, for additional details.

10.5.6 Spin/Slide Function

A. The propulsion, dynamic brake and friction brake shall all have spin/slide protection to prevent wheel tread damage and to make optimal use of available adhesion.

1. The functions shall be as specified in Section 12, Friction Brake.

2. Each propulsion logic package shall contain all the capability needed to provide the spin/slide detection and correction function, shall receive speed signals from each axle and shall interface with the corrective channels and the friction brake spin/slide control valves.

10.5.7 Traction/Doors Interlock

A. A traction interlock system, and bypass switch, to inhibit propulsion application unless all doors are closed in a train, shall be provided as detailed in Section 6, Passenger Doors.

10.5.8 Friction Brake Interlock

A. A propulsion interlock shall prevent a car or train from developing propulsion unless all friction brakes are released when the train is running (see Section 12, Friction Brake).

1. The train speed shall be included in the detection process so that application of power is not delayed when the train is at rest, the brakes released, doors closed, and brake cylinder pressure is bleeding off.

2. The friction brake interlock shall permit a short term application of propulsion power of no more than 12% for a maximum duration of 2 seconds. Any train movement shall be limited to 5 mph. This function will be used for a “bump test” on a daily basis.

3. When snow brake is active, the detection pressure level shall be above the snow brake cylinder pressure.

4. The interlock shall operate both on a train basis and on a per-car basis by means of the propulsion control unit.

5. The interlock shall immediately inhibit propulsion power if the emergency braking is applied.

6. A propulsion/friction brake interlock bypass switch shall be provided in the cab of each car.

    a. It shall be used in the controlling car to bypass the interlock in the event of an insoluble problem with the friction brakes or the handbrake circuits but shall not bypass their cab LED indicators. The switch shall be labeled and sealed in the "Normal" position.

    b. In addition to being reported to the FRA event recorder (refer to Section 20, Automatic Train Control and Positive Train Control), the use of this switch shall be logged in the Propulsion Event Recorder and shall be annunciated in the active cab.

    c. The bypass switch shall only be effective when its cab is in control of the train.

10.5.9 Speed Interlock

A. The propulsion system shall provide a Zero-speed signal to all relevant systems. The generation of the Zero-speed signal shall be of minimum complexity.

10.5.10 Traction Master Bypass Switch

A. A sealed master bypass switch shall be provided in the cab.

1. It shall function to bypass all interlocks and their circuits which are external to the propulsion inverter and their control logic and shall have the ability to permit the releasing of brakes and the development of tractive effort.

2. When used, use shall be logged in the Propulsion Event Recorder, and "Bypass in Use" shall be annunciated.

10.6 Friction Braking Control

A. Friction brake control is covered in Section 12, Friction Brake. The propulsion system shall provide blending and wheel slip signals as needed for this control.

1. Supplemental friction braking shall be used as needed to achieve the commanded brake rate, per Section 2, Design and Performance Criteria.

2. An emergency brake application shall use only friction braking.

10.7 Electrical Protection

A. The propulsion apparatus shall have the following minimum level of electrical protection. Other protection deemed necessary or advisable by the propulsion supplier shall be provided. Full details of electrical protection and the means and styles of annunciation for train operators and train maintainers, and the means of fault reset shall be submitted. **(CDRL 10-02, Electrical Protection)**

10.7.1 Overcurrent & Overvoltage Protection

A. In addition to the high voltage (primary) current collection protection specified in TS 10.20, DC link overcurrent protection shall be provided to sense any propulsion system fault that might endanger cabling or equipment boxes and their contents.

1. Any such fault shall be cleared by the four-quadrant controller and the over voltage protection/dynamic brake chopper.

B. The inverter output current to each motor shall be monitored to detect loss of phase or excessive phase current.

C. Overvoltage protection shall be provided to sense any voltage level that might endanger any part of the propulsion system. As a minimum, line voltage and DC link voltage shall be monitored. All relevant parts of the propulsion system shall be inhibited and isolated as necessary to avoid damage or degradation to any part of the propulsion system.

D. Full details of overcurrent and overvoltage protection shall be submitted. **(CDRL 10-02, Electrical Protection)**

10.7.2 Ground Protection

A. Grounding of the output of any converter due to wire, cable, motor, or other faults shall be detected and shall cause appropriate converter response to prevent damage to equipment.

B. Grounding of either pole of any DC link due to wire, cable, motor, or other faults shall be detected and shall cause appropriate system response to prevent damage to equipment.

C. The differential current in the high voltage feed from the pantograph to the transformer, and the current from the ground return of the transformer shall be used to detect excessive ground leakage current or a ground fault in the primary circuit. Low levels of ground leakage current shall be annunciated for maintenance action. Higher levels of ground leakage current shall result in circuit isolation to prevent damage to equipment. Contractor to propose responses to different levels of ground fault.

D. The method and criteria for each ground fault type and means of annunciation shall be submitted. **(CDRL 10-02, Electrical Protection)**

E. Annunciation to operating personnel and reset operations shall be fully independent of overcurrent protection.

10.7.3 Overtemperature Protection

A. Overtemperature detection shall be provided to protect all converter power conversion devices from excessive temperature from any cause.

1. Such detection shall initially cause a reduced level of performance of the particular converter in an attempt to avoid a complete loss of operation. Annunciation of reduced performance shall be provided to operating personnel.

2. Continued increase in temperature above a pre-defined threshold shall result in the protective shut down of the power converter.

3. Reset shall be automatic when the temperature falls below set thresholds.

4. Full details of the thermal protection shall be submitted. **(CDRL 10-02, Electrical Protection)**

10.7.4 Brake Resistor Protection

A. The requirements of this section apply equally to braking resistors, and transient voltage limiting resistors if used.

B. The logic control shall contain monitoring functions to ensure that the braking resistors are not overheated as a result of any single power device failure in the circuit.

C. The logic control shall contain monitoring functions (which might include a software thermal model to estimate temperature) to ensure that the braking resistors are not overheated because of operation at too high a usage rate. Contractor to propose response to high resistor temperatures; noting that adaptive power control shall be used to maintain vehicle operation to the extent possible.

10.8 Fault Indicators

A. Fault indication and fault logging shall be provided in accordance with Section 18, Monitoring and Diagnostics.

B. The specifics of the categories and types of faults, their impact on system operation and required operator responses shall be submitted. **(CDRL 10-03, Fault Indications)**

C. The Contractor and subsuppliers shall not compromise the utility and function of their equipment, its suitability for the intended service or the ability of the train to complete its trip by being overly protective.

10.9 Traction Motors

A. Full details of traction motors and all attachments, including description, drawings, and the means to achieve compliance with all requirements shall be submitted. **(CDRL 10-04, Traction Motors)**

10.9.1 General

A. Each truck shall be equipped with two 3-phase asynchronous alternating current traction motors designed for rail transit service with characteristics as are necessary to obtain the performance required by Section 2, Design and Performance Criteria.

B. Where the motors contain thermal sensors, operation of the inverter shall not be fully dependent on the operation of the thermal sensors.

1. In the event of the failure of any thermal sensor, the inverter shall continue to function using a motor temperature estimator or equivalent function to generate a usable motor temperature for control purposes.

2. In the event of failure of any other motor mounted sensor, inverter operation shall continue using an alternate data source or data estimation.

3. Any sensors included in or on the motor shall be fully replaceable without removing the truck from the car, and without removing the motor from the truck.

4. Any sensor failure shall be annunciated.

5. Details of any sensors included on the motor, including details for inverter operation in the event of sensor failure, and failure annunciation shall be submitted. **(CDRL 10-04, Traction Motors)**

C. Each motor shall drive one axle through a gear unit.

D. All traction motors shall be identical.

E. Traction motors shall be self-ventilated.

1. Alternate designs may be proposed for Approval.

F. The motors shall be full frame type with the stator magnetic material fully supported by an independent structural frame.

10.9.2 Ratings

A. Forced cooled or drip proof self-ventilated traction motors proposed for this service shall be capable of meeting all the requirements of this specification while not exceeding 155 degrees C rise at any point in the machine. Shaft and bearing temperatures shall be well within recommended limits for the lubricants.

B. TEFC motors may be applied with higher temperature rise. **(CDRL 10-04, Traction Motors)**

C. Ratings shall be adequate for the duty cycles, and intended motor lifetime, including rescue operations as detailed in Section 2, Design and Performance Criteria.

10.9.3 Noise

A. The traction motor, gear unit and inverter design shall be integrated to hold noise to a minimum, particularly as regards pure tone and magnetically induced noise and harmonic noise at lower speeds when other motion-related noise is at a minimum.

B. In addition to the noise and vibration criteria of Section 2, Design and Performance Criteria, the motor noise at any speed shall not exceed 93 dB(A) when measured at a distance of 15 feet.

10.9.4 Mounting And Handling

A. Each motor shall be resiliently mounted relative to the axle and shall drive through a purpose-designed traction gear drive.

1. The motor shall be supported resiliently by the gear unit on elastomer cushioned trunnions or rigidly by a gear unit that is resiliently supported by its quill on the axle.

2. At the motor drive end, a coupling shall accommodate any resilience and assembly misalignment.

3. The truck attachment shall be resilient.

4. No part of the motor shall be within 0.5 inch of the axle.

5. All mounts shall incorporate elastomers whose design and application shall be such as to provide a minimum 10-year service life for the mounts and their connected parts.

    a. Mount life shall not be achieved at the expense of other parts of the assembly.

6. Special tools, shims and precision measuring devices shall not be required to assemble the motor to the gear drive or the motor and gear combination to the truck.

7. The motor shall be equipped with lifting lugs or eye bolts to facilitate removal and handling.

8. The bottom of the motor shall be shaped or otherwise equipped so that the motor can rest on a flat surface with complete stability.

9. Safety hangers shall be provided so that the motor and gear unit combination cannot drop in the event of any mount failure.

10. The motor frame shall be grounded with metal straps in such a way as to prevent damaging electric current flow through any motor bearings.

10.9.5 Coupling

A. Torque shall be transmitted from the motor to the gear unit through a grease lubricated flexible coupling of a design with prior electric traction experience in a similar service.

1. The coupling shall allow for ease of assembly and disassembly without special tools, shims, or precision measuring devices.

2. A readily accessible (when installed in a truck) grease fitting or plug of an approved type shall be provided.

a. If a plug is provided, its location shall be such that its loss will not cause coupling failure due to loss of lubricant.

3. All details of the coupling shall be submitted prior to production. **(CDRL 10-04, Traction Motors)**

4. Oil lubricated couplings with equal ease of assembly and maintenance may be proposed.

10.9.6 Windings

A. The motor shall have a form-wound stator for maximum robustness and vibration endurance.

1. Coils ends shall be securely braced to ensure resistance to magnetic forces under fault conditions.

2. The insulation system shall have proven satisfactory prior manufacturing, operating and maintenance experience.

3. Insulation shall be class H or better and highly resistant to moisture, oil vapor and grease. The windings shall be given class H (or better) synthetic resin vacuum-pressure impregnation treatment as necessary to ensure that the winding insulation will last for the specified life of the motor under the specified operating conditions and environment.

4. Windings shall be conformally coated after impregnation as necessary to further reduce any moisture ingress.

10.9.7 Rotor

A. The rotor shall be designed for minimum slip and minimum losses.

B. It shall be of laminated construction with copper or aluminum bar conductors and brazed short-circuiting end rings with retainer rings to guarantee structural integrity at the high speed and thermal cycling of traction service.

C. Any detail deviations shall require technical justification and Approval.

D. Cast aluminum rotors may be proposed if satisfactory service experience establishes their suitability. **(CDRL 10-04, Traction Motors)**

10.9.8 Balance

A. The rotor shall be balanced dynamically to less than 1.5 inch-ounce by means of machining or welding.

10.9.9 Motor Bearings

A. The traction motor shall be equipped with anti-friction bearings.

1. Grease cavities shall contain sufficient lubricant to allow operation for 7 years without relubrication.

a. It is intended that lubrication shall not be required except at motor overhaul, and that the lubricant be selected to achieve this.

2. Lubricant shall be readily available through several normal industrial supply sources.

3. Bearings shall be designed for a minimum L-10 life of 750,000 miles of service.

4. The motor shall be equipped with insulated bearings as necessary to avoid stray current in any bearings or through the rotor shaft of the motor.

10.9.10 Connections

A. The terminals, leads, and motor frame shall be clearly marked for positive identification.

B. Leads shall be adequately secured to avoid insulation chafing.

C. Lead identification shall be stamped on the carbody and motor lead exits.

1. Motor leads shall receive approved durable markers. See Section 16, Materials and Workmanship, for additional details.

D. The motor to carbody connections shall be by means of a quick disconnect type connector. Alternate connections may be proposed. **(CDRL 10-04, Traction Motors)**

E. The carbody side connector shall be mounted on a support attached to the carbody in the vicinity of the truck center.

F. One connector shall be supplied for each motor and shall include the axle ground cable.

G. Details for the proposed connector shall be submitted. **(CDRL 10-04, Traction Motors)**

H. The motor connection box and motor wiring routing shall be arranged such that motor wiring shall not run towards the front of a car in such a manner as to create the risk of electromagnetic interference with the ATC/PTC system.

I. A discrete wire shall be run from the motor frame to the enclosure of the feed inverter in parallel with the motor power wiring to carry any parasitic high frequency ground current that might otherwise run through the car shell.

10.10 Gear Units

A. Full details of gear units and all attachments, including description, drawings, and the means to achieve compliance with all requirements shall be submitted. **(CDRL 10-05, Gear Units)**

10.10.1 General

A. Each traction motor shall be coupled to a purpose-built parallel drive gear unit from a design family with extensive railcar experience.

B. Gear units shall be constructed of cast iron, cast steel, or be fabricated of welded steel.

C. Mounting arrangements compatible with the truck specified in Section 11, Trucks, shall be proposed.

1. The gear unit shall be of the helical gear type designed for long service life, low noise, and minimum oil leakage.

2. Split gear unit designs that separate at the bearings are not acceptable.

3. Single or double reduction gearing may be used.

D. Shims, special tools, and precision measuring devices shall not be required to mount the gear unit to the truck.

E. Gear ratio shall be as selected by the Contractor for the application.

F. Any sensors included in or on the gearbox shall be fully exchangeable without removing the truck from the car, and without removing the motor or gearbox from the truck.

10.10.2 Performance

A. All gear units shall be designed to operate satisfactorily with the proposed traction motors while conforming with the performance levels required in Section 2, Design and Performance Criteria.

B. The design shall accommodate torque pulsations inherent in the inverter drive and torsional shock loads as arise in railroad operation.

10.10.3 Gear Unit Bearings

A. The gear unit shall be equipped with adequate anti-friction bearings throughout.

B. Where necessary to avoid leakage current, insulated bearings shall be used.

C. Bearings shall be designed for a minimum L-10 life of 750,000 miles of service.

10.10.4 Gears

A. Helical gears provided throughout the gear unit shall be:

1. Of a service-proven quiet design carburized to a hardness of Rc 55 to an approved depth with a minimum of 0.040 inch

2. Made from forged blanks of AISI 8620, 9310 or 4320H grade steel or Approved equal.

3. Post-ground to AGMA-8 or better classification and adequate for the duty required.

B. Gears shall be designed and applied to require inspection and adjustment no more frequently than once every 500,000 miles.

1. One or two "break-in" inspections during the first 500,000 miles of operation will be acceptable.

C. Gears shall be designed to have a fatigue life of not less than 1,000,000 miles and shall not suffer more than initial wear-in pits or any service life threatening defects during this interval.

1. The gear shafts shall also meet this fatigue life requirement.

10.10.5 Safety Support

A. The gear unit mounting shall include a safety support to prevent the gear unit and motor combination from dropping in the event of failure of the normal means of support.

1. The gear unit mounting arrangement and safety support design and arrangement shall be submitted. **(CDRL 10-05, Gear Units)**

10.10.6 Lubrication

A. The gear unit shall be oil lubricated and provided with sufficient baffles, dams, passages, etc., to ensure an adequate flow of lubrication to all bearings and gears under all conditions of rotation, speed, load, temperature, and weather, including continuous operation in either direction at maximum design speed, as specified in Section 2, Design and Performance Criteria.

B. The gear unit shall be designed to inhibit infiltration of moisture, dust, or dirt into lubricant from all sources.

C. The gear unit shall have a large oil capacity for adequate cooling.

D. With proper maintenance, the gear unit shall not lose oil except as vapor, shall not require lubricant level check at less than 30,000 mile intervals and shall not require lubricant additions at less than 60,000 mile intervals.

10.10.7 Seals

A. All seals on high speed rotating parts shall be of the labyrinth type.

1. They shall not require replacement any more frequently than at the time of gear unit major overhaul.

2. Seals between static components shall be of the following types:

a. Fibrous gasket,

b. Sealing compound, or

c. Elastomeric.

3. Use of fibrous materials, cements or sealing compounds on rotating parts is not permitted.

4. The mounting of O-rings shall meet the requirements of Section 16, Materials and Workmanship.

10.10.8 Inspection Openings

A. Adequate bolted and gasketed inspection openings shall be provided.

1. Inspection covers and gaskets shall be designed and constructed to prevent lubricant leakage.

2. They shall be accessible for full interior inspection of all gears with the truck installed on a car.

10.10.9 Plugs

A. The drain plug shall be of the magnetic type.

1. There shall also be a magnet in the oil stream accessed through an inspection opening.

2. All fill, drain, and inspection plugs shall be lock wired when installed.

3. The filler plug location shall be such that proper lubricant level is at the bottom of the opening and no gauge is required.

4. The exposed portion of the drain plug shall be protected from foreign object damage through orientation or metallic shielding.

10.10.10 Ground Brush System

A. Each axle shall be equipped with a single ground return ring, a ground return brush holder, and a ground return brush, all of a proven design in wide use in the railway industry.

1. The ground brush system shall be installed as part of the gear unit and shall properly shunt return ground current to the axles around all journal, gear unit and motor bearings.

2. The ground return ring shall be made of an approved steel or bronze material, pressed on the axle.

3. Each ground brush shall have a service life of no less than 65,000 miles, and the ring shall last for at least 10 brush life cycles. Ground brush pigtails shall be protected from wear to the extent that pigtail wear shall not be a cause for brush end of life.

4. The ground brush assembly shall be bolted to the gear unit and shall be provided with a cover to protect the ground brush and holder from mechanical injury, dirt, and oil, yet be easily removable for inspection and access.

    a. The housing shall be made of nonconductive material so that brush failure does not result in injurious current through any bearings.

5. The ground brush system shall be so mounted as to provide a readily attachable means to connect them to their electrical wires by means of a two-bolt cable lug. In recognition of the high vibration levels encountered at the axle, the arrangement shall be carefully designed to avoid fatigue at the ground brush assembly terminations. Sufficient support for the electrical wires shall be provided to avoid fatigue at the cable lugs.

6. The arrangement of the brush box and the connections shall be such as to allow easy access from a maintenance pit for brush inspection and replacement.

    a. It shall not be necessary to disconnect the ground cables for such work.

    b. The ground brush return system and cabling shall be sized such that two such brushes can carry the full car operating currents indefinitely without exceeding injurious working temperatures.

10.10.11 Speed Sensing

A. Each traction motor or gear unit shall have provisions for mounting the required speed sensors of an approved type.

B. The Contractor shall coordinate the design of the sensors so that all propulsion sensors shall be freely interchangeable, without shimming or other mechanical adjustment.

C. It shall be neither necessary nor possible to make any mechanical adjustments to set the gap between the sensor probe tip and the gear tooth.

    1. If mounted to count drive gear teeth, the mounting plate shall be precision milled for this purpose and shall be above the normal lubricant level so that removal will not cause lubricant loss.

D. The speed sensor shall be located and/or fully shielded to provide for maximum protection from flying objects.

E. Leads shall be connected to the sensors in a rugged, watertight manner and shall be fitted with an approved transit quality watertight locking connector.

F. Speed sensors and attachments shall be impervious to lubricating oils present in the gear unit.

G. Provisions shall be made for the independent speed sensing needs of the ATC/PTC equipment, per Section 20, Automatic Train Control and Positive Train Control.

10.11 Electrical Filtering

A. Each inverter shall have adequate electrical filtering on its direct current side to protect the power apparatus from transient power system voltages that would produce electrical stresses above recommended application limits and to ensure operating compatibility with car equipment and the signaling system.

B. The filter and charging arrangements must be designed to provide the specified service life.

C. All filtering capacitors shall be of a type with prior experience in similar applications on traction power and control systems.

D. Operational stresses of all types shall be such as to assure a 20 year minimum service life.

1. Data shall be submitted to substantiate this. **(CDRL 10-01, Propulsion System Functional Description)**

E. All electrical devices shall meet the requirements of Section 16, Materials and Workmanship.

10.12 Arrangement Of Components

10.12.1 General

A. All propulsion apparatus shall be standardized to the greatest extent practicable. Details to be submitted. **(CDRL 10-01, Propulsion System Functional Description)**

1. Pre-assembled wire harnesses shall be used to the maximum extent practicable for wiring control items together.

2. Wiring of all groups shall be identical.

10.12.2 Packaging

A. The devices shall be mounted on a lightweight framework or rigid partitions.

1. The apparatus shall be coordinated in the design by the manufacturer, giving special consideration to insulation and arcing distances and the accessibility of items requiring maintenance.

2. All aspects of the packaging shall be submitted prior to manufacture. **(CDRL 10-01, Propulsion System Functional Description)**

3. Power and control circuits and solid-state switching devices shall be isolated or physically separated from power switches and contactors. Compartments containing devices with the potential to create an arc shall be suitably ventilated to avoid the buildup of ozone; however, any ventilation device or means of ventilation shall not compromise the ingress protection of that compartment.

4. Power converters shall be mounted under the car in watertight boxes with hinged gasketed cover or covers meeting the requirements of Section 16, Materials and Workmanship, and shall be accessible from the side of the car.

10.12.3 Connections

A. For enclosures requiring removal from the car for mid-life overhaul:

1. All high voltage and high current connections shall be made such that connections are easily internally accessed, grouped such that the cable entrances are on a removable gasketed panel to facilitate removal of the unit from the car.

2. All entrances of single conductors shall be through approved watertight fittings or directly from fully enclosed ducts or conduits. All conduits shall use compatible interface fittings that will ensure the specified level or better of watertightness.

3. All low voltage connections to these enclosures shall be by means of connectors meeting the requirements of Section 16, Materials and Workmanship, for external use.

4. Low voltage cables that are not connectorized shall pass through watertight fittings attached to a gasketed, removable mounting plate designed to permit disengagement for apparatus box removal from the car.

5. Other enclosures that have non-connectorized cables and wires shall have cables and wires entering the box through watertight fittings and shall terminate on devices, bus bars or terminal blocks.

6. All cables entering enclosures shall have drip loops to direct liquid away from the entrance.

7. All connection methods shall be designed to meet all EMC (electromagnetic compatibility) requirements as detailed in Section 2, Design and Performance Criteria. All high voltage and low voltage cabling shall be segregated.

10.12.4 Maintainability

A. Power semiconductor components and power modules shall be arranged for ease of replacement by requiring a minimum of component removal and by providing generous access for tools and equivalent access to fasteners.

B. Insulation of devices from heat sinks shall be accomplished in a manner requiring a minimum of skill and care.

   1. To this end, preassembled and insulated power modules which require only mechanical fastening in place shall be used to the maximum degree possible.

C. Components shall be indexed and/or polarized to preclude incorrect installation.

D. All plug-in type control components shall be interlocked electrically such that the subject circuit function will be made operative only if all components are completely inserted in their proper location.

E. Removal of connectors with power connected shall not cause damage. In cases where damage during removal under power is unavoidable, non-hot-swappable connectors will be declared in the service manual.

F. The system design shall be based on the incorporation of all control units into components, completely isolated in their function and arranged so that complete units can be replaced, with all tests and repairs made at a shop.

G. Control components or systems such as accelerating current regulation, wheel slip/slide system, speed sensing shall not require periodic calibration or testing.

H. Any and all control components or systems that may be tested for troubleshooting purposes shall be arranged with test points so that it is not necessary to remove any wires to perform this testing.

I. In addition, test points shall be located and arranged so that testing can be performed by one maintainer.

10.12.5 Physical Protection

A. Appropriate screens and guards shall be provided to protect under floor apparatus from flying ballast or similar foreign object damage.

B. Splash guards shall be provided where required to protect underfloor apparatus such as electrical connectors and control boxes from wheel splash.

C. Guards shall be provided to protect all valves, fittings and piping mounted in locations vulnerable to ballast damage.

D. All current carrying parts and all high temperature parts under the car shall be insulated or located or guarded to prevent accidental contact.

E. Appropriate approved electrical warnings, labeling, and safety placarding shall be provided. All aspects of electrical warnings, labeling, and safety placarding shall be submitted. **(CDRL 10-01, Propulsion System Functional Description)**

F. All apparatus shall be fully housed in watertight enclosures.

G. Air exhausts shall be protected and otherwise treated to ensure that no entry of contamination would take place should a car be towed in a dead condition.

H. Where force cooled equipment is employed, air exhaust temperatures shall not be so high, nor shall air exhaust be directed so as to cause injury to maintainers or passengers or members of the public.

I. Screens and guards shall be easily removable and designed so as not to interfere with adequate cooling of apparatus.

10.13 High Voltage Apparatus

10.13.1 General

A. The B-car of a married pair shall be equipped with a pantograph, lightning arrester, pantograph ground switch and pantograph control apparatus.

B. All cars shall be equipped with a high-tension lead, primary circuit breaker, current transformer, main transformer ground switch, mounting and piping provisions for the pantograph and all necessary appurtenances to provide a complete, functioning high voltage current collection system.

C. Any tapped blind holes in these mounting provisions shall be plugged by stainless steel bolts coated with corrosion-inhibiting compound.

D. Where feasible, components should be located toward the longitudinal centerline of the car to avoid contact with low hanging tree limbs along the wayside.

10.14 Pantograph

A. All aspects of the pantograph design, including the mounting arrangements, manual pantograph lockdown and grounding mechanism, pantograph pole and pantograph control apparatus, including description, drawings, and the means to achieve compliance with all requirements shall be submitted. **(CDRL 10-06, Pantograph)**

10.14.1 General

A. Every "B" car of a married pair, shall be equipped with a pantograph, mounted so that the pantograph head is centered directly above the center of the A-end truck pivot.

1. The pantograph shall be fully suitable for bidirectional operation over the catenary system of the SEPTA Railroad Division and the Amtrak Northeast Corridor and Harrisburg Line, as detailed in Section 2, Design and Performance Criteria, at the defined wire contact height, under all weather conditions.

2. Maximum current for a married pair under normal operating conditions shall not exceed 300 Amps at 11,500 Volts. The pantograph shall have all of the salient features of Schunk type WBR drawing 1-4120.5469, or Approved equal.

3. The pantograph shall be totally interchangeable as a unit with the existing SEPTA Silverliner V cars including all mechanical, electrical and control interfaces, and shall mount exactly on the pantograph insulators.

4. With the exception of the carbon strip, the pantograph shall be capable of operating for 10 years without overhaul, under the operating conditions listed in Section 2, Design and Performance Criteria.

10.14.2 Raising And Lowering

A. The pantograph shall be arranged to be spring raised and pneumatically lowered.

1. The spring raising system shall have an adjustable pneumatic/hydraulic damping of the raise rate.

2. The pantograph shall be pneumatically lowered when commanded, and when fully lowered shall be secured by a spring-loaded mechanical latch in the lowered position.

a. This mechanical latch shall be pneumatically controlled to release the pantograph, when so commanded.

b. Mechanical supplemental release levers shall be located on the pantograph base on each side of the car, arranged so that in the absence of air pressure on the car, a pantograph pole can be used to unlock the pantograph and permit it to rise.

c. It shall also be possible to manually pull the pantograph down to the lowered and locked position with the pantograph pole.

d. Normal working motion of the pantograph while in operation shall be suitably dampened.

3. The pantograph raising and lowering arrangement shall be identical to that used on the SEPTA Silverliner V cars.

10.14.3 Construction

A. The pantograph shall be of a frangible, lightweight, tubular design.

B. Reduction or elimination of damage to the catenary wire system is of great importance, and the pantograph shall incorporate a shear pin automatic lowering feature in the event the collector head is snagging wires or subject to abnormal loads.

C. A quantity of 250 shear pins shall be shipped with the Pilot Cars.

D. The pantograph assembly shall be sacrificial to the catenary wire, clips and hardware, and the car roof and roof hardware, in the event of failure or collision.

1. The frangible design shall not compromise lateral stability.

E. All moving parts shall rotate on sealed bearings.

F. "DANGER - HIGH VOLTAGE - DO NOT TOUCH" porcelainized signs decals including an appropriate icon shall be provided at the base on the lower frame of the pantograph, one on each side of the car.

G. All pantograph hardware shall be stainless steel.

H. Each pantograph shall be painted red and provided with reflective tape similar to the present SEPTA pantographs.

10.14.4 Wire Tracking

A. The pantograph shall be designed to satisfactorily track the catenary wire at all speeds up to maximum operating speed as defined in Section 2, Design and Performance Criteria, for wire heights of 15 feet to 24 feet above top of rail (i.e., a 9 foot working range).

B. The maximum working height of the pantograph as installed on the car shall be greater than the maximum wire height.

C. Catenary wire contact pressure shall be easily adjustable between a range of 15 pounds to 24 pounds and shall be initially set to 20.9 pounds.

1. The selected contact pressure shall be kept constant over the entire working range of pantograph height.

10.14.5 Collector Head

A. The pantograph collector head shall be constructed of approved corrosion resistant yet lightweight materials and shall maintain the carbon strip against the catenary wire without damage to the strip.

1. A floating head assembly with spring support shall be provided.

2. The head shall be designed to accommodate 4 foot 6 inch long carbon wear strips of an approved "lead free" type providing long life and selected so as to minimize catenary wire wear.

3. The design shall prevent any arcing damage between the carbon strips and any other parts of the pantograph assembly.

B. Overall collector head width including end horns shall be 6 foot 6 inches.

1. The end horns shall be designed as part of the current collection path, as would be the case if the wire should temporarily ride off the carbon strip.

C. There shall be no points on the head that could snag the wire or the wire hardware, even with wire hardware broken or out of place.

D. Cushioned down stops shall be provided on the base frame assembly to firmly secure the head assembly when the pantograph is in the lowered and locked position.

10.14.6 Pneumatic Connections

A. All pneumatic connections to the pantograph shall be by means of high dielectric non-tracking elastomer tubing, as presently used on Silverliner V cars.

10.15 Manual Grounding Switches

A. A manual pantograph lockdown and grounding mechanism shall be installed on the car roof at each pantograph, with its operating handle accessible and operable from inside the car.

1. This device shall combine a manual hold down hook along with a grounding knife switch to ground the pantograph to the carbody.

2. The hook shall redundantly hold the pantograph down in the event the pantograph hold-down latch fails or is released.

3. A second manual grounding knife switch of an approved similar design shall be provided, located downstream of the primary circuit breaker, to ground the main transformer primary windings to the carbody if the primary circuit breaker is open.

4. Rotation of the pantograph grounding switch handle clockwise shall ground the pantograph and redundantly latch the pantograph in the down position.

5. The main transformer grounding switch shall be similar in operation.

6. Operation of the main transformer grounding switch shall:

   a. Cause an immediate inhibition of the propulsion and auxiliary systems,

   b. Cause an immediate opening of the main circuit breaker, which shall open before the grounding circuit is complete,

   c. Cause an immediate command for pantograph lowering.

7. A keyed interlocking system shall be provided to ensure safe operation of these grounding switches, and for access to the car end roof ladder.

   a. A cover shall be provided for the car end roof access ladder that prevents use of the ladder when the cover is in place. The cover shall be locked in position. The lock may be released by use of a roof access interlock key.

   b. When not in use, the roof access interlock key shall be retained in an interlock system. It shall only be possible to remove the roof access interlock key from the interlock system when the pantograph is lowered and in the locked down position and grounded.

   c. When the roof access interlock key is removed from the interlocking system, it shall not be possible to release the pantograph lock down and grounding device. It shall not be possible to raise the pantograph.

   d. Means shall be provided to tether the roof access interlock key so that it cannot be removed from the vehicle.

8. The switch handle and ladder cover shall have a fiberglass sign panel reading "DANGER - GROUND PANTOGRAPH BEFORE GOING ON ROOF" in permanent letters.

9. All parts of the mechanism shall be stainless steel and shall have a rugged, smooth operating interface linkage.

10. Details of the grounding switch and interlock design shall be submitted. **(CDRL 10-06, Pantograph)**

10.16 Pantograph Control

A. When a pantograph lower command is received on a car, the primary circuit breaker shall open (on both cars of a married pair) prior to the pantograph being lowered.

1. After an adjustable time delay, the primary circuit breaker will automatically reclose so as to be ready for the next raising of the pantograph.

2. The primary circuit breaker shall also be commanded to close whenever pantographs are commanded to rise unless fault conditions otherwise dictate.

B. Trainline control of the pantographs shall be provided by a "lower" switch and a momentary contact "raise" switch in the Operator's cab.

1. A local car pantograph down switch shall be provided in the "F" end cab electrical locker of each car equipped with a pantograph which, when activated, shall cause the pantograph on that individual car to lower and remain locked down regardless of trainline commands.

C. The pantograph itself shall be operated by main reservoir air pressure, supplied from a protected reservoir through raise (Up) and lower (Down) magnet valves.

1. The two magnet valves shall be interchangeable and mounted on a common bracket.

D. To lower the pantograph, the Down magnet valve shall be operated by the "lower" trainline controlled by the "lower" switch in any cab.

1. In addition, a pantograph may be lowered on a local car basis in a train either by activation of the local car pantograph down switch, or by fault signals originating in other equipment on the car.

E. In all cases, the primary circuit breaker will first open, the Down magnet valve shall then admit air to the pantograph lowering pneumatic cylinder, and the pantograph shall latch mechanically in the down position.

1. The time from the actuation of the magnet valve until the pantograph is fully down and latched shall not exceed 6 seconds.

2. The latching of the pantograph shall be smooth and easy.

3. Components of the latching mechanism shall not require periodic adjustment other than at overhaul.

F. To raise the pantographs on a train, the Up magnet-valve shall be operated by the "raise" trainline via a momentary-contact switch which is functional only in an active cab.

1. If permitted by the local car pantograph down switch or the fault system, the primary circuit breaker will be commanded to close, and this magnet valve shall respond and admit air to the pantograph unlatching cylinder which will release the pantograph hold-down latch.

   a. The latch shall be a spring-engaged, air-release type.

2. The pantograph springs will then raise the pantograph, provided that the Down magnet valve is de-energized, and the manual grounding switch is in the ungrounded/hook retracted position.

3. The time from the actuation of the cab switch until the pantograph begins to raise and clears the latch shall not exceed 3 seconds.

4. The magnet valve shall be arranged to exhaust all pressure from the actuation line when the switch is released.

5. The piping arrangement for the unlatching cylinder shall be designed to minimize the volume of air required.

G. To raise the pantograph on a car without air pressure, each car equipped with a pantograph shall have a battery operated air pump. A momentary action switch to command operation of the pump shall be located under the car, readily accessible from the car side.

1. This pump shall be piped to the pantograph latch with appropriate air cocks and check valves, and shall have sufficient capacity to release the pantograph, on a car without air pressure, after no more than 30 seconds of operation.

2. The pump shall automatically switch off when sufficient air pressure is achieved.

3. An Approved sign shall be provided in a location convenient to the pump user, to clearly depict valve handle positions and describe proper, safe operation. Isolation cocks shall be provided to completely isolate and exhaust all air supply to the roof mounted pneumatic actuated equipment without affecting any other car pneumatic system.

4. A valve arrangement similar to that used on the Silverliner V cars shall be provided.

5. Details of the battery operated air pump and air feed design shall be submitted. **(CDRL 10-06, Pantograph)**

10.17 Mounting Insulators

A. The pantograph and high voltage jumper cables shall be supported on insulators having the salient features of Tyco/Raychem part number HVIB-0381-11-085-01.

1. All insulators shall be identical and interchangeable.

2. The insulator sheds shall be of a polyolefin copolymer material, assembled by controlled heat shrink to produce a tight impervious unit with integral metal attachments.

3. All energized pantograph portions and jumper cables shall be designed for adequate electrical clearance to the roof for the worst-case environmental conditions.

4. The insulators shall be mounted to one or more car roof structural members. Attachment only to the car roof sheet without attachment to car roof structural members is not acceptable.

10.18 High Voltage Wiring

A. All details of the high voltage wiring and protection, including all wiring, surge and lightning arresters, current and voltage sensors, grounding switch and primary circuit breaker, including description, drawings, and the means to achieve compliance with all requirements shall be submitted. **(CDRL 10-07, High Voltage Wiring)**

10.18.1 Transformer Cable

A. The wiring from the primary circuit breaker to the main transformer shall be a single piece of high-tension cable, without splices, which is rated for 30 kV service.

B. It shall have the salient features of Kerite part number J1016, or approved equal, in a wire size suitable for 180 Amperes continuous current.

C. The cable shall be enclosed in rigid galvanized steel conduit where it passes through the carbody and for as much as possible of its run on the roof and under the car.

1. The conduit shall be assembled with threaded fittings and sweep bends and be securely grounded to the carbody at each end.

2. The conduit shall be internally smooth and arranged for easy pulling of a replacement lead.

3. Junction boxes or Erickson fittings shall not be used.

D. The high-tension cable shall be connected at the primary circuit breaker via a bolted terminal, and to the transformer via either a screened bolted connection or an Approved screened connector which provides ease of access for connections.

1. Treatment of the cable insulation at the terminations shall be in accordance with the cable manufacturer's recommendations.

2. The top connection shall be of rigid construction and have an impact-resistant non-tracking polymeric housing with creepage distance greater than 2 feet 9.5 inches (850 mm).

3. The cable, top termination, and transformer connection shall be supplied as a complete assembly.

10.18.2 Other High Voltage Wiring

A. Small lengths of high voltage wiring on the roof, such as between the pantograph and lightning arrester, shall be made with insulated cable of suitable strength and flexibility.

1. Cable with insulation rated at 600 volts may be used, provided it is supported using adequate insulators.

10.18.3 Intercar Jumper Cable

A. A high voltage intercar jumper cable shall be used between the two cars of a married pair, interchangeable with the SEPTA jumper cable as depicted on SEPTA drawing C2979 but rated for 30 kV service.

B. Each end of the jumper cable shall be supported on an insulator described in TS 10.18. which shall be located on the car centerline.

C. The jumper cable shall be located to permit the married pair to negotiate the combined extreme conditions of vertical and horizontal curvature as specified in Section 2, Design and Performance Criteria without damage.

10.18.4 Lightning Arrester

A. A lightning arrester shall be provided on the car roof near the pantograph on each car equipped with a pantograph.

1. The lightning arrester shall be suitable for operation up to 18 kV and shall provide protection for car equipment under all specified normal and fault conditions.

10.18.5 Surge Arrester

A. A surge arrester shall be provided on the car roof downstream of and near to the primary circuit breaker on each car equipped with a primary circuit breaker, with provisions for future installation on unequipped cars.

1. The surge arrester shall be suitable for operation up to 18 kV and shall provide protection for car equipment under all specified normal and fault conditions.

10.19 Primary Fault Protection

A. Suitable current and voltage measuring and protection systems shall be provided to provide fault protection of the car's high-tension components and main transformer.

1. Fault clearing shall be by means of a primary circuit breaker, with a pantograph pneumatic grounding switch working in parallel, coordinated with pantograph lowering.

2. Details for the primary fault protection scheme shall submitted. **(CDRL 10-08, Primary Current Fault Protection)**

10.19.1 Fault Protection Sensing

A. Sensing of the primary current, and monitoring its magnitude, its rate of rise, and its root mean square (rms) average over time shall be employed on each car to sense primary faults, using the current transformer.

B. Thresholds for each of these parameters shall be adjustable by PTU.

C. For faults which are not classified as major, i.e., primary current slightly over the threshold, the system shall command the primary circuit breaker to open on that car.

D. For more serious faults, the system in sequence shall command the primary circuit breakers on both cars to open, operate the pneumatic ground switch, and lower and lock the pantograph.

E. The primary circuit breaker shall provide inherent overcurrent protection without any further control unit or supplemental circuits being active.

10.19.2 Primary Current & Voltage Transformers

A. Primary current and voltage measuring transformers shall be installed on the car roof of each car.

1. They shall be connected upstream of the primary circuit breaker for measuring the main transformer primary current and voltage. The primary current transformer shall also have the ground lead of the pneumatic grounding switch pass through it as well.

2. The primary current and voltage transformers shall be used for primary fault sensing, and for control of the line converter of the propulsion system to limit line current draw to 150 Amperes per car at 11,500 Volts.

3. The sensed current and voltage signals shall be processed to provide diagnostic signals and to initiate high voltage circuit protective functions.

4. The transformer installations shall permit ease of replacement.

5. The current transformer shall be capable of withstanding a permanent open circuit or a permanent short circuit on the secondary terminals without damage.

6. The voltage transformer shall be provided with fuses or equivalent protective elements to permit it to withstand a short circuit on the secondary terminals without damage except to the protective elements. The protection shall not operate unless the short circuit is present for long enough to present a risk of damage to the voltage transformer. Protective elements shall be replaceable.

7. The voltage transformer primary shall be suitable for direct connection to the 11,500V, 25Hz overhead power supply. The secondary windings shall have a low output voltage, suitable for interface to the propulsion control system.

8. A suitable low voltage current transformer may be used, provided it is mounted on a short length of cable rated for 30 kV service, having the salient features of Kerite part number J1016, or approved equal, in a wire size suitable for 180 Amperes continuous current.

9. The cable shall be terminated with an approved termination system at both ends.

10.19.3 Primary Circuit Breaker

A. A primary high voltage circuit breaker shall be used to protect the main transformer and its high voltage cable, located on the car roof downstream of the current transformer.

1. It shall be capable of interrupting car fault currents when tripped by an external signal.

2. The device shall include current magnitude sensing and shall be self-tripping. When tripping, the device shall send an external signal to activate other functions such as pantograph lowering.

3. The primary circuit breaker shall be rated for the maximum voltage of the overhead line as defined in Section 2, Design and Performance Criteria.

4. The breaker shall be of a robust design suitable for railroad vehicle application, shall be resistant to vibrations, and shall operate for 10 years between overhauls without periodic maintenance being required.

5. It shall be arranged to open prior to commanded pantograph lowering, and to close prior to pantograph raisings, as detailed in TS 10.16

6. There are frequent possibilities that a stored Silverliner VI car in a remote yard location with a lowered pantograph will have a depleted storage battery and

no air pressure. Completely manual means are therefore required to permit a car to be activated, and the primary circuit breaker be manually closed, if open, by use of a pantograph pole from track level or by an approved handle or push-button located inside the electric locker, when the normal activation energy source is absent.

a. The roof location of the primary circuit breaker shall facilitate access by a maintainer standing on the ground alongside the car with a pantograph pole to trip a mechanical latch, or by roof ladder access to a remote operating handle.

b. In coordination with this requirement, the primary circuit breaker shall be arranged to automatically reclose at an approved time period following a major fault which initiates the lowering and locking of the pantograph and shall always be closed after the pantograph is normally lowered in the absence of fault conditions.

c. The primary circuit breaker shall also be opened prior to a normal lowering of a pantograph, followed automatically by reclosing once the pantograph is latched down.

7. Where the Primary Circuit Breaker is required to open due to phase break, system change, pantograph bounce, ice, unexpected shutdown, or any other catenary power condition, it shall do so automatically, without operator intervention. When line voltage conditions permit, the Primary Circuit Breaker shall automatically reclose without operator intervention.

10.20 Pantograph Pole

A. A pantograph pole made of fiberglass dielectric shall be provided in a carrier under a side sill at the pantograph end of each pantograph-equipped car.

B. This pole will be used to manipulate the pantograph and primary circuit breaker during emergency situations and shall be of sufficient length, strength, and dielectric quality to permit safe and satisfactory use with an energized catenary.

C. The pole shall be 1.5 inch diameter by 20 feet long, as manufactured by A.B. Chance Company, part number SPO-1748, or Approved equal.

D. The carrier shall be equipped with a clamp suitable to hold a stored pole clean, dry, and securely in place, and shall be sloped so that any water will drain.

E. The pantograph pole and its carrier shall comply with the requirements of 49 CFR Part 229.81.

10.21 Main Transformer

10.21.1 Design

A. All details of the main transformer design, ancillary components, and its cooling system, including description, drawings, and the means to achieve compliance with all requirements shall be submitted. **(CDRL 10-09, Main Transformer)**

10.21.2 General

A. The main power transformer shall receive single phase overhead catenary system AC power on its primary side and step it down to required voltages.

B. The main power transformer shall have primary windings, secondary windings, and a tertiary auxiliary winding, as required for the car design.

1. The secondary windings shall feed the propulsion system and auxiliary power system, and for heating loads not supplied by the tertiary winding.

2. The tertiary winding shall feed specific auxiliary loads such as layover floor heat and battery charging. The design goal is to reduce the use of transformer cooling fans during periods of car layover to conserve energy and reduce acoustic noise.

3. Alternate means of accomplishing the same goal may be proposed. **(CDRL 10-09, Main Transformer)**

4. If needed, an auxiliary tank shall be included in the design of the main transformer for the mounting of any main and/or auxiliary smoothing reactors in the transformer coolant.

C. The main transformer shall be of sufficient capacity to supply all power requirements of the car, and shall continuously supply the performance specified, including normal short time overload conditions.

D. The transformer shall be designed and constructed specifically for railroad service and shall withstand without injury the primary voltage transients and interruptions due to substation switching, operation through phase breaks, pantograph bounce, ice accumulation, catenary system faults, or other such conditions inherent in operation on the SEPTA Railroad Division.

E. The transformer shall meet all the requirements of the latest revision of ANSI C57.12.00.

F. Telephone Interference Filters (TIF) shall be provided to ensure no interference with any communications networks along the SEPTA or Amtrak right-of-way.

10.21.3 Primary Winding

A. The main transformer windings shall be arranged as required to meet the performance requirements as detailed in Section 2, Design and Performance Criteria.

B. The main transformer shall be a robust design suited to service on a legacy overhead supply system that can be routinely grounded by the present rolling stock that does not have on-board current interrupting capability beyond lowering the pantograph.

10.21.4 Secondary Windings

A. The transformer shall have secondary windings as necessary to provide the required functionality.

1. Secondary windings shall be used to supply line converter(s) that feed a regulated DC intermediate link.

a. The secondary voltage and DC link voltage shall be coordinated to minimize converter and transformer losses for nominal 11,500 Volts 25 Hertz supply conditions.

b. The line converters and main transformer shall provide capability for regenerative energy return to the overhead power supply as well as presenting an essentially unity power factor load to the supply.

c. Windings shall be of sufficient rating to supply the continuous and overload traction power and auxiliary power requirements.

d. Continuous traction operation shall include operation under rescue conditions as detailed in Section 2, Design and Performance Criteria.

2. A second set of secondary windings shall be used to directly supply the maximum amount of resistance heater loads (overhead and floor heat, and cab heater elements) at a nominal voltage of 600 volts AC for nominal 11,500 volts 25 Hertz supply conditions. This set of windings shall not feed the layover heater supply.

3. The Contractor may propose alternative arrangements. **(CDRL 10-09, Main Transformer)**

10.21.5 Tertiary Winding

A. The transformer shall have one tertiary winding.

1. It shall supply only the layover heating elements, and a rectifier used to solely power the low voltage power supply and to charge the storage battery.

a. This winding shall be designed to produce an output of 600 volts DC when rectified, with a nominal 11,500 volts 25 Hertz input.

b. This winding shall be of sufficient rating to supply the continuous power requirements.

c. It is intended that during car layover conditions, the tertiary winding shall have all the electrical loadings (layover heating under conditions of low ambient temperatures, plus battery charger load) placed upon it, and there shall be no need for the operation of the main transformer coolant pump or heat exchanger fans.

d. The Contractor may propose alternative arrangements. **(CDRL 10-09, Main Transformer)**

10.21.6 Core And Windings

A. All current carrying parts of the transformer shall be copper.

B. The transformer construction shall give the best mechanical protection to the windings for railroad service and shall be designed to eliminate gap variations.

C. The windings shall have large surface areas for the dissipation of heat. The winding insulation system shall be rated to ensure that the transformer windings will achieve a life of no less than 40-years when operated under the conditions specified in Section 2, Design and Performance Criteria.

D. Ceramic button separators, or approved equal, shall be placed between the windings to absorb heat, and dissipate it into the coolant to eliminate potential hot spots.

E. The core and windings shall be adequately braced, strengthened, and provided with sufficient spring packs at the ends of the coil stacks to secure the coils to withstand without injury the effects of shocks and vibration during railroad operation.

1. The coils shall also withstand thermal stresses as well as radial and axial pulsating forces due to the fluctuating pattern of the load current, system faults and the presence of harmonics.

F. The core and windings shall be securely braced in the tank under pressure to preclude any movement of the assembly under any attainable current flow, including that obtained with a short circuit across any or all of the low voltage taps with the highest primary voltage available.

1. For design purposes it shall be assumed that two such short circuits will occur each year over the 40-year transformer lifetime.

G. Internal connections and bus bars shall be secured to prevent movement under normal and short circuit conditions.

H. All flexible connectors shall be tied together to prevent spreading.

I. All non-metallic nuts shall be locked with epoxy cement.

J. Lock washers must be flat, with radiused edges on both sides.

K. Full nylon insert nuts are preferred, where possible.

L. Alternate winding designs that provide equivalent or better performance may be proposed. **(CDRL 10-09, Main Transformer)**

10.21.7 Impedance and Magnetizing Current

A. The impedance of the transformer shall be sufficient to protect the unit from mechanical and thermal damage under short circuit conditions.

1. The minimum transformer impedance shall be 4 percent at 25 Hertz using the primary winding kVA as a base and considering each winding to every other winding.

B. The transformer shall be designed to limit the magnetizing current inrush to no greater than 1,600 Amperes at 11,500 Volts when voltage is applied to a fully demagnetized transformer.

1. This need not be proven by test, but the design calculations shall be submitted for review and Approval prior to transformer construction. **(CDRL 10-09, Main Transformer)**

C. Transformer impedance shall be coordinated with the SEPTA traction power system protective relaying to prevent unnecessary tripping of catenary feed circuit breakers.

10.21.8 Transformer Tank

A. The transformer tank shall be of sound, welded steel construction, designed for a full vacuum and capable of withstanding a pressure of 15 psig for 12 hours without leaking or any permanent deformation.

1. Prior to assembly, the interior and exterior of the tank assembly, including all welds, shall be completely grit blasted.

B. The tank shall be provided with two self-resetting type relief valves, set at 14.22 psig pressure, located, and arranged in such a manner as to avoid the possibility of escaping coolant coming in contact with passengers or undercar apparatus. The reset pressure of the relief valve shall be 0 psig pressure.

C. All cover plates and appurtenances shall be secured with elastic stop nuts where attached with fasteners.

D. An approved method shall be used to absorb the change of volume of the coolant caused by a change of temperature, in order to keep the transformer at atmospheric pressure.

E. Each transformer tank shall be equipped with a drain valve, top filter press valve, sampling valve, air vent valve and coolant fill pipe.

1. The valves shall have plugs in the open ends and be clearly identified.

2. Gauges shall be provided for measuring the coolant pressure and for checking coolant pump rotation.

3. In addition, a liquid-level sight gauge, Tedeco MS248 "High Contrast" type, or Approved equal, shall be provided.

    a. This gauge shall have no moving parts and shall indicate both the hot and cold range from low to full.

4. All gauges shall be located to be easily visible from the side of the car.

F. A drywell shall be incorporated into the tank containing a resistance temperature device (RTD) to allow coolant temperature to be measured and recorded.

1. The RTD shall be copper platinum with a resistance of 100 ohms at 25 degrees C, and its electrical connections shall be easily accessible.

G. All valves, gauges, bushings, heat exchanger fins, piping and other accessories shall be provided with protection against damage from flying objects or chunks of ice breaking away from the carbody at maximum speed.

10.21.9 Cooling System

A. The main transformer shall be of the liquid-immersed, self-cooled/forced-air-cooled/forced-liquid-cooled, class OA/FA/FOA type.

B. All materials, including insulations and gaskets, shall be compatible with the coolant.

C. The coolant shall be Cooper Power Systems/Fluid Products division Envirotemp 200 fire-resistant fluid, or if approved, General Electric Company model SF 97-50 silicone transformer dielectric fluid. Coolant shall meet the requirements of the U.S. Environmental Protection Agency at the time of NTP.

1. An alternate coolant (including ester-based) may be proposed. **(CDRL 10-09, Main Transformer)** Any proposal for an alternate coolant must be accompanied with suitable details for long term operational service experience for the proposed coolant. The entire coolant system and transformer insulation system must be compatible with any proposed coolant.

2. Particular attention shall be given to the design of the cooling system to allow satisfactory operation in the environmental conditions to which it will be subject, to prevent dirt fouling and to aid in cleaning.

D. The transformer shall be provided with a coolant pump and heat exchanger with forced air cooling, arranged to prevent the heat exchanger exhaust from being recycled.

E. An interlock shall be provided to remove all traction power and normal (non-layover) heating loads when the coolant pump and fan motors are not receiving electrical power.

F. To reduce wayside noise, the cooling fans shall be dual speed. Fans shall be operated under thermostatic control, using the lowest speed consistent with maintaining the transformer coolant at an appropriate temperature.

G. The cooling system shall have sufficient capacity to provide full rated transformer power output for a 2-hour period with a car underfloor ambient air temperature of 140 degrees F without overheating or damage.

H. The cooling system heat exchanger coil shall be a minimum of 5 percent oversized to counter the long-term drop in efficiency from dirt accumulation.

10.21.10 Coolant Pump

A. The coolant pump shall be driven by a 3 phase, 60 Hertz, totally enclosed squirrel cage induction motor taking power from the auxiliary power system.

B. The pump motor shall include a venting arrangement and shall be readily accessible for maintenance and replacement.

1. A method to visually verify proper pump operation shall be provided.

2. Suitable valves and compensators shall be provided to isolate the pump from the cooling system and to permit pump removal and replacement with minimal loss of coolant.

C. The pump shall be mounted transverse to the car centerline unless equipped with thrust bearings.

D. The pump motor electrical connection box/connector shall be watertight as necessary given the mounting location.

E. Details of the pump shall be submitted for review.

10.21.11 Heat Exchanger

A. The heat exchanger coil assembly shall use ambient air for cooling.

B. It shall consist of fabricated copper tubing, using high thermal efficiency straight copper fins allowing line of sight airflow with a minimum spacing of 0.125 inch.

C. Except as otherwise approved, the thickness of the coil shall not exceed 3 inches, to prevent dirt plugging and to aid in cleaning.

D. The tube support interface with the tube sheet shall be as recommended by the coil supplier for high vibration and thermal stress applications.

1. Long lengths of tubing shall be supported at proper intervals to prevent resonance from taking place, but also allowing for expansion.

E. Any tube expansion collars within the fins shall be firmly secured to the tubes and shall be free of metal edge splits.

F. The coil shall be protected against debris damage by a heavy stainless steel mesh screen, positioned a suitable distance from the coil surface to prevent any contact from the mesh if it deflects when struck.

1. The coil design shall take into account the airflow restrictions caused by dirt accumulation, protective screens, clearance from underfloor equipment, and waste heat from adjacent apparatus.

G. The coil "U" bends and external piping shall be protected by metal guards of sufficient strength to protect all coil fins and pipes against damage from flying debris in either direction of car travel and shall be V-shaped to deflect rather than absorb direct hits.

H. The coil housing shall have hinged panels to provide full access to the total face area of both sides to facilitate the cleaning of the coil.

I. Contractor may propose alternate designs that provide equivalent functionality, reliability, and maintainability.

10.21.12 Cooling Fans

A. One or more dual speed heat exchanger impeller fans shall be provided, complete with corrosion resistant shrouding and screening.

B. The fan system shall be designed to meet the acoustic noise requirements as detailed in Section 2, Design and Performance Criteria.

C. Baffles shall be provided as necessary to achieve a uniform air velocity over the entire heat exchanger coil assembly.

D. The fan motor shall be a two-speed 3 phase, 60 Hertz, totally enclosed induction motor of the highest efficiency available meeting the requirements of Section 16, Materials and Workmanship.

E. Long-life (minimum 8 years) sealed bearings shall be used.

F. The motor shaft shall be corrosion resistant, and a weathertight shaft seal shall be used.

1. If the motor shaft is vertical, a slinger shall be used to prevent moisture entry into the motor.

G. The motor frame shall be separately grounded to the carbody.

H. An arrow on the motor easily visible when installed shall indicate the correct direction of rotation.

I. An arrow shall be etched or stamped into the fan to indicate the correct mounting orientation unless the fan can only be installed in the correct orientation.

J. The motors shall be powered from the auxiliary power system.

K. Each multiple blade impeller fan shall be constructed of UV stabilized, long-life, high-density polypropylene which is die cast to a true airfoil shape or other approved corrosion resistant design, directly connected to the fan motor using a piloted connection.

1. Except as otherwise approved, the fan tip speed shall not exceed 140 feet/ second, with noise control being of primary concern in the fan design.

L. If mounting bolts are used, the bolts shall be permanently attached, and the connection shall be designed to prevent out of round mounting.

M. The shaft mountings and all hardware shall be stainless steel.

N. The fan shall be individually one-plane rotationally balanced to a limit of 0.02 ounce-inch.

O. The motor and fan assembly shall not exceed a displacement perpendicular to the motor shaft of 0.003 inch when checked at the motor frame while operating at normal speed.

P. The motor-fan assembly shall be installed using elastomer mounts per Section 16, Materials and Workmanship, and shall not vibrate or cause objectionable noise when operating.

Q. The fan assembly shall be easily accessed for cleaning, inspection, or repair, and shall be easily removable. The assembly shall be easily removable without requiring removal of other components.

10.21.13 Electrical Connections

A. The high-tension cable from the pantograph shall be connected to the transformer via either a bolted connection or an approved screened connector which provides ease of access for connections.

1. A primary fuse shall not be used, unless Approved.

2. Treatment of the cable insulation at the terminations shall be in accordance with the cable manufacturer's recommendations.

B. All other cables shall use bolted connections.

C. The ground and low voltage bushings shall be of ceramic material or Approved equal.

D. All transformer bushings shall be protected from flying objects by a solid metal shroud.

E. The transformer ground bushing shall be connected to the negative return system per TS 10.23.

F. The transformer tank shall be grounded to the carbody.

G. Cable or leads shall be run in a plastic covered metal tube of approved design. Nylon conduit may be proposed. **(CDRL 10-07, High Voltage Wiring)**

H. Junction boxes must be waterproofed.

10.21.14 Mounting

A. The transformer shall be solidly mounted to the carbody:

1. Its support shall be of adequate design permitting no deflection or vibration in service.

2. The mounting of the transformer shall be approved by the transformer supplier.

10.21.15 Nameplate

A. All transformer nameplates, warning signs, and identification tags shall be manufactured of stainless steel with all information and data visibly stamped and shall be mechanically fastened to the transformer at an easily accessible location. All text shall be clearly legible.

B. Nameplate data shall include ratings at all input voltages, connection diagrams, and other required information.

10.21.16 Protective Devices

A. The transformer shall be protected from damage from any long-term overvoltage and undervoltage conditions which may exist.

B. An interlock shall be provided to remove all transformer loading, except battery charging and layover heat, when cooling oil flow is not detected, or the heat exchanger fans are not operating when required to do so.

C. The transformer shall be provided with a coolant temperature thermostat, Fenwall or Approved equal, and overtemperature annunciation and protection including, as a minimum, adequate fluid venting, reduction or removal of propulsion power, and remote indications.

D. A Buchholz relay shall be provided to detect excess gas in the transformer oil cooling system and potential dielectric failure, and automatically shut down the propulsion system.

10.21.17 Reactors

A. If any main and/or auxiliary smoothing or filter reactors are required by the car design, they shall be of adequate rating for the service intended.

1. If desired, they may be installed either as part of the associated converter equipment and utilize the cooling provisions of that equipment, or they may be installed in an auxiliary tank to the main transformer tank as separate components.

a. If used, this reactor auxiliary tank shall be of steel construction and shall be fully compatible with the main transformer tank.

b. The reactors shall be cooled by the main transformer cooling system.

2. The reactor cores shall be of laminated electrical grade steel type construction.

3. The reactor coils shall be fabricated of copper and shall have an insulation system equally as effective as that provided for the transformer windings.

4. The reactor coil insulation system shall be compatible with the main transformer coolant.

10.22 Ground Return System

A. The grounding system on the car shall meet the requirements of APTA standard SS-E-005-98, Standard for Grounding and Bonding.

B. All grounding system components shall meet the requirements of Section 16, Materials and Workmanship.

C. The Contractor shall submit a complete grounding scheme, including description, drawings, and details for the means to achieve compliance with all requirements. **(CDRL 10-10, Ground Return System)**

10.22.1 Primary Ground Return

A. An approved primary ground return system using the carbody shall be used for return of the main transformer primary winding current to the running rails using axle ground brushes.

1. This shall be done through all wheels acting as parallel conduction paths to minimize any adverse consequences of localized poor wheel-to-rail contact.

B. Each axle shall be equipped with a ground return brush holder, as detailed in TS 10.10.

1. Both brush holders shall be electrically connected within each truck and connected to a ground pad connection on the carbody structure by means of a bolted connection.

C. The main transformer primary power return shall be connected to the carbody structure by a dedicated ground pad bolted connection.

10.22.2 Safety Grounding

A. All electrical equipment on the car shall be safety grounded to the carbody using ground pads.

1. Adequate ground return for proper operation of the pneumatic and manual pantograph grounders, and the lightning arrester, shall be provided for which the voltage drop shall not exceed 25 Volts. An analysis shall be performed and submitted to demonstrate that the safety grounding provides adequate control of step and touch potential. **(CDRL 10-10, Ground Return System)**

2. No current shall be returned to the running rail through the gear unit bearings, traction motor bearings, or journal bearings, or through any suspension system elements or any part of the brake system. This shall include both normal current and overload current due to insulation failures in the traction motor.

3. Details shall be submitted for the grounding system that clearly highlight how the system arrangement ensures that any ground return current can only flow in well-defined paths.

10.23 Energy Measurement System

A. The primary current and voltage transformers shall be used to supply signals to an energy measurement system.

B. The energy measurement system shall record energy consumption measurement. Separate readings and recordings shall be made for:

1. Positive energy flow from the line,

2. Negative energy flow from the line,

3. Auxiliary energy,

4. Energy dissipated by brake resistor.

5. Further details are provided in Section 18, Monitoring and Diagnostics.

C. The energy measurement system shall be incorporated in the propulsion control system.

D. Except as otherwise required in these specifications, energy measurement shall comply with the requirements as detailed in the relevant parts of EN 50463, EN 50591 and relevant standards referenced therein to permit verification of energy consumption.

E. All details of the energy measurement system, including description, drawings, and the means to achieve compliance with all requirements shall be submitted. **(CDRL 10-11, Energy Measurement System)**

10.24 Contract Deliverable Requirements List (CDRL)

The following contract deliverables have been identified in this section; however, the Contractor is responsible for providing and submitting anything necessary to fulfill the requirements of this contract, including those not identified by CDRL number.

CDRL 10-01,Propulsion System Functional Description....10-2
CDRL 10-12, Interference Current Monitoring Unit....10-6
CDRL 10-02,Electrical Protection....10-20
CDRL 10-03, Fault Indications....10-21
CDRL 10-04, Traction motors....10-22
CDRL 10-05, Gear Units....10-26
CDRL 10-06, Pantograph....10-34
CDRL 10-07, High Voltage Wiring....10-40
CDRL 10-08, Primary Current Fault Protection....10-42
CDRL 10-09, Main Transformer....10-45
CDRL 10-10, Ground Return System....10-54
CDRL 10-11, Energy Measurement System....10-56

10.25 CDRL Details

This section lists the expected content for each CDRL required above. The lists provided for each CDRL are an outline only and should not be considered exhaustive, all CDRLs are subject to SEPTA review and approval.

CDRL 10-01 Propulsion System Functional Description

1. Provide a detailed and comprehensive system functional description (SFD) for the propulsion system prior to each design review, and at propulsion converter FAI. Details shall include description, drawings, and the means to achieve compliance with all requirements.

2. The SFD shall include detailed descriptions of all major components of the propulsion system, how the components function and how they interact.

3. The SFD shall contain (but not be limited to):

    a. All descriptions

    b. Block diagrams

    c. Schematics

d. Details for the control unit, control logic and its parameters, and any alternate arrangements

e. Details for the propulsion converter packaging and wiring arrangements

f. Details of protective methods

g. Details of control trainline loadings

h. Details of all speed limits

i. Details of wheel spin/slide control

j. Details of DC link failure detection and response

k. Details of alternate switching devices (if proposed)

l. Details for cooling systems

m. Details for rollback prevention and protection

n. Details for friction brake interface

o. Details for brake resistors

p. Details for wheel wear compensation

q. All aspects of electrical warnings, labeling, and safety placarding.

r. Other features necessary for SEPTA to clearly understand how the propulsion system functions and how it meets the requirements of this specification.

4. Except where assigned a specific CDRL, or where another CDRL as listed below is not clearly suitable, all design and equipment details for the propulsion system noted as requiring submission for approval shall be included in this CDRL and be clearly identified as such in the submittal.

5. The SFD shall be updated at each design stage as the system design is refined.

CDRL 10-02 Electrical Protection

1. Provide full details of electrical protection and the means and styles of annunciation for train operators and train maintainers. Details shall include description, drawings, and the means to achieve compliance with all requirements. Details shall include but not be limited to:

   a. Overcurrent and overvoltage protection

   b. Ground fault detection and means of annunciation

   c. Thermal protection

2. Provide details for the means of fault reset.

CDRL 10-03 Fault Indications

1. Provide details of fault indication and fault logging for the propulsion system. Details shall include description, drawings, and the means to achieve compliance with all requirements.

2. Provide details of specifics of the categories and types of faults, their impact on system operation and required operator responses.

CDRL 10-04 Traction Motors

1. Provide full details of traction motors and all attachments, including description, drawings, and the means to achieve compliance with all requirements. Details shall include but not be limited to:

    a. Details of any sensors included on the motor

    b. Details for inverter operation in the event of sensor failure, and failure annunciation

    c. Details for motor temperature rating and insulation methods

    d. Details for motor cooling

    e. Details for stator and rotor materials and means of manufacture

    f. Details for motor ratings

    g. Details for motor couplings

    h. Details for motor to carbody connections.

CDRL 10-05 Gear Units

1. Provide full details of gear units and all attachments, including description, drawings, and the means to achieve compliance with all requirements.

2. Provide full details for the gear unit mounting arrangement and safety support design and arrangement.

CDRL 10-06 Pantograph

1. Provide full details for all aspects of the pantograph design. Details shall include descriptions, drawings, and the means to achieve compliance with all requirements.

2. Details are required for (but not limited to) the following components and features:

    a. Pantograph

b. Component mounting arrangements

c. Manual pantograph lockdown and grounding mechanism

d. Pantograph pole

e. Pantograph control apparatus

f. Pantograph grounding switch and interlock design

g. Battery operated air pump and air feed design.

CDRL 10-07 High Voltage Wiring

1. Provide full details of the high voltage wiring and protection arrangements. Details shall include descriptions, drawings, and the means to achieve compliance with all requirements.

2. Details are required for (but not limited to) the following components and features:

   a. Wiring

   b. Conduit for high voltage wiring

   c. Surge and lightning arresters

   d. Current and voltage sensors

   e. Grounding

   f. Primary circuit breaker.

CDRL 10-08 Primary Current Fault Protection

1. Provide full details for the primary fault protection scheme. Details shall include descriptions, drawings, and the means to achieve compliance with all requirements.

CDRL 10-09 Main Transformer

1. Provide full details of the main transformer design. Details shall include descriptions, drawings, and the means to achieve compliance with all requirements.

2. Details are required for (but not limited to) the following components and features:

   a. Main transformer

   b. Winding details, including winding material and insulation details

   c. Design calculations, including thermal calculations and magnetizing inrush current.

d. Ancillary components

e. Cooling system, including details for proposed coolant

f. Description of any proposals to provide alternate means of compliance.

CDRL 10-10 Ground Return System

1. Provide a complete grounding scheme, including description, drawings, and details for the means to achieve compliance with all requirements.

2. Provide an analysis to demonstrate that the safety grounding provides adequate control of step and touch potential.

CDRL 10-11 Energy Measurement System

1. Provide full details of the energy measurement system, including description, drawings, and the means to achieve compliance with all requirements.

2. Provide details for the energy data logging functionality for all recorded values.

CDRL 10-12 Interference Current Monitoring Unit

1. Provide full details for the ICMU.

2. Submittal shall include details for:

   a. How the ICMU will operate

   b. How the ICMU will interface to the propulsion system

   c. How the system will ensure a failsafe shutdown of the propulsion system

   d. Reaction to exceedance events

   e. Physical implementation of the ICMU.

10.26 Referenced Standards

49 CFR 229.81	Emergency pole; shoe insulation
49 CFR 238.225	Electrical System
EN 50155:	Railway applications — Electronic equipment used on rolling stock.

EN 50463-2:	Railway applications - Energy measurement on board trains - Part 2: Energy measuring
EN 50591:	Railway Applications - Rolling Stock - Specification and verification of energy consumption.
IEEE 16:	IEEE Standard for Electrical and Electronic Control Apparatus on Rail Vehicles
ANSI C57.12.00:	IEEE Standard for General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
APTA standard SS-E-005-98:	Standard for Grounding and Bonding

SECTION 11
TRUCKS

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11.1 General

11.1.1 Design Restrictions

A. Each car shall be equipped with two roller bearing trucks equipped with air suspension, and all major components shall be service proven in North American service or shall be a derivative of such a service proven design. Fabricated or cast steel truck frame and bolster designs may be proposed. All structural and load-bearing members of the truck shall be of steel. The use of aluminum castings is prohibited.

B. The truck supplied shall be of a design configuration which has been service proven in operation at speeds up to 100 mph.

C. There shall be two motors mounted on each truck, with one motor geared to each axle.

D. Friction brake equipment shall be mounted as per Section 12, Friction Brake, requirements.

E. The truck design shall follow the recommended practices of APTA Standard PR-M-RP-009-98, Truck Design.

F. The truck design shall be such that the carbody load is supported by two air springs located at the ends of the truck bolster which, in turn, is supported on the truck frame.

G. The truck shall be designed to the dimensions and operating conditions specified in Section 2, Design and Performance Criteria.

H. The complete truck shall be designed with consideration and control of total mass and unsprung mass, consistent with the requirements of strength, performance, ride quality, P2 forces and low maintenance specified herein.

I. The truck frame, bolster and each of the truck components shall be interchangeable between both ends of each car, and between cars.

J. The Contractor shall provide a complete system design description of the truck and vehicle interfaces. **(CDRL 11-01, Truck System Design Description)**

K. The truck shall be a corrosion-resistant design with appropriate drainage. Trucks shall be treated with Approved corrosion protection systems **(CDRL 16-03, Corrosion Control of Materials)**. Pockets, cavities, and partially enclosed spaces shall have provisions to prevent buildup of debris, liquids, snow, and condensation.

L. Components such as air valves and linkages, wheel slide sensors, speed sensors, ground brushes and wiring shall be located to the greatest extent possible to protect them from debris strikes or have shields added.

11.1.2 Performance and Testing

A. The truck shall be suitable for revenue operation and provide a comfortable ride at speeds up to 100 mph. The truck shall be stable up to the maximum design speed of 110 mph without "hunting" or "nosing" for all combinations of wheel wear and compensating adjustments, but allow the cars to negotiate curves and crossovers as specified in Section 2, Design and Performance Criteria, without causing excessive wheel flange or rail wear.

B. The trucks shall be tested per Section 15, Test Program, requirements. Detailed testing plans shall be submitted for Approval.

C. The Silverliner VI car shall be designed and tested to verify successful curving speed operation with 5.0 inches of unbalanced elevation (cant deficiency) in accordance with the requirements of 49 CFR Part 213.329. Tests shall also be conducted with instrumented wheelsets as well as truck and carbody accelerometers to demonstrate compliance with the requirements of 49 CFR Part 213.333 and Part 213.345 for a maximum revenue operating speed of 100 mph. The Contractor shall fully support SEPTA's submission to the FRA regarding these requirements.

11.1.3 Reliability

A. All non-wearing mechanical components of the truck shall be designed for a minimum service life of 40 years. The truck and its components shall be capable of operating a minimum of 10 years or 500,000 miles, whichever occurs first, between overhauls.

B. The Contractor shall provide instructions in the appropriate Maintenance Manuals for future field repair welding procedures for the truck.

11.2 Truck Structural Design

11.2.1 General

A. The two trucks on a car shall be designed and constructed to support the weight of an AW2 loaded car (fatigue) or an AW3 loaded car (static and overload) at revenue operating speed of 100 mph.

B. All truck components shall have the necessary strength, with factors of safety, to resist all stresses that may develop in service. The truck frame and all truck parts, including propulsion and braking apparatus, shall be capable of withstanding the maximum stresses imposed by the forces acting on the truck, including all static and dynamic carbody loads, track impact loadings, acceleration, dynamic and regenerative braking, friction braking, parking brakes, and any possible combination of these forces.

C. The truck frame and all components shall be retained to the truck bolster and to the carbody in accordance with the requirements of 49 CFR Part 238.219 and APTA Standard PR-CS-S-034-99 section for Truck to Car Body Attachment Strength.

D. The ultimate strength of the truck and the truck-to-carbody connection shall be sufficient to secure the entire truck to the carbody in a manner which will prevent truck separation during derailments, collisions, or other untoward events in which a horizontal load of 250,000 pounds is applied on the truck frame. This load may be transmitted from the truck frame through structural members, positive stops, or other rigid, mechanical safety devices and/or combinations thereof to the carbody bolster. Bolster anchors/radius rods shall not be used to provide any part of this strength.

E. The yield strength of the truck and the in-service truck-to-carbody connections shall be sufficient to withstand the maximum in-service tractive effort, braking, and suspension loads with a factor-of-safety of 1.5.

F. The yield strength of the truck and the in-service truck-to-carbody connections shall be sufficient to withstand a 3g acceleration of a fully assembled truck.

G. The Contractor shall provide an analysis of the truck-to-carbody connections. **(CDRL 11-02, Truck-to-Carbody Connection Analysis Report)**

11.2.2 Structural Validation Plan

A. The Contractor shall provide a complete structural validation plan as outlined by APTA PR-M-RP-009-98, Section 3.1.5, Structural Validation Plan **(CDRL 11-03, Truck Structural Validation Plan)**

1. The purpose of the validation plan is to describe in detail the list of the steps planned to demonstrate structural safety and compliance with the requirements defined in the technical specification.

2. The validation plan shall act as a guide for the design and testing process.

3. After the structural validation plan is accepted by SEPTA, each of the subsequent truck structural analysis and test documents listed below shall be submitted for review and approval.

11.2.3 Truck Structural Analysis and Test

A. The Contractor shall submit each document outlined below, detailing each step of the structural validation plan and results, for SEPTA review and approval. See APTA PR-M-RP-009-98, Section 3.1.5, Structural Validation Plan, for additional information on each document.

B. At its discretion, SEPTA may require review of FEA models and results during live interactive sessions with the engineers who performed the FEA. At these sessions, SEPTA shall have full access to the FEA model input and output in the native software used for the analysis.

1. Truck Stress Analysis Plan **(CDRL 11-04, Truck Stress Analysis Plan)**

2. FEA Model Input Package **(CDRL 11-05, FEA Model Input Package)**

3. Truck Stress Analysis Report **(CDRL 11-06, Truck Stress Analysis Report)**

4. FEA Model Output (Results) Package **(CDRL 11-07, FEA Model Output (Results) Package)**

5. Truck Stress Test – Laboratory, Plan **(CDRL 11-08, Truck Stress Test – Laboratory, Plan)**

6. Truck Stress Test – Laboratory, Report **(CDRL 11-09, Truck Stress Test – Laboratory, Report)**

7. Truck FEA Structural Model Validation Plan **(CDRL 11-10, Truck FEA Structural Model Validation Plan)**

8. Truck FEA Structural Model Validation Report **(CDRL 11-11, Truck FEA Structural Model Validation Report)**

9. Truck Stress and Load Test – On-Track, Dynamic Plan **(CDRL 11-12, Truck Stress and Load Test – On-Track, Dynamic Plan)**

10. Truck Stress and Load Test – On-Track, Dynamic Report **(CDRL 11-13, Truck Stress and Load Test – On-Track, Dynamic Report)**

11. Fatigue Assessment Validation Report **(CDRL 11-14, Fatigue Assessment Validation Report)**

12. Manufacturing Validation Report **(CDRL 11-15, Manufacturing Validation Report)** (if required by Structural Validation Plan))

11.2.4 Allowable Stress

A. Fatigue - Contractor shall determine the maximum allowable stresses for the truck frame, bolster, and truck components in order to perform without degradation over the 40-year useful life. The allowable stresses shall be based on the standards listed below, or determined by the Contractor using industry standard practice and supported by test data with statistical analysis. **(CDRL 11-04)**

   1. Cast Truck Design - published endurance limit values (with statistical analysis showing survival and confidence level percentages) for notched rotating beam or as-cast surface flat tension-tension specimens when plotted on the modified Goodman diagram.

   2. Welded Truck Design – Stress range by weld category for each weld and base material according to AWS D1.1.

B. Static – Maximum allowable stress shall be 55% of the yield strength of the material.

C. Overload – Maximum allowable stress shall be the yield strength of the material. No permanent deformation allowed in structural elements.

11.2.5 Truck Design Loads

A. Truck design loads used for the truck structural analysis and laboratory test shall be defined by the Contractor. **(CDRL 11-04)** The loads specified herein are considered minimum values. These loads shall be confirmed by testing according to, Truck Stress and Load Test – On-Track, Dynamic as defined in Section 15, Test Program. The highest vertical load of all car types, as seen at the truck, shall be used for the loadings. Loads marked by double asterisk (**) shall be included in the stress analysis but will not be applied during the laboratory truck stress test.

1. Fatigue

    a. Vertical – 1.0g +/-0.25g x AW2 loaded carbody weight per truck.

    b. Lateral – +/-0.15g x AW2 loaded carbody weight per truck applied at the carbody center of gravity.

    c. Longitudinal – +/-0.15g x AW2 loaded carbody weight per truck applied at the carbody center of gravity.

    d. Braking – Full-service braking, according to Section 12, Friction Brake.

    e. Twist – One wheel lifted/lowered length equal to 1.25 inches.

    f. **Dampers – +/-100% of maximum dynamic condition.

    g. **Truck-Mounted Equipment Mass Inertia Loads, see TS 11.2.5.

B. Vertical, lateral, longitudinal, and braking loads shall be applied simultaneously with phasing and directions which represent the operating environment. Damper and truck-mounted equipment loads are for localized analysis of brackets and mounts. Twist load shall be applied in combination with vertical load only.

1. Static

    Vertical, lateral, and longitudinal loads shall be applied simultaneously.

    a. Vertical – 110% of AW3 loaded carbody weight per truck.

    b. Lateral – 25% of the vertical load, applied at the carbody center of gravity.

    c. Longitudinal – 15% of the vertical load, applied at the carbody center of gravity.

2. Overload

a. Vertical – 1.5g x AW3 loaded carbody weight per truck.

b. Lateral – 25% of the vertical load, applied at the carbody center of gravity.

c. Longitudinal – 15% of the vertical load, applied at the carbody center of gravity.

d. Braking – Maximum specified deceleration, according to Section 12, Friction Brake.

e. Twist – Complete wheel unloading at one wheel with Vertical – 1.0g x AW3 loaded carbody weight per truck.

f. **Dampers – 2 x damper force at reference speed.

g. **Truck-Mounted Equipment Mass Inertia Loads, see TS 11.2.5.

C. Vertical, lateral, longitudinal, and braking loads shall be applied simultaneously. Damper and truck-mounted equipment loads are for localized analysis of brackets and mounts. Twist load shall be applied in combination with vertical load as listed.

11.2.6 Truck-Mounted Equipment Mass Inertia Loads

A. Mass inertia loads used for the truck structural analysis fatigue and overload cases shall be defined by the Contractor. **(CDRL 11-04)** See APTA PR-M-RP-009-98, Section 3.1.4, Truck-Mounted Equipment Design Loads, for additional information on recommended practices.

B. These loads shall be confirmed by testing according to Section 15, Test Program.

11.3 Weight Transfer

A. The car shall be capable of high instantaneous deceleration rates during emergency braking per Section 2, Design and Performance Criteria. The truck design shall minimize the likelihood of wheel slide by minimizing weight transfer between axles, accomplished through the design geometry.

B. The amount of actual weight transfer produced by the proposed truck and the wheel-rail adhesion required to prevent wheel slide shall be submitted for qualification of the design during each Design Review phase.

11.4 Clearances and Access

11.4.1 Clearances

A. The complete truck with all equipment must not exceed the clearance limits required between the truck and the carbody, or between the truck and the right-of-way, for safe operation with maximum wear and load, over limiting horizontal and vertical curves as well as tangent track.

B. The minimum clearance above the top of rail, except for wheels, shall be 2.75 inches with fully worn wheels, full vertical travel of the suspension system (including failed condition) and AW3 load.

C. All truck parts shall negotiate the minimum radius curve and other track characteristics specified in Section 2, Design and Performance Criteria.

D. A minimum clearance of 1.5 inches (including construction tolerances) shall be maintained between moving truck parts and carbody parts, including wiring, hoses, cables, wheels, and chains, under the most unfavorable combinations of vertical and horizontal track curvature, wheel wear, lateral and vertical motion, roll, and failed springs.

E. The trucks shall be so designed that the maximum vehicle vertical and lateral deflection and roll are within the clearances specified in Section 2, Design and Performance Criteria. The method of meeting these requirements shall be submitted during the Design Review process. **(CDRL 11-16, Truck Clearance Diagrams)**

11.4.2 Access

A. The truck design shall provide unobstructed access to all parts which require inspection, lubrication, and/or removal and replacement on a 3 year or less basis and without requiring removal of any other apparatus.

B. Inspection covers on equipment, when removed, shall provide clear visibility of all apparatus which requires inspection and/or maintenance.

C. Oil level and lubrication fittings on the truck and its components shall be accessible for servicing from a pit or from the side of the car with the carbody in its normal position.

D. All truck mounted and/or carbody mounted parts which must be removed to allow the removal of the trucks shall be affixed with accessible bolts, pins, and/or removable fastenings.

E. The design of the car and its trucks shall permit SEPTA to make unrestricted use of its existing wheel truing machines, and it will be the responsibility of the Contractor to specifically verify this issue during Design Review, and to submit details . **(CDRL 11-16)** SEPTA currently operates wheel truing machines at the following two locations:

1. Stanray TN-84C Underfloor Wheel Milling Machine at Overbrook Shop

2. Hegenscheidt U2000-400D Tandem Wheel Lathe at Frazer Shop

F. Axle centers shall be accessible without removing any covers, usage of access covers for axle ends requires Approval.

G. No part of the truck assembly or car, including brake discs and bolster anchor brackets, shall interfere with or foul any part of the wheel truing apparatus.

H. The truck shall be designed for maintainability and ease of access to components. Maintainability analysis shall be part of each design review phase.

11.5 Truck Structure

A. In accordance with Section 16, Materials and Workmanship, all castings and all complete joint penetration welds of the first truck produced shall be subjected to 100 percent volumetric radiographic inspection. Ultrasonic inspection may be used if radiographic inspections are not possible, on a case by case basis for specific casting and weld areas, subject to Approval.

11.5.1 Frame

A. The truck frame shall be a service proven design or a derivative of a service proven design. The truck frame may be either a cast steel design, which shall meet or surpass the requirements of AAR Specification M-201, Grade "B" with the exception of the addition of 2.0 percent nickel, or welded steel design using HSLA steel per Section 16, Materials and Workmanship, stress relieved after welding. Equivalent cast and plate steel materials may be proposed, subject to Approval.

B. All cast steel truck frame members shall be of one-piece construction and shall not contain welded joints or connections.

C. All cast steel truck frames shall be normalized. Where pockets or partially enclosed spaces exist, adequate drainage shall be provided so that no moisture collects.

D. Each truck shall be a true rectangle as measured from identically positioned gauge marks at each corner of the frame, being within 0.0625 inch between the marks on each side, or between diagonally opposite marks. Each frame shall also have accurately located permanent gauge marks so that it can be easily checked for tram.

E. Fabricated truck frames shall not utilize partially welded or intermittently welded seams, with the exception of wear plates, subject to Approval.

11.5.2 Bolster

A. The truck bolster shall be a service proven design or a derivative of a service proven design. The bolster may be either a cast steel design, which shall meet or surpass the requirements of AAR Specification M-201, Grade "B" with the exception of the addition of 2.0 percent nickel, or welded steel design using HSLA steel per Section 16, Materials and Workmanship, stress relieved after welding. Equivalent cast and plate steel materials may be proposed, subject to Approval.

B. All cast steel truck bolsters shall be normalized. Where pockets or partially enclosed spaces exist, adequate drainage shall be provided so that no moisture collects.

C. The truck bolster shall support the carbody by means of two air springs, with one located at each end of the bolster.

D. The bolster shall be arranged to move laterally by distortion of the air springs, but hydraulic shock absorbers shall dampen, and stops shall limit, this motion.

E. The bolster shall be prevented from moving longitudinally and from swiveling by radius rods between the ends of the bolster and the carbody.

F. Loads shall be transmitted from the bolster to the truck frame by a central bearing or side bearings. The truck frame shall be attached to the bolster with a locking center pin.

G. A means shall be provided for retaining the bolster with the carbody for jacking and removing the truck frame. The "safety straps" shall be designed to support the truck assembly without distortion or bending.

H. The bolster may also act as an air reservoir, connected to the air springs. The interior of the bolster shall be thoroughly cleaned to remove scale, weld flux, sand, and all other potential contaminants, and shall be treated to resist corrosion prior to final assembly.

11.5.3 Equalizers

A. Equalizer beams, if considered necessary for compliance with the specified requirements as required by the design, shall be used between the journal boxes.

B. The selected equalizer beam material and design shall be consistent with the truck design and specified loading conditions. The design and manufacturing technique shall be submitted for Approval.

C. The centerline of the equalizers and primary springs shall coincide with the centerline of the journal bearings.

D. The equalizer coil spring seats shall be made of cast steel to AAR Specification M-201, Grade "B".

E. The springs shall be mounted on insulation pads in the spring seats. Steel shims may be used under the insulation pads for initial wheel load adjustments per TS 11.17.6(1)(b).

F. Removable cast steel equalizer seats shall be used between the equalizer beams and the journal boxes.

G. These seats shall be furnished in three thicknesses to provide adjustment for wheel wear in 0.50 inch thick increments.

H. All cars shall be delivered with the minimum thickness seat installed. The Contractor shall ship to SEPTA a number of each alternate thickness seat, per the capital spares list.

11.5.4 Radius Rods (Bolster Anchors)

A. Two radius rods shall be provided on each truck, connecting the carbody to the truck bolster. The rods shall extend horizontally from brackets attached to the side sills to brackets attached to the ends of the truck bolster.

B. Each of the rods shall withstand a minimum longitudinal load of two times the weight of the complete truck, including all propulsion and braking apparatus, without exceeding the yield strength of the materials used or the critical buckling stress. Each of the brackets by which the radius rods are attached to the truck, the truck bolster, and/or the carbody, and the members to which these brackets are attached, shall exceed that of the radius rods such that under conditions of extreme loading, the rods will fail without causing permanent deformation to the anchor brackets, their attachments to the carbody, or the carbody structure. The Contractor shall provide fatigue, static and overload analysis of the radius rods as part of the truck-to-carbody connection analysis. **(CDRL 11-02)**

C. The radius rods shall be designed and located to minimize noise, longitudinal vibration and weight transfer during acceleration and braking.

D. The radius rods shall be located near the truck centerline and shall be designed to decouple the effects of truck pitch. Elastomeric pads shall be installed between the radius rod assembly and anchor brackets to permit vertical and lateral movement.

11.6 Suspension

11.6.1 Primary Suspension

A. The primary suspension at each journal box shall consist of single or nested pairs of steel coil springs manufactured in accordance with AAR Specification M-114 and the recommended practices of APTA PR-M-RP-009-98, Section 3.5, Helical Coil Spring Design Guidance, using alloy spring steel in compliance with AISI 5160H, or elastomeric elements of service proven design.

B. Journal boxes shall be supported and suspended in a manner as to comply with the specified performance and ride quality.

C. All coil springs shall be shot peened, painted black and the surfaces upon which they bear shall be provided with sound and vibration-deadening inserts.

D. Retainers must be provided to prevent an axle from leaving the truck when the car is lifted with the trucks attached, or in the event of a derailment. Retainers shall also prevent any primary suspension element from leaving its proper position when the axle is carried by its retainers, as will occur in order to spin motors and axles.

E. Removal and replacement of a wheelset assembly shall not require de-trucking.

F. Primary springs shall be grouped by height under AW0 load after manufacturing, then marked to clearly identify group for each spring (banding, color-coded, etc.). All springs must be in the same group for a given truck.

G. The Contractor shall submit coil spring design stress calculations. **(CDRL 11-17, Coil Spring Design Stress Calculation Report)**

11.6.2 Secondary Suspension

A. The secondary suspension shall consist of air springs of a single or double convoluted design, along with an auxiliary air volume internal to the truck bolster if necessary.

B. All air springs shall be fabricated of natural or other forms of rubber to increase product life, and designed for ease of maintenance and replacement.

C. Means shall be provided so that when one air spring of a truck is deflated for any reason, the other air spring will also be deflated regardless of whether or not the two air springs are controlled by the same leveling valve.

D. A replaceable elastomeric stop with metal facing shall be provided in each air spring housing to limit downward carbody vertical motion and to support the carbody in the event of an air spring failure. The stop shall be designed with a progressive rate to produce a low force at initial contact which then builds up as the stop is compressed, and shall permit safe operation at maximum speed without discomfort to passengers, although specified ride quality requirements need not be met under this condition.

E. Bosses shall be provided on the members on either side of the air spring so that a go/no-go gauge may be inserted to verify proper spring height. White-painted metal indicator pointers which align when the air spring is at the proper height shall be provided for purposes of yard inspection. These shall be mechanically fastened for ease of replacement.

F. Shims required to compensate for truck construction tolerances shall be welded in place on the bolster. Shims required to correct for carbody construction tolerances which result from carbody warpage or twist shall be permanently welded to the carbody.

11.6.3 Leveling Valves

A. Leveling valves shall be provided on each car. The valves shall detect variations in height between the carbody and truck bolsters due to passenger load. Each valve shall admit or exhaust air from the air springs to maintain the carbody at a constant preset height above the truck.

B. 3 Point leveling with two leveling valves for roll control mounted on the "F" end truck and a single leveling valve mounted on the A end is preferred. Alternate arrangements may be proposed subject to Approval.

C. These valves shall not be damaged by any possible normal movement of the truck.

D. The normal failure mode of these valves shall cause deflation of the air springs.

E. Leveling valves shall be Westcode Incorporated WD12155/008 (Left Hand) and WD12155/005 (Right Hand) or Approved equal service proven design with service in North America.

F. The valve linkage shall be easily adjustable from the side of the car or from a maintenance pit, with measurement reference points provided to permit one maintainer to perform the adjustment in approximately 5 minutes per truck. The valve arm travel and linkage shall be sufficient to allow the carbody to be lifted complete with the trucks without damage.

G. The leveling valve action shall be controlled through a mechanical linkage. The leveling valve shall have a clearly pronounced "dead band" tuned to provide the indicated ride quality without excess operation of the air supply system.

H. A choke shall be provided in the leveling valve air supply pipe to both trucks to prevent rapid air loss from the car in the event of air spring rupture.

I. At each end of the car, a self-locking cutout cock with yellow painted handle shall be provided to supply air to the truck air suspension system from the main reservoir system. An alternate supply shall be provided from the brake pipe, through a cutout cock which is safety-wired closed, along with a check valve and choke. Accessible and suitable test fittings shall be provided at each leveling valve to monitor and calibrate air spring pressure.

J. The Contractor shall include as part of the design review process a detailed procedure for leveling the cars. This procedure shall be based upon an easily performed carbody-to-bolster dimensional measurement, and shall contain tolerances and all tools required to adequately perform the task. To provide for an expedient method for future adjustments and inspections, the car centerline at each end of each bolster shall be identified with a permanent plate showing the actual "as-built" centerline of the car.

11.6.4 Vertical Shock Absorbers (Dampers)

A. Hydraulic shock absorbers shall be installed between the truck bolster and the carbody to provide vertical damping and to ensure that specified ride quality is attained. Mountings for the shock absorbers shall be sufficiently resilient to provide sound and vibration isolation between the truck and the carbody. Dampers shall have a minimum functional life (95% survival) of five years.

11.6.5 Lateral Shock Absorbers (Dampers)

A. If required by the design, a hydraulic shock absorber shall be mounted between the truck bolster and the carbody to adequately damp lateral movement, and ensure that the specified ride quality is attained. These shock absorbers shall not prevent the carbody from centering on the truck after a lateral movement. The mountings for the shock absorber shall be sufficiently resilient to provide sound and vibration isolation

between the truck and the carbody. Dampers shall have a minimum functional life (95% survival) of five years.

11.6.6 Wear Adjustment

A. The truck design shall allow for vertical height adjustment to compensate for maximum wheel wear, elastomeric suspension creep (if applicable) and wear of other truck parts without impacting leveling valve calibration.

B. If shims are used, they must be held in place by retaining features, loose shims shall not be used.

C. Provision shall be made for a minimum of 1.50 inches adjustment, in at least three equal steps of the truck height to compensate for wheel wear. This equates to 3.0 inches reduction in wheel diameter from nominal new to minimum worn.

D. The design and method of height adjustment shall allow for quick and easy adjustment without disassembly of truck or removal of the truck from the car. It is recognized that the carbody weight will need to be removed to make the adjustment. The Contractor shall include as part of the design review process a detailed procedure for wear adjustments.

11.7 Center Bearing and Side Bearings

A. Center and side bearings, when used, shall be designed to permit rotation of the truck and to transmit vertical loads from the bolster to the truck frames. Bearings shall be designed to dampen truck swiveling and to prevent truck nosing and hunting.

B. The center bearing or side bearings shall be of the flat type, achieving load bearing contact over a minimum of 85% of the surface, and of sufficient diameter or lateral spacing to meet structural requirement.

C. All center bearing and side bearing liners shall be of non-metallic material with no lubrication required. The material shall not exhibit defects such as peeling, uneven wear, or uneven contact.

D. Effective sound deadening shall be achieved.

E. The material shall be chosen to produce minimum truck turning forces, yet have sufficient friction to make the truck critical speed greater than 90 mph with fully worn wheels without the need for any supplementary damping.

F. Wear limits shall be inscribed on the material.

G. The bearing shall be sized to produce a service life of at least 10 years without the need for any intermediate inspection.

H. The members used to attach the truck to the carbody shall be designed and located in a manner that shall minimize the possibility of damage during low speed derailments.

11.8 Stops

A. In order to limit truck lateral, vertical and rotational movements, a combination of replaceable elastomer stops shall be provided. Truck parts which are contacted by elastomeric stops shall have stainless steel wearing surfaces. Lateral and vertical elastomeric stops shall be designed with a progressive rate to produce a low force at initial contact, which shall build up as the stop is compressed.

B. Stops shall develop sufficient force to limit motion properly, but shall not go solid under any conditions that can be developed in the truck during normal operation. There shall be elastomeric stops to support the carbody weight in the event of an air suspension failure.

C. Under extreme conditions, solid mechanical stops shall prevent lateral displacement in excess of the allowable motion stipulated on the clearance drawing. Rotational stops shall be arranged to limit truck rotation but shall not interfere with normal operations. Rotational stops shall resist a moment equivalent to 20,000 lb (89 kN) at 4 ft (1.2 m) from the center of rotation of the truck.

D. Stops shall be adjustable for wear and shall not require removal of the truck from the car when changed.

E. The Contractor shall include as part of the design review process details on the location and characteristics of each stop.

11.9 Safety Straps

A. A means shall be provided for retaining the bolster and truck frame with the carbody during vertical jacking or lifting of the carbody.

B. These safety straps shall be designed to provide a safety factor of two, based on the yield strength of the material.

C. They shall be designed and located in a manner which shall minimize damage during derailments at speeds below 15 miles/hour.

D. Truck mounted brackets shall also be provided to engage safety lugs on the traction motors and gear units in the event of failure of the motor support arrangement.

E. Additional safety hangers and safety stops shall be provided where necessary, per APTA PR-M-RP-009-98, Section 2.5, Fail-Safe Design.

11.10 Wiring and Piping

A. The truck grounding system shall be sized to allow operation with up to two shunt paths per car disconnected without exceeding the current ratings of the remaining electrical grounding apparatus, per Section 10, Propulsion and High Voltage System. The ground brushes shall meet the requirement of Section 10, Propulsion and High Voltage System.

B. Flexible ground cables shall be provided between the carbody and the trucks connected as specified in Section 16, Materials and Workmanship and between the traction motors and the trucks. **(CDRL 11-01)**

C. Special attention shall be given by the Contractor to prevent damage to wiring or connectors by vibration or cable flexing. Any electric cables shall be carried on the truck members only as specifically approved. It is intended that cables will drop directly from the carbody connector. All piping, wire and cables and their installation shall meet the requirements of Section 16, Materials and Workmanship and APTA-PR-M-RP-009-98, Section 3.7.2, Electrical Wiring and Pneumatic Piping.

D. All truck piping shall conform to the requirements of Section 16, Materials and Workmanship.

E. Journal bearings and journal bearing boxes shall be electrically isolated from the truck frame by the primary suspension or other means. The grounding scheme for the car shall ensure that the conduction path shall not be through the journal bearing or journal bearing box.

11.11 Wearing Parts

A. There shall be no metal-to-metal sliding contact surfaces in the truck unless specifically Approved. **(CDRL 11-01)** All wearing parts in the truck shall be provided with renewable liners of suitable non-metallic materials not requiring lubrication. Pedestal liners, if used, shall be made of manganese steel attached to the truck frame in a suitable manner. All wearing elements shall minimize the transmission of noise and vibration and shall have frictional characteristics suitable for the intended purpose.

11.12 Propulsion Equipment Mounting

A. The traction motors and gear units shall be mounted per Section 10, Propulsion and High Voltage System. Shims shall not be used to accommodate manufacturing tolerances in the truck. There shall be no noticeable vibration inside the car from the traction motors and gear units at speeds up to 110 mph. The traction motor installation shall be designed for ease of removal. The Contractor shall include as part of the design review process detailed figures illustrating motor installation, access, and removal.

11.13 Wheelset Components

A. All wheelset components shall be manufactured and assembled by a supplier currently certified under the AAR Standard M-1003.

11.13.1 Axle

A. The axle shall meet the requirements of APTA PR-M-RP-008-98, Recommended Practice for Rolling Stock Axle Design, as well as all additional requirements herein. Where conflicting requirements between standards and the Specifications occur, the

more restrictive requirement shall govern. Material shall be solid wrought steel, chemistry Class APTA 1052 (equivalent to AAR M-101 Grade F or H with maximum 0.05% silicon), mechanical Grade F or H1.

B. Hollow axles are not permitted. Axle ends may be extended, as required by the disc brake installation method used, in order to permit access by a wheel truing machine. The axle shall have an oversize wheel seat to provide longer service life.

C. Axle fillet and groove radiuses shall be cold rolled per APTA PR-M-RP-008-98.

D. The contractor shall provide an axle stress calculation report for SEPTA review and approval. Car loading of AW3 shall be used for axle analysis. **(CDRL 11-18, Axle Stress Calculation Report)**

E. Material and heat treatment certification shall be provided with each vehicle history book. Each axle shall be inspected by both the wet fluorescent magnetic particle and ultrasonic methods. A record of all inspections shall be provided with each vehicle history book.

11.13.2 Wheel

A. Wheels shall be either 32 inch diameter nominal new, 29 inch diameter worn, or 36 inch diameter nominal new, 33 inch diameter worn, AAR Class B, wrought steel multiple-wear type.

B. The wheel profile currently used on the Silverliner V cars is based on the AAR S-621-79 profile with a 1:20 tread taper and 68 degree nominal flange angle. The wheel profile for the Silverliner VI cars shall be one of the two listed below, based on supporting analysis for ride quality, curving flange wear and flange climb derailment risk to be provided by the Contractor:

1. APTA 120 per APTA PR-M-S-015-06 with 72 degree minimum flange angle.

2. APTA 320 per APTA PR-M-S-015-06 with 75 degree nominal flange angle.

C. All wheels shall meet the requirements of APTA PR-M-S-012-99, Revision 3, Standard for the Manufacture of Wrought Steel Wheels and requirements specified herein, where conflicting requirements between standards and the Specifications occur, the more restrictive requirement shall govern.

D. Each wheel shall be inspected by both wet fluorescent magnetic particle and ultrasonic methods.

E. Analytical evaluation of the wheel design for combined mechanical and thermal overload conditions shall be performed according to AAR S-660, with thermal input load adjusted to represent the braking configuration and SEPTA service. Analytical evaluation of the wheel design for fatigue loading shall be performed according to AAR S-669. Car loading of AW3 shall be used for wheel analysis. The results of these analyses shall be submitted. **(CDRL 11-19, Wheel Stress Analysis Report)**

11.13.3 Journal Bearing

A. The journal bearings shall be fully enclosed, grease lubricated roller bearings without grease fittings (NFL), AAR Class K. Bearing shall be approved for service according to AAR Specification M-934. Seals shall be approved for service according to AAR Specification M-959. The journal boxes shall be interchangeable. All journal bearings shall be designed for 1,000,000 miles of revenue service under AW2 car loading with 1.3 loading factor with no more than 10 percent bearing failure (ABMA L10 life rating). The results of the bearing life analysis shall be submitted to SEPTA. **(CDRL 11-20, Journal Bearing Life Analysis Report)** Bearings shall not require inspection more than once every 500,000 miles.

11.13.4 Component Mounting

A. All axle components shall be mounted on axles using pressures and fits as specified in APTA-PR-M-S-019-17, Passenger Wheel Set Assembly, using an AAR certified facility.

B. When assembling the wheels and axles, the wheel pairs shall be matched with respect to tape size in accordance with AAR Standards. More restrictive practices shall apply for gear unit mounting if recommended by its manufacturer.

C. Brake disc mounting characteristics shall comply with manufacturer's recommendations.

D. Pressure graphs and inspection sheets for every axle component shall be contained in each Car History Book, along with all serial number records.

11.14 Elastomeric and Non-Metallic Elements

A. Complete design and purchasing information shall be provided for all elastomeric and non-metallic elements in the as-built drawings (see Section 25, Program Management and Commissioning) including material composition, spring rate, hardness, process details, dimensions, tolerances, coefficient of friction, etc. to enable SEPTA to specify and purchase replacement parts during the life of the car.

11.15 Shock and Vibration

A. All pneumatic, electrical, and electronic equipment/components mounted to the truck shall be tested for shock and vibration in accordance with IEC 61373 (1999) – Railway Application, Rolling Stock Equipment, Shock and Vibration Tests.

B. All electrical equipment and electrical enclosures should be protected from the effects of the environment and have NEMA 4 or at minimum IP64 ingress protection.

11.16 Vehicle/Track System Qualification

11.16.1 Vehicle Dynamic Performance Qualification Plan

A. The Contractor shall submit a vehicle dynamic performance qualification plan . **(CDRL 11-21, Vehicle Dynamic Performance Qualification Plan)**

1. The purpose of this plan is to outline the documentation, process and steps which will be followed to ensure all vehicle dynamic performance requirements are met and ensure timely FRA approval of the planned operation.

2. The plan shall outline the approach for each project phase through concept development, design, simulation, testing and model validation.

3. After the vehicle dynamic performance qualification plan is Approved, each of the subsequent documents listed in TS 11.16.2 through TS 11.16.5 shall be submitted for review and Approval.

4. Periodic vehicle dynamic simulation review meetings between the Contractor and SEPTA will be required as the project progresses through each phase. It is SEPTA's intent to work collaboratively with the Contractor to ensure that the vehicle dynamic model properly represents the vehicle design and that track inputs represent the actual operational environment. During these vehicle dynamic simulation meetings, SEPTA must be able to review the fully detailed simulation model, track inputs and results in the native simulation software environment.

11.16.2 Vehicle Dynamic Simulation Plan

A. The Contractor shall submit a detailed vehicle dynamic simulation plan **(CDRL 11-22, Vehicle Dynamic Simulation Plan) .** The purpose of this plan is to describe all planned dynamic simulations along with inputs and pass/fail criteria for each simulation. Vehicle dynamic simulations must be performed using an industry recognized software (NUCARS, VAMPIRE, SIMPACK, etc.).

11.16.3 Vehicle Dynamic Simulation Report

A. A vehicle dynamic simulation report must be submitted during the vehicle design process. **(CDRL 11-23, Vehicle Dynamic Simulation Report)** This report must include results demonstrating compliance with all performance requirements in TS 11.16.6.

11.16.4 Vehicle Dynamic Model Validation Plan

A. The vehicle dynamic simulation model must be validated based on testing results. A vehicle dynamic model validation plan must be submitted **(CDRL 11-24, Vehicle Dynamic Model Validation Plan)** . This plan must include planned quasi-static vehicle characterization tests (static lean, wheel equalization, truck rotational resistance,

other tests as proposed by the Contractor), planned suspension component tests (springs, dampers, bumpers, traction rods, friction elements, etc.) and planned dynamic on-track tests per 49 CFR Part 13, Appendix D, Section (1)(a).

11.16.5 Vehicle Dynamic Model Validation Report

A. A vehicle dynamic model validation report must be submitted **(CDRL 11-25, Vehicle Dynamic Model Validation Report)**. The purpose of this report is to demonstrate that the simulation model has been validated by correlating the simulation predicted results with the physical testing results. If this validation effort requires updates to the model, a revision of the vehicle dynamic simulation report must also be submitted.

11.16.6 Vehicle Dynamic Performance Requirements

A. Wheel Load Equalization

1. The truck shall provide wheel load equalization such that the lifting or lowering of any one wheel in a truck a height of 2 inches shall not unload any other wheel in the truck by more than 25 percent when the truck is under the carbody with air springs inflated, which is a value SEPTA considers necessary for its existing track conditions and has been achieved on its present equipment. Wheel load equalization limits shall be met with the carbody at any load between AW0 and AW3. SEPTA may consider some relaxation of the wheel unloading limits based on simulations demonstrating full compliance with TS 11.16.6, using a validated model per TS 11.16.4 and TS 11.16.5.

2. Per FRA Safety Advisory 2013-02, the suspension system shall control static wheel-load distribution when the equipment is stationary on level track such that the lightest wheel load deviates by no more than 5% from the nominal wheel load for a given truck.

B. Static Lean

1. Maximum Cant Deficiency – Each car type shall meet the requirements of 49 CFR Part 213.329 (d) for wheel unloading and carbody roll angle.

2. Maximum Cant Excess – No wheel shall experience more than 50% wheel unloading when the train is stopped on a 6 inch superelevation.

C. Low Speed Curving

1. Simulations shall be performed according to the requirements of APTA-PR-M-S-031-22 Low-Speed Curving Performance Standard.

2. Simulations shall not exceed the 49 CFR 213.333 single wheel L/V ratio for warp amplitude of 3 inches and all warp lengths of 20 feet, 40 feet and 62 feet as defined by the standard.

3. Simulations shall not exceed the 49 CFR 213.333 single wheel L/V ratio for warp amplitude of 1.25 inches and warp length equal the truck wheelbase as defined by the standard.

    a. This is based on SEPTA SMW-100, Manual for the Inspection, Maintenance and Construction of Track, Part 1 Track Safety Standards, SUBPART C – Track Geometry, Section 213.63(a): The difference in cross level between any two points less than 10' apart is designated as "Short Warp" and may not be more than 1-1/4".

D. Minimally Compliant Analytical Track (MCAT)

1. MCAT simulations shall be performed per 49 CFR 213 Appendix D.

2. For the purposes of 49 CFR Part 213.345 qualification with the FRA, MCAT simulations shall be run with AW0 car loading and all truck components in the new condition.

3. A select sub-set of additional MCAT simulations for SEPTA information, to be proposed by the Contractor and approved by SEPTA, shall be run with AW3 car loading and all truck components in the new condition.

E. Representative Service Route

1. Each car type shall demonstrate acceptable performance for simulations on track segments representative of the planned operation. Measured track geometry for these simulations shall be coordinated by and gathered at the expense of the Contractor.

2. Simulations on representative track segments shall be run with 1) AW0 car loading and 2) AW3 car loading with all truck components in the new condition.

    a. Simulations in the new condition must meet all 49 CFR 213.333 vehicle/track interaction safety limits for wheel-rail forces, carbody accelerations and truck lateral acceleration.

3. Additional simulations shall be run to ensure safety with truck components in the worn or failed condition: broken or collapsed coil spring, deflated air springs, inoperative damper, high friction at sliding interfaces, stiffening of elastomeric elements due to low temperature and aging, worn wheels. Measurements of representative worn wheel profiles shall be coordinated by and gathered at the expense of the Contractor.

    a. Simulations with truck components in the worn or failed condition must meet 49 CFR 213.333 vehicle/track interaction safety limits for wheel-rail forces and truck lateral acceleration. Exceedances of 49 CFR 213.333

vehicle/track interaction safety limits for carbody accelerations will be reviewed for acceptance on a case-by-case basis.

F. High Speed Stability

1. Each car type must not exhibit truck hunting or sustained vehicle body lateral oscillation up to a maximum design speed of 110 mph by vehicle dynamic simulation and up to a maximum speed of 100+5 mph during testing.

2. Limits for sustained truck lateral and vehicle body lateral accelerations are defined by 49 CFR Part 213.333.

3. Linear Modeling – Stability simulations must be performed by linear Eigenvalue analysis with creep factor range of 0.67-1.00 and equivalent wheel conicity range of 0.025-0.400.

4. Non-Linear Modeling – Stability simulations must be performed in both new and worn conditions using the full non-linear model running through a lateral track perturbation at sufficient speed to cause hunting. A “top-down speed sweep” must then be used to determine the critical hunting speed. Simulations must use friction coefficient of 0.5 along with combinations of new/worn wheel profiles, new/worn rail profiles and new/worn truck components (dampers, friction elements, elastomer elements, etc.). Measurements of representative worn rail profiles shall be coordinated by and gathered at the expense of the Contractor.

G. Ride Quality

1. A comfortable ride (as defined in Section 2, Design and Performance Criteria) shall be provided at all permissible speeds under normal operating conditions.

2. Ride quality for all proposed truck designs shall be demonstrated analytically and through actual track testing per the requirements of Section 15, Test Program.

3. Weighted rms acceleration and crest factors shall be calculated according to ISO Standards 2631-1 and 2631-4.

4. Simulations shall be performed in the AW0 and AW2 load conditions.

H. Natural Frequencies and Damping Rates

1. Eigenvalue analysis must be performed to determine the characteristic damped natural frequencies of the vehicle body and trucks (pitch, bounce, yaw, upper center roll and lower center roll).

2. Truck hunting modes (free wheelset kinematic) and truck oscillation modes (parallel wheelset kinematic) must be determined over the full range of speed and expected equivalent wheel conicity range of 0.025-0.400.

3. Characteristic frequencies and damping rates as a percentage of critical damping must be provided.

I. P2 Forces

1. A calculation must be made to show that the vertical track dynamic (P_2) forces do not exceed 68,000 lbs for a 0.5 degree dip angle and all speeds up to the operating speed limit. The calculation is to consider nominally stiff concrete tie track and to use the British Rail Equation (as defined in British Railways Board Group Standard GM/TT0088 Issue 1).

2. The specific equation to be used is as follows:

$$P_2 = P_0 + 2\alpha v \sqrt{\frac{m_u}{m_u + m_t}} \left(1 - \frac{\pi c_t}{4\sqrt{k_t (m_u + m_t)}}\right) \sqrt{k_t m_u}$$

Where:

P_0 Static wheel load in pounds

α Dip angle in radians

v Vehicle speed in inches/second

m_u Unsprung mass per wheel in lbf/in/sec2

m_t Track mass per wheel in lbf/in/sec2

c_t Track damping per wheel in lbf/in/sec

k_t Track stiffness per wheel in lbf/in

Track parameter values are as follows:

α 0.0085 Total dip angle in radians based on ½ degree on both sides of the dip

m_t 1.1335 Track mass per wheel in lbf/in/sec2 for nominally stiff concrete tie track

c_t 671 Track damping per wheel in lbf/in/sec for nominal track conditions (from literature)

k_t 392,900 Track stiffness per wheel in lbf/in for nominally stiff concrete tie track (corresponds to track modulus of 5,100 lb/in/in, assuming a track deflection of 0.084 inches under a 33,000 pound wheel load)

11.17 Identification and Traceability

A. Provide permanent identification for each component as follows. Serial numbers shall conform with requirements in Section 25, Program Management and Commissioning:

1. Truck frame and bolster:

   a. Serial number plate: Permanently attached and located in a conspicuous place.

   b. Figure size: Minimum 0.8 in (20 mm) high.

2. Wheel: Mark according to AAR M107/M-208 and APTA PR-M-S-012-99.

3. Axle: Mark according to AAR M-101 and APTA-PR-M-RP-008-98.

4. All other major truck components: Serialize and mark with date of manufacture.

11.18 Contract Deliverable Requirements List (CDRL)

The following contract deliverables have been identified in this section; however, the Contractor is responsible for providing and submitting anything necessary to fulfill the requirements of this contract, including those not identified by CDRL number.

CDRL 11-01, Truck System Design Description 11-1
CDRL 11-02, Truck-to-Carbody Connection Analysis Report 11-3
CDRL 11-03, Truck Structural Validation Plan 11-3
CDRL 11-04, Truck Stress Analysis Plan 11-3
CDRL 11-05, FEA Model Input Package 11-4
CDRL 11-06, Truck Stress Analysis Report 11-4
CDRL 11-07, FEA Model Output (Results) Package 11-4
CDRL 11-08, Truck Stress Test – Laboratory, Plan 11-4
CDRL 11-09, Truck Stress Test – Laboratory, Report 11-4
CDRL 11-10, Truck FEA Structural Model Validation Plan 11-4
CDRL 11-11, Truck FEA Structural Model Validation Report 11-4
CDRL 11-12, Truck Stress and Load Test – On-Track, Dynamic Plan 11-4
CDRL 11-13, Truck Stress and Load Test – On-Track, Dynamic Report 11-4
CDRL 11-14, Fatigue Assessment Validation Report 11-4
CDRL 11-15, Manufacturing Validation Report 11-4

CDRL 11-16, Truck Clearance Diagrams 11-7
CDRL 11-17, Coil Spring Design Stress Calculation Report 11-11
CDRL 11-18, Axle Stress Calculation Report 11-16
CDRL 11-19, Wheel Stress Analysis Report 11-16
CDRL 11-20, Journal Bearing Life Analysis Report 11-17
CDRL 11-21, Vehicle Dynamic Performance Qualification Plan 11-18
CDRL 11-22, Vehicle Dynamic Simulation Plan 11-18
CDRL 11-23, Vehicle Dynamic Simulation Report 11-18
CDRL 11-24, Vehicle Dynamic Model Validation Plan 11-18
CDRL 11-25, Vehicle Dynamic Model Validation Report 11-19

11.19 CDRL Details

This section lists the expected content for each CDRL required above. The lists provided for each CDRL are an outline only and should not be considered exhaustive, all CDRLs are subject to SEPTA review and Approval.

CDRL 11-01 Truck System Design Description

1. Shall be submitted as part of each design review meeting (CDR, PDR, FDR).
2. Complete system design description of the truck.
3. High level design description of all major components.
4. Listing of key dimensions and component weights.
5. Show location of flexible ground cables.
6. Show location and type of wearing parts.

CDRL 11-02 Truck-to-Carbody Connection Analysis Report

1. Shall be submitted as part of the PDR design review meeting.
2. Definition of applied loads and constraints.
3. Free body diagrams showing reaction loads.
4. Calculation of reaction loads.
5. Comparison of calculated and allowable stresses.
6. Fatigue, static and overload analysis of the radius rods.

CDRL 11-03 Truck Structural Validation Plan

1. A draft version shall be submitted after NTP +120 days.
2. Shall be submitted as part of each design review meeting (CDR, PDR, FDR).

3. See APTA PR-M-RP-009-98, Section 3.1.5, Structural Validation Plan, for detailed requirements.

CDRL 11-04 Truck Stress Analysis Plan

1. Shall be submitted as part of the CDR design review meeting.
2. Truck Stress Analysis and Testing Plan shall be Approved before submittal of Truck Stress Analysis Report.
3. The plan shall describe the approach and design load cases to be analyzed.
4. Contractor’s chosen static and fatigue allowable stress values, whether published or test values.
5. Table of material properties, at minimum, including the guaranteed minimum yield and ultimate strengths, elongation, Young's modulus, and allowable fatigue stress data for each material.
6. Outline of the procedure to be used to analyze and test the design of the truck.
7. Table of loads to be used for static analysis and test, with load magnitudes and points of application.
8. Description of the analysis to be used for each load condition.
9. Description of the assumptions used during the analysis and their effect on the uncertainty of the results.
10. Derivation of the static loads to be applied.
11. Table of loads to be used for fatigue analysis and test, with load magnitudes, points of application, and phasing.
12. Derivation of the fatigue loads to be applied.
13. Table of loads to be used for truck-mounted equipment mass inertia analysis, with load magnitude and points of application.
14. Diagrams of load applications.
15. Table of allowable stress levels.
16. Description of how meshing accuracy is assessed, globally and at stress concentrations.
17. Description of how analysis results will be correlated with test results.
18. Structural sketches as required.

19. Whenever the process for the analysis and testing of the truck assembly is revised, the plan shall be updated and resubmitted, but not more than monthly. Each revision shall include revision level indications with descriptions of each change.

CDRL 11-05 FEA Model Input Package

1. Shall be submitted as part of the CDR design review meeting.

2. In addition to submitting FEA input data with the FEA Model Input Package, submit the input files each time the files are changed, but not more often than monthly.

3. Submit and receive Approval of the FEA Model Input Package before performing the FEA and submitting the Truck Stress Analysis Report.

4. FEA input data on electronic media as Approved.

5. Element grid, assumptions, and input data, such as loads, section properties, boundary conditions, and material properties.

6. Boundary reaction forces of the truck under its own weight.

7. Key to symbols and colors.

8. Format:

    a. Number each page, and clearly label columns of data on each page.

    b. Define terms, symbols, abbreviations, and units.

9. Each revision shall include revision level indications with descriptions of each change.

10. The element mesh, details of element selection, modeling assumptions, applied loads, boundary conditions, material properties, geometry (area) properties and all other inputs to the FEA shall be included as part of the model submittal, along with the drawings and supporting information used in developing the models.

11. The finite element model shall comply with AAR MSRP, Section C-II Specification M-1001 Chapter 7, Section 7.7. Solid elements shall be used to the extent necessary to ensure that the actual truck geometry is accurately modeled. The model shall contain sufficient detail to adequately model all of the significant structural elements and any highly stressed connections.

12. Excessively distorted, warped, or otherwise misshapen elements that generate warning or error messages during the FEA runs shall be reported with the warning or error, and shall be permitted only if the elements are not located in critical regions, are not located in high stress gradient regions, and do not adversely affect the overall results as determined by the SEPTA.

CDRL 11-06 Truck Stress Analysis Report

1. Submit after receiving Approval for the Truck Stress Analysis Plan and the FEA Model Input Package.

2. Submit before truck frame static load test and fatigue endurance test (see Section 15, Test Program).

3. Format:

    a. Include a Table of Contents.

    b. Number each page, and clearly label columns of data on each page using terms defined in the analysis.

4. Include the following as a minimum:

    a. Structural diagram (layout) of the truck frames and bolster showing member locations and shapes, and indicating the material and thickness of each.

        i. Completely define the methods of joining, including AWS D1.1/D1.1M weld classifications for fatigue for all welds.

        ii. Clearly show connections between the truck, bolster, and carbody.

    b. Diagrams displaying external loads and supports applied to the truck frames and bolster.

    c. Calculated stresses, allowable stresses, and MS for all elements for all specified loading conditions.

    d. The safety margin shall be:

        i. Defined as the allowable stress divided by the calculated stress, including safety factors required by the structural design criteria, minus 1.00, and

        ii. Greater than zero.

    e. Summary of the results of calculations of stresses in all members:

        i. Show in a separate table the locations where calculated stress levels equal or exceed 85% of the allowable stress criteria Approved in the Truck Stress Analysis and Testing Plan, along with the design or operating conditions (loads) that cause them.

        ii. Calculated stresses shall be supported, where available, by the results of actual tests of trucks of identical design.

    f. Listing of all critical connections and casting areas of the truck frames and bolster.

g. Calculations of stresses in all load bearing elements, in all mechanical and welded structural joints, all connection elements, fasteners, mounting brackets, and other critical areas of the truck.

h. For the truck frame and bolster members that are fatigue critical, include a tabulation of the Contractor's selection of allowable truck frame and bolster static and fatigue stresses and assumed applied fatigue stress ranges. Allowable stress levels shall be substantiated by the Contractor's test data or by citing published sources.

i. Critical welds including, as a minimum, all welds or portions of welds which, based on the results of the stress analysis and truck tests, are expected to be critical in fatigue.

j. Table showing the engineering properties of each grade and temper of each material:

   i. Include the material designation, yield strength, ultimate strength, elongation, Young's modulus for tension and compression, and shear elastic moduli.

   ii. In each case, use minimum-guaranteed values from the specifications for the corresponding grade and heat treatment of the material.

k. Furnish English language references for all formulas and calculation procedures used in the analysis.

5. Manual Calculations:

   a. Manual (conventional) calculations shall include manual or computerized calculations of the stresses in bolted and huck-bolted joints, joint elements, and other important elements such as axles, and other connections and structural details as appropriate that are not readily evaluated in the FEA.

   b. The manual analysis format shall consist of the following:

      i. Title, including description of the item and load(s).

      ii. Structural arrangements and layout of the truck showing the items to be analyzed with material, allowable stresses, dimensions, method of fastening, and applied forces.

      iii. Free body diagram of the items to be analyzed with dimension, applied forces and reactions (boundary conditions). Forces and moments for the analysis may be obtained from the FEA.

      iv. Detailed stress calculations shall be provided, including calculation of the safety margin, including allowable stress and conclusions for each structural element of the items being analyzed.

6. FEA portion of the report:

    a. FEA output data on electronic media as Approved.

    b. Element grid, all assumptions, and all input data, such as loads, section properties, boundary conditions and material properties.

    c. Boundary reaction forces of the truck at all load cases showing that the input forces equal the reaction forces.

    d. Color plots showing the following:

        i. Deflections in all three axes separately plotted and imposed over the deflected shape.

        ii. Von Mises, or other Approved combination stresses

        iii. Maximum and minimum principal stresses

        iv. Direction of maximum and minimum principal stresses

        v. Meshing accuracy index

        vi. Locations of strain gauges, shown on plots of the FEA truck and bolster mesh with dimensions.

        vii. Furnish nodal (averaged) and element (unaveraged) stress plots in order to verify mesh density adequacy.

            (1). If the nodal and element stresses differ by more than 10%, refine the mesh in that region, or generate and analyze a detailed sub-model to reduce the difference.

            (2). Also furnish strain energy plots for the model and sub-models.

7. Whenever the stress analysis of the truck assembly is revised, update and resubmit the analysis, but not more than monthly. Each revision shall include revision level indications with descriptions of each change.

CDRL 11-07 FEA Model Output (Results) Package

1. Submit at the same time as the Truck Stress Analysis Report.

2. In addition to submitting FEA output data with the Truck Stress Analysis Report, submit the output files each time the files are changed.

3. Submit on electronic media as Approved.

4. For all FEA load cases:

a. Nodal (averaged) and element (unaveraged) stresses.

b. Nodal displacements.

c. Reaction forces at all boundary conditions.

5. Each revision shall be accompanied by detailed revision notes that explain each change and indicate where changes were made in the report as a result of the change.

CDRL 11-08 Truck Stress Test – Laboratory, Plan

1. Shall be submitted as part of the FDR design review meeting.
2. Define all fixturing for load application and reaction.
3. Define all instrumentation and strain gauge placements.
4. List all fatigue, static and overload forces to be applied.
5. Show phasing of fatigue loads for dynamic cycling.
6. List pass/fail criteria for each test.
7. Provide a description of the sequence of the test steps.
8. Provide FEA predicted stresses for each gauge location and each load case which will be used for FEA model validation.

CDRL 11-09 Truck Stress Test – Laboratory, Report

1. List date, location and personnel involved with the test.
2. Provide documentation (photos) of all fixturing for load application and reaction.
3. Provide documentation (photos) of all instrumentation and strain gauge placements.
4. Report raw strains and calculated stresses for each load combination applied.
5. Document acceptance of pass/fail criteria for each test.
6. Provide calibration certificates for all instrumentation.

CDRL 11-10 Truck FEA Structural Model Validation Plan

1. Shall be submitted as part of the FDR design review meeting.
2. List the load cases to be used for correlation by comparing FEA predicted stresses with recorded test stresses.

3. Define how strain gauge locations of interest will be identified for each test.
4. Define the pass/fail criteria for correlation.
5. See APTA-PR-M-RP-009-98, Recommended Practice for Truck Design, Section 4.3, Structural Model Validation for additional requirements.

CDRL 11-11 Truck FEA Structural Model Validation Report

1. Report correlation by comparing FEA predicted stresses with recorded test stresses.
2. Provide detailed description of cause for any locations which do not meet pass/fail criteria.
3. See APTA-PR-M-RP-009-98, Recommended Practice for Truck Design, Section 4.3, Structural Model Validation for additional requirements.

CDRL 11-12 Truck Stress and Load Test – On-Track, Dynamic Plan

1. Shall be submitted as part of the FDR design review meeting.
2. See Section 15, Test Program (TS 15.8.6) for test requirements.
3. Define all instrumentation and strain gauge placements.
4. Define the on-track test locations and mode of operation for each test.

CDRL 11-13 Truck Stress and Load Test – On-Track, Dynamic Report

1. See Section 15, Test Program (TS 15.8.6) for test requirements.
2. List date, location and personnel involved with the test.
3. Provide documentation (photos) of all instrumentation and strain gauge placements.
4. Report raw accelerations and strains.
5. Report post-processed accelerations and stresses.
6. Provide calibration certificates for all instrumentation.

CDRL 11-14 Fatigue Assessment Validation Report

1. Comparison of design stresses (FEA) and operating stresses (on-track test).
2. Comparison of laboratory test cumulative damage and on-track life assessment.
3. Certification that fatigue life will exceed 40 years in the actual operating environment.

CDRL 11-15 Manufacturing Validation Report

1. Shall be submitted as part of the CDR design review meeting, if applicable.
2. Demonstrate dimensional similarity between proposed design and service-proven design.
3. Comparison of truck materials, specifications, and drawings.
4. Comparison of manufacturing process: welding and casting process control.
5. Comparison of non-destructive testing (NDT).

CDRL 11-16 Truck Clearance Diagrams

1. Shall be submitted as part of each design review meeting (CDR, PDR, FDR).
2. List inputs for maximum vertical and lateral deflection, yaw, and roll.
3. Provide drawings of the truck against the allowable clearance outline.
4. Provide clearance drawings between the truck and carbody.
5. Provide interface drawings between the truck and wheel truing machines.
6. Confirm minimum truck to top-of-rail clearance.

CDRL 11-17 Coil Spring Design Stress Calculation Report

1. Shall be submitted as part of the PDR design review meeting.
2. List input loads used for the calculation.
3. List allowable material stresses and source.
4. Provide calculations of loaded stresses.

CDRL 11-18 Axle Stress Calculation Report

1. Shall be submitted as part of the PDR design review meeting.
2. List input loads used for the calculation.
3. List axle dimensions at all stress calculation locations.
4. Document allowable stress for material type selected and by axle location.
5. Provide stress results for all load cases.

6. See addition requirements per CEN TS 13103-2 2020 Design Method for Axles with Internal Journals or EN 13103-1_2017 Design Method for Axles with External Journals.

CDRL 11-19 Wheel Stress Analysis Report

1. Shall be submitted as part of the PDR design review meeting.
2. List input loads used for the calculation.
3. Provide details of the FEA model mesh and input properties.
4. Document allowable stress for material type selected.
5. Provide stress results for all load cases.
6. See additional requirements per AAR S-660 Wheel Designs, Locomotive and Freight Car, Analytic Evaluation and AAR S-669 Analytic Evaluation of Locomotive Wheel Designs.

CDRL 11-20 Journal Bearing Life Analysis Report

1. Shall be submitted as part of the PDR design review meeting.
2. List input loads used for the calculation.
3. List all assumptions for the operating environment including average speed.
4. List all life factors applied to the bearing life equations.
5. Provide bearing L10 life results in miles.

CDRL 11-21 Vehicle Dynamic Performance Qualification Plan

1. A draft version shall be submitted after NTP +120 days.
2. Shall be submitted as part of each design review meeting (CDR, PDR, FDR).
3. Overview of proposed qualification process, key milestones, and planned documentation.
4. Outline of planned simulation cases and pass/fail criteria.
5. Preliminary listing of track geometry inputs and rail profiles.
6. Listing of planned tests and test locations for all component and pilot car tests.
7. Outline of FRA submittal required for vehicle qualification per 49 CFR Part 213.57.

8. Outline of simulation model validation plan (i.e. plan for correlation of simulation predicted results with physical test results to ensure validity of the simulation model).

CDRL 11-22 Vehicle Dynamic Simulation Plan

1. Shall be submitted as part of the CDR design review meeting.
2. Details of all planned simulation cases and pass/fail criteria.
3. Preliminary listing of key simulation model parameters (mass, suspension type, key dimensions, wheel profile, coefficient of friction, Kalker coefficients).
4. Description of vehicle model and planned simulation software.
5. Definition of speed and track geometry inputs.
6. Definition of modeling settings for wheel-rail contact solver.
7. Definition of track model (stiffness and damping of rail, ties, and ballast).

CDRL 11-23 Vehicle Dynamic Simulation Report

1. Shall be submitted as part of the PDR design review meeting.
2. Tabulation of results for all simulation cases.
3. Model parameters fully defining all dimensions, masses, wheelsets, suspension components and friction elements along with an indication of the source of the data (manufacturer specification, Contractor specification, measured data, calculation, etc.).
4. Wheel profile(s), rail profile(s) and resulting wheel-rail contact plots.
5. Detailed plots of simulation results as requested.

CDRL 11-24 Vehicle Dynamic Model Validation Plan

1. Shall be submitted as part of the PDR design review meeting.
2. List of planned quasi-static vehicle characterization tests (static lean, wheel equalization, truck rotational resistance, other tests as proposed by the Contractor).
3. List of vehicle dynamic on-track tests (curving, lateral track perturbation, vertical track perturbation, high speed stability).
4. List of planned suspension component tests (springs, dampers, bumpers, traction rods, friction elements, etc.).

5. Proposed methods for comparing simulation and test data, including variables to be compared (force, acceleration, modal frequencies, etc.) and acceptance criteria which demonstrated the model has been validated.

6. Reference APTA-PR-M-S-031-22 Low-Speed Curving Performance, Chapter 2.7, Validations, for additional guidance.

CDRL 11-25 Vehicle Dynamic Model Validation Report

1. Demonstrate that the simulation model has been validated by correlating the simulation predicted results with the physical testing results.

2. This report must include correlation of suspension component and vehicle level test results with model inputs and results.

3. Tabulate the correlation differences between the simulation and test results based on methods established by the Vehicle Dynamic Model Validation Plan.

4. Provide explanations of all correlation differences outside the acceptance criteria.

5. List all model revisions required to obtain correlation with test results.

11.20 Referenced Standards

AAR M-101	Axles, Carbon Steel, Heat-Treated
AAR M-107/M-208	Wheels, Carbon Steel
AAR M-114	Spring – Heat-Treated Steel
AAR M-201	Castings, Steel
AAR M-959	Lubrication Seals for Freight Car Journal Roller Bearings
AAR M-934	Freight Car Journal Roller Bearings
AAR M-1003	Specification for Quality Assurance
AAR S-660	Wheel Designs, Locomotive and Freight Car, Analytic Evaluation
AAR S-669	Analytic Evaluation of Locomotive Wheel Designs
APTA-PR-M-RP-008-98	Passenger Rolling Stock Axle Design
APTA PR-M-RP-009-98	Recommended Practice for Truck Design
APTA PR-M-S-012-99	Manufacture of Wrought Steel Wheels for Passenger Cars and Locomotives

APTA PR-M-S-015-06	Wheel Flange Angle for Passenger Equipment
APTA-PR-M-S-019-17	Passenger Wheel Set Assembly
APTA-PR-M-S-031-22	Low-Speed Curving Performance
APTA PR-CS-S-034-99	Design and Construction of Passenger Railroad Rolling Stock
AWS D1.1	Structural Welding Code
CEN TS 13103-2	Design Method for Axles with Internal Journals
EN 13103-1	Design Method for Axles with External Journals
FRA Safety Advisory 2013-02	Low-Speed, Wheel-Climb Derailments of Passenger Equipment With “Stiff” Suspension Systems
GM/TT0088	Permissible Track Forces for Railway Vehicles
IEC 61373	Railway Application, Rolling Stock Equipment, Shock and Vibration Tests
ISO 2631-1	Evaluation of Human Exposure to Whole-Body Vibration, Part 1: General Requirements
ISO 2631-4	Evaluation of Human Exposure to Whole-Body Vibration, Part 4: Fixed-Guideway Transport Systems
FRA NPRM 2023-05576	Federal Register / Vol. 88, No. 63 / Monday, April 3, 2023 / Proposed Rules
SEPTA SMW-100	Manual for the Inspection, Maintenance and Construction of Track, Part 1 Track Safety Standards, SUBPART C – Track Geometry
49 CFR Part 213	Track Safety Standards
49 CFR Part 238	Passenger Equipment Safety Standards

SECTION 12
FRICTION BRAKE

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12.1 General

A. Comply with the following:

1. Each married pair shall be equipped with the equipment and functions specified herein such that complete, fully integrated, and acceptably functioning friction brake and pneumatic systems are produced. All valving and related pneumatic apparatus needed to procure a fully functional friction brake system shall be designed and supplied by one qualified subcontractor.

2. No hydraulic or air/hydraulic braking equipment in any arrangement is permitted.

3. WSP, load weighing and blending functions shall be integral to the brake control equipment.

4. The individual components, other than generic standard materials, shall be supplied by an experienced air brake equipment supplier who has confirmable previous satisfactory operating experience on North American commuter railroad passenger systems.

5. All pneumatic piping shall meet the requirements of Section 16, Materials and Workmanship.

6. Within the operation of a Silverliner VI train consist, the service friction brake will normally be used during deceleration below the regenerative/dynamic brake system fade out point and above the taper point as required, but it will also provide inshot and snow brake functions and supplementary braking in the event of partial or complete dynamic brake failure. Emergency braking will be pneumatic.

7. The Contractor shall coordinate with the designs of the propulsion, friction brake and pneumatic system suppliers such that a fully integrated friction brake system meeting all the relevant requirements of Section 2, Design and Performance Criteria, Section 10, Propulsion and High Voltage System, and Section 11, Trucks is produced. The thermal capacity of the friction brake system shall meet the duty cycle requirements of Section 2, Design and Performance Criteria with full friction braking.

8. The friction brake system shall provide pneumatic service and emergency braking using a combination of electrical trainline control signals and brake pipe pressure reductions. The Operator's cab brake controller shall output trainline signals as hereinafter specified. Each car shall respond to these signals through the friction brake electronic control units and brake control units to develop the proper friction brake effort.

9. Brake control functionality shall be provided at a per truck level.

10. A brake pipe trainline shall be provided for pneumatic emergency braking functionality and pneumatic service brake control when towed by legacy equipment. Modulation of brake pipe for service brake control is not required by the Silverliner VI brake systems.

11. Service and emergency brake control commands shall be electrically transmitted through analog brake demand and redundant trainlines.

12. SEPTA's legacy equipment utilizes brake systems such as PS68, 26R, and 26L, which may be used for towing Silverliner VI cars. The locations of devices and changeover procedure requiring configuration from electropneumatic to brake pipe control for towing functionality shall minimize required actions and shall be subject to Approval. This shall enable a Silverliner VI car to respond with graduated service brake and emergency brake functionality to brake pipe pressures generated by the above systems while being towed. The design of the friction brake system shall allow the car to function as a fully responsive trailing unit, when towed, if the electropneumatic brake system is disabled.

13. The system shall comply with all applicable FRA regulations and APTA safety standards and recommended practices. The brake system supplier shall support SEPTA in an application to the FRA to extend the test interval of valves as requested, with a minimum interval of 1,840 days and a target of extended intervals.

14. The brake system control shall be provided by a modern microprocessor-based system, service proven in North America.

15. Each married pair shall contain an air compressor system, passenger emergency application valves, and all necessary reservoirs, cocks, hoses, valves, pressure switches etc. to provide a fully functional system.

16. Fail safe, fail soft or redundant approaches shall be used throughout the design of the brake system. The Contractor is responsible to ensure the proper integration of the propulsion, air supply, wheel slide protection, and friction brake systems.

17. All system valves shall be air brake rack tested. The design and components of the friction brake system shall be submitted. **(CDRL 12-01, Brake System Component and Functional Description)**

18. A piping diagram detailing the layout, connections, and piping requirements for the Friction Brake System shall be submitted. **(CDRL 12-02, Brake System Piping Diagram)**

19. A wiring diagram detailing for the Friction Brake system detailing the electrical connections and wiring requirements shall be submitted. **(CDRL 12-03, Brake System Wiring Diagram)**

20. Friction brake system components shall be serialized as required by Section 25, Program Management and Commissioning.

12.2 Operator's Cab Equipment

12.2.1 Brake Controller

A. Each Operator's cab shall be equipped with a brake controller, located on the right side of the cab console, arranged for ease of Operator operation. The cab brake controller shall be a console style unit with a single, non-removable operating handle. The handle movement shall be in a longitudinal (front-back) direction, with the release position closest to the Operator. The controller shall be an electronic unit, pneumatic interfaces to the controller are prohibited.

B. The operating handle shall have the following positions, from front to back:

1. Handle Off
2. Emergency
3. Full Service
4. Suppression
5. Minimum
6. Release

C. A mechanical interlock between Emergency and Handle off shall be provided to prevent unintended overtravel during emergency initiation. Movement between Handle Off and Emergency shall be available to the Operator at all times. The Emergency position shall be functional at all times.

D. The design of the handle shall make it impossible to place the unit in the Handle Off position without initiating an emergency brake application.

E. Mounted on the brake controller housing shall be a control device to permit the Operator to activate/deactivate the controller. This device shall, within the brake system, cutout the brake controller except as noted, deactivate the PTC brake system commands on the car, and prevent the brake controller handle from responding except between the Handle Off and Emergency positions.

F. It shall not be possible for the Operator to override a penalty or prevent the PTC commands from applying a penalty by changing brake controller modes at speed or other means.

G. The Operator's control handle shall be of suitably rugged design to allow forceful movement into the emergency position without damage.

H. The brake controller shall be capable of driving trainlines up to the maximum consist size specified in Section 2, Design and Performance Criteria.

I. Alternate proposals or arrangements shall be subject to Approval.

12.2.2 Air Pressure Gauges

A. Main Reservoir, Brake Pipe and Brake Cylinder Pressures indications shall be integrated into the TOD. Each display shall be in bar graph form with numerical pressure callout.

B. Test fittings shall be provided in the cab area to allow for monitoring and verification of the pressure readings provided to the operator.

C. Mechanical gauges shall also be provided, and they shall meet the following requirements:

1. The gauges shall be located adjacent to the brake control equipment, not in the cab, and shall be easily visible when accessing the brake control equipment.

2. Each gauge shall have a white on black dial graduated from 0 to 200 pounds/ square inch and shall be illuminated.

3. One gauge shall indicate the brake cylinder pressure output of the brake control (red pointer), and also the brake pipe pressure (white pointer).

4. The other gauge shall indicate the main reservoir pressure (red pointer) and the white pointer shall not be used.

5. Gauge needle identification shall be shown in matching color on the gauge face with the red over a white background or by identification nameplates permanently mounted adjacent to each gauge.

6. A shatter-resistant clear lens shall be securely fitted to withstand hard use and occasional impacts.

7. Gauges shall be calibratable while installed on the vehicle.

12.2.3 Indicators

A. Each cab console shall have a "Friction Brakes Applied" amber LED indicator, a "Friction Brakes Released" green LED indicator, a "Parking Brake Applied" blue LED indicator, and an illuminated when applied “Apply Local Parking Brake” button.

B. These indicators shall be functional in all cabs (active or non-active) and shall display the status of all truck friction brakes and parking brakes of all cars in the train.

C. The "Friction Brakes Applied" indicator shall function when all trucks on the train have friction brakes applied at a Brake Cylinder pressure equivalent to an AW0 suppression value.

D. The "Friction Brakes Released" indicator shall function when all trucks on the train have friction brakes released, defined as a brake cylinder pressure mutually agreed to by the Contractor and SEPTA.

E. The "Parking Brake Applied" indicator shall function if any parking brake is applied on the train. Means shall be provided to change indicator status when manual releases have been activated on spring applied, pneumatic release parking brakes.

F. All indicator lights must use dedicated trainlines and loop circuits and shall not be displayed through the train data bus; but may be monitored by the train diagnostic system for information.

G. Exterior signal lights shall also be provided on a local car basis per Section 8, Lighting to assist in troubleshooting.

H. Trainline indicators shall be monitored by the vehicle diagnostic system and displayable on the TOD.

12.3 Friction Brake Controls

A. The friction brake controls shall include provisions for charging of brake pipe pressure and control of brake cylinder pressures for the car. The friction brake controls shall be mounted under the car in a location easily accessible from the side of the car for maintenance.

B. The friction brake controls shall respond to the trainlines in accordance with the commands received from the operating cab brake controller.

C. The friction brake controls shall provide pneumatic brake effort for friction braking, modulated for blending with propulsion and service load weigh.

D. The friction brake controls shall provide diagnostics to the vehicle fault monitoring system.

E. The friction brake controls will interface with the propulsion system as per the requirements of Section 10, Propulsion and High Voltage System for brake blending, rollback brake, emergency indication and wheel slide.

F. Any cutout or isolation of braking or braking control functionality shall be annunciated.

G. The design of the friction brake controls, locations of equipment and system integration shall be submitted. **(CDRL 12-04, Layout for Brake System)**

12.4 Blending

A. Service friction braking shall be blended with propulsion in order to achieve the nominal deceleration rates specified in Section 2, Design and Performance Criteria.

B. Dynamic braking shall have preference over friction braking to optimize friction material wear life.

C. The service friction brake shall normally be used to supplement dynamic braking effort at higher load weights and below the dynamic braking fade-out point. In the event of a malfunction of dynamic braking, the friction brake system shall provide the required service brake levels.

D. Blending scheme shall be submitted. **(CDRL 12-01)**

12.5 Service Load Weighing

A. The passenger load weight variations on a car shall be measured within the friction brake controls by monitoring of truck secondary suspension air spring pressures using transducers. Transmission of the vehicle load data shall be provided by the brake system to the propulsion system for its load weigh control.

B. The specified braking performance shall be achieved for passenger loads between AW0 and AW3 to provide for a constant braking rate independent of passenger load. Under failure conditions, the load weigh system shall not cause braking effort less than that provided for AW0 nor more than that provided for AW3.

C. Load limiting valve settings for emergency brake application shall be preset.

12.6 Foundation Brake Equipment

A. A combination of disc and tread brake equipment shall be provided at each wheel location.

B. A Brake Calculation shall be submitted to demonstrate that the equipment has sufficient braking capacity to meet the deceleration requirements of Section 2, Design and Performance Criteria and the parking brake requirements of this Section. **(CDRL 12-05, Brake Calculation)**

C. The brake equipment arrangement shall have adequate thermal capacity to meet the requirements of Section 2, Design and Performance Criteria and shall not produce any thermal damage to the wheels, discs, and brake pads at train speeds up to 88 miles/hour under any operating condition. The thermal distribution shall be determined by the brake equipment supplier and submitted in a Thermal Calculation. **(CDRL 12-06, Thermal Calculation)**

D. Disc braking is preferred with reduced numbers of tread brakes. In the event disc braking can perform 100% of braking demand wheel tread scrubbers shall be provided.

E. Each disc brake caliper and tread brake unit shall be pneumatically connected with an individual hose from the truck frame piping and shall operate at the same brake cylinder pressure.

F. Connections shall utilize reusable fittings which permit quick disconnection and facilitate brake actuator removal. The hoses shall be provided with helical steel wire guards to protect the hose from debris damage.

G. All wearing surfaces shall be provided with renewable pins and bushings or wear plates. All bushings, pins, and other components that require periodic lubrication shall be supplied with protected grease fittings.

H. The application and release of all brake pads and brake shoes shall be visible to the train crew alongside the car.

I. The design of the foundation brake equipment shall be submitted. **(CDRL 12-07, Foundation Brake Equipment Design Description)**

12.6.1 Disc Brake Equipment

A. Each truck wheel location shall be equipped with a disc and disc brake caliper unit of a service proven design.

B. The mounting location of the disc, in decreasing order of preference, is outside mounted to wheel hub or cheek mounted to wheel plate.

C. The disc shall be ventilated type design.

D. Wear indicating marks shall be provided to indicate the condemning limits of the disc.

E. The disc shall be located so as to be concentric to and parallel with the wheel.

F. The disc hub, if used, shall be fastened to the wheel hub using lock-wired bolts of the grade specified by the disc manufacturer. Any use of spacers between the disc and the wheel shall be submitted. **(CDRL 12-07)**

G. If the disc cannot be removed and replaced on the truck without removing the wheel from the axle, it is required that discs be of a split rotor design, or other Approved design which does not require wheel removal. The rotor shall have the necessary thermal characteristics and strength to resist warping and cracking due to thermal stress.

H. The disc brake calipers shall be arranged for air-apply, spring release operation, and shall incorporate an automatic slack adjuster to maintain an optimum brake pad clearance which shall not require additional pneumatic airlines to function.

I. The slack adjusters shall be easily overridden to facilitate replacing the brake pads.

J. The disc brake calipers shall be installed on the truck in a manner that allows ready access for inspection, maintenance, removal, and installation of the units without de-trucking.

K. The caliper mounting to the truck shall be a floating type, designed to follow the disc and move normal to the disc with each brake application as required. Calipers shall be

designed such that even wear shall occur throughout the life of the brake disc and pads.

L. The disc brake pad holders shall be made of a material with proven service history and shall be designed to permit brake pads to be readily removed and replaced while located on yard track, without requiring disassembly of the actuator unit or use of a maintenance pit. The brake pad holders shall incorporate a UIC type dovetail arrangement, and the brake pad retaining latch and locking pin arrangement shall be submitted. **(CDRL 12-07)**

M. Spring applied, air released Parking Brake actuators shall be incorporated as needed to meet a 5 % grade.

12.6.2 Tread Brake Equipment / Wheel Scrubber

A. Usage of tread brake for friction brake control is allowed only if disc braking cannot meet the thermal duty cycle in full friction operation, as demonstrated by the approved Thermal Calculation. If tread brake units are not required, wheel scrubbers are required to maintain wheel tread due to wet leaves common to the operating environment.

1. Each truck wheel location shall be equipped with a self-contained tread brake unit / wheel scrubber unit, of service proven design.

2. The design shall provide lateral restraint in order to prevent override and to position the brake head properly for use with an unflanged shoe.

3. Shoe heads shall be made of a material with proven service history and shall be designed to permit shoes to be readily removed and replaced.

4. The units shall be installed on the truck in a manner that allows ready access for inspection, maintenance, shoe replacement, and removal and installation of the units without de-trucking.

5. The geometry of the unit and its installation shall prevent any self-energization effect.

6. If tread brake units are provided, they shall be arranged for air apply, spring release operation, and shall incorporate automatic slack adjusters which shall not require additional pneumatic air lines to function. The slack adjusters shall be manually adjustable to facilitate replacing brake shoes.

12.7 Cab Signal/PTC Interface

A. A cab signal/PTC interface for each cab shall be provided either through pneumatic valves or via service proven electronic means. The cab signal interface shall be controlled by both the cab signal/PTC system (per Section 20, Automatic Train Control and Positive Train Control) and the cab deadman system (per Section 5, Operator's

Cab), to provide a penalty brake application when required. The cab signal interface shall be inactive when the brake controller in that cab is cut out.

12.8 Friction Brake Control Electronics

A. Friction brake control electronics shall be provided for each car.

B. The Friction brake control electronics shall provide the control interface between operator commands, vehicle inputs, propulsion interfaces and other subsystems to the pneumatic valves leading the generation of brake cylinder pressure supplied to the truck mounted brakes.

C. Harness wiring shall be used to the maximum extent practicable for wiring these control items together.

D. Internal temperatures of modules and components, including power supplies, shall be designed to provide a large thermal margin. No degradation of reliability shall occur during the design life of the equipment when the equipment is operated continuously with ambient temperatures per Section 2, Design and Performance Criteria.

E. All friction braking electronic modules shall be interchangeable between cars without user adjustment.

F. Arrange control components requiring periodic calibration or testing with test points or test fittings so it is not necessary to remove wires or disconnect pipes to perform testing or calibration and locate and arrange so that one person can perform calibration unassisted. These include systems such as the following:

1. Load-weighing

2. Electric brake feedback signals

3. Pressure sensors

12.8.1 Control Logic

A. Service friction brake control logic shall consist of one or more microcomputers with peripherals necessary to meet the required functions and performance criteria.

1. Control programs shall be stored in non-volatile memory.

2. Provide sufficient non-volatile memory for the purposes of storing, by manual command, significant data that occurred over a period of at least 2 seconds before a fault event, as indicated by any of the friction brake fault indicators when the friction brake system is last turned off.

a. These data shall be held until normal car operation is resumed, a reset command is received from a PTU, or a reset pushbutton on the control logic monitoring panel is pushed.

b. These data shall be addressable by the PTU for troubleshooting purposes and by the set of built-in troubleshooting displays.

3. Control logic cabinet(s) on each car shall include LEDs for indicating system states and faults.

4. The friction brake controller shall have a comprehensive diagnostic system capable of diagnosing failed components. The level of fault reporting shall be sufficiently detailed to allow operating and maintenance personnel to uniquely identify common faults.

5. Fault data shall be recorded in a structured format so that statistical analysis may be conducted after download.

6. Data shall be timed, dated, and recorded in local time as appropriate and shall be adjustable as specified in Section 18, Monitoring and Diagnostics.

7. The fault logging system shall also record a sufficient amount of trace data, sampling data at a rate no slower than 100 ms and recording relevant data for 3 seconds before and 2 seconds after the fault.

8. Trace data shall be triggered by major system faults.

9. All data shall be downloaded in a common, spreadsheet-style format that can be directly loaded into Microsoft Excel. No data conversion shall be required.

10. The system shall also be capable of downloading data via the wireless Train-to-Wayside Data Transfer (TWDT) system, as specified in Section 18, Monitoring and Diagnostics.

11. The system shall incorporate a self-test to verify that all system components are working normally within predefined limits, and to check and troubleshoot the integrity of the system.

    a. The system shall initiate a self-test upon startup.

    b. It shall be possible to initiate a test-on-demand from the VMDS or by PTU.

    c. Failure conditions from the electronics self-tests or tests-on-demand shall be communicated to the VMDS and shall be downloadable as part of the fault log by the PTU.

    d. Submit documentation for Friction Brake Self-Test and Test-on-Demand Capability. **(CDRL 12-08, Friction Brake Self-Test and Test-on-Demand Capability)**

12. System shall have sufficient memory capacity to store collected data and fault traces for a minimum of 72 hours without loss of data or overwrites. The memory data shall not be lost when the main power is cut off.

13. Provide log file validation and replacement within the control algorithm to ensure against file corruption during file creation.

14. Make provision within the system and any other data storage device to take advantage of higher capacity media as it becomes available to prevent obsolescence constraints.

15. Submit documentation for Friction Brake Diagnostic System. **(CDRL 12-09, Friction Brake Diagnostic System)**

16. Control logic and signals from the friction brake system shall be easily accessed from a PTU.

    a. Both analog and digital data shall be readily accessible and shall have the ability to address logic signals significant to analysis and diagnosis, including signals to and from relays and external inputs and outputs.

    b. Unless otherwise specifically Approved, the control logic shall have the capability of supplying a sufficient number of channels available as analog outputs to a high impedance chart recorder for real-time recording of control signal data.

    c. The PTU for the friction brake system shall comply with the requirements of this Section and the PTU requirements of Section 27, Special Tools and Test Equipment. The interface to the PTU shall be an addressable output using an RJ45 connector.

17. Friction brake system shall provide real time data for display on the Train Operators Display, providing relevant information for service operation and additional details available through maintenance screens.

12.9 Air Compressor

12.9.1 General

A. Each married pair shall be equipped with a complete air compressor system, including air compressor, filters, air dryers, controls, and all needed accessories, mounted on a unitized subframe arranged for ease of replacement on the car.

B. The air compressor system shall comply with the requirements of APTA Standard PR-M-S-011-99, Standard for Compressed Air Quality for Passenger Locomotive and Car Equipment.

C. The air compressor shall operate on 230 Volts, 60 Hertz, 3 Phase AC from the auxiliary power system.

D. The air compressor shall be oil-lubricated and sized with sufficient capacity to fulfill air demand requirements of the married pair under all operating conditions while also operating within all supplier application requirements. The compressor shall be service proven in North American rail applications.

E. The air compressor system overhaul interval in Silverliner VI service shall not be less than six years.

F. The air compressor shall be sized to meet the worst-case air consumption requirements, including air dryer consumption and leakage, without exceeding a maximum duty cycle specific to the unit's design.

G. Compressor components and function shall comply with the following:

1. The compressor shall be direct-driven from a close-coupled AC motor.

2. The proper direction of compressor rotation shall be clearly and permanently marked such that is easily visible to maintenance technicians.

3. The compressor shall be protected against damage from incorrect direction of rotation. If the motor rotation is dependent on carbody wiring connections external to the unit, then critical functions such as oil pump shall be arranged to provide adequate lubrication in either direction of motor rotation.

4. All carbody electrical connections to the air compressor assembly shall be made through cable connectors.

H. The mounting frame shall be so arranged that the complete air compressor unit can be handled with a forklift truck and placed upright on a flat surface without damage to any part of the unit. It is desirable that the carbody not require jacking in order to replace the air compressor system when using a forklift in a maintenance pit.

I. Air compressor accessories, such as air filters, oil pump, oil filter, solid state pressure switches, and any other required components shall be mounted within the frame clearance envelope, arranged to be easily replaced while the air compressor is mounted in the frame.

J. The compressor unit shall be resiliently mounted to the frame and shall be arranged for mounting under the carbody in such a manner as not to conduct noises or vibration into the car, and to permit overall access, inspection, and interchangeability between cars.

K. A safety feature shall be implemented to retain the compressor in case of resilient mount failure.

L. All electrical and pneumatic connectors shall permit rapid replacement of the compressor with minimum disconnect time.

M. The air compressor shall not be located in the splash area of the wheels.

N. The air compressor shall not be located such that external heating sources, for example braking resistors, will affect air compressor operation.

O. Sufficient intercooler and aftercooler capacity shall be provided such that the air supply system outlet air temperature after the air compressor unit has operated continuously under full load for one hour does not result in condensation in the system.

P. Safety valves shall be provided to protect against over-pressurization of the compressor internal components and pneumatic system. A Main Reservoir safety valve, compliant with 49CFR 229.49, shall be provided at the outlet of the air dryer unit.

Q. An hour meter and cycle counter shall be provided on the air compressor unit. A means shall also be provided for the VMDS to monitor and display operating hours and starts/stops.

R. Compressor duty cycle calculations shall be provided. **(CDRL 12-10, Compressor Duty Cycle)**

S. The air compressor shall be arranged for ease of performing an orifice test.

12.9.2 Lubrication

A. The air compressor shall use an Approved lubricating oil suitable for year-round operation under the climate conditions defined in Section 2, Design and Performance Criteria, without the need for seasonal oil changes. **(CDRL 12-11, Compressor Lubricating Oil Details) .** A sight glass shall be provided to permit easy determination of the oil level, which shall be suitably rugged in design and located so as to minimize any chance of breakage. Permanent markings for maximum and minimum oil levels shall be provided. The sight glass shall be readily visible from the side of the car.

12.9.3 Motor

A. The air compressor motor shall be a 230 Volts, 60 Hertz, 3 phase induction motor of the totally enclosed fan cooled (TEFC) type, fully suitable for operation from the auxiliary inverter output.

B. The motor shall meet the requirements of NEMA MG1-1.26 rated for continuous operation, with the exception that the insulation shall be Class F per NEMA MG1-12.43.

C. The motor shall be equipped with sealed bearings sized to provide 6 years of operation without requiring relubrication.

D. The motor shall not be overloaded in starting the air compressor with a main reservoir pressure of 160 psig at any ambient condition as defined in Section 2, Design and Performance Criteria.

12.9.4 Compressor Control

A. The air compressor shall be controlled by a solid state pressure switch and a contactor with solid state overload protection.

1. The pressure switch shall be adjusted to maintain the main reservoir pressure at 130 to 150 psig. These settings shall not be affected by vibration and set point drift with temperature shall not exceed 1 psi when referenced to a 70^{o}F (21^{o}C) ambient temperature.

2. When the train is in layover mode, the main reservoir shall maintain a minimum pressure of 100 psig in order to conserve energy and compressor wear.

3. A test fitting for the connection of a pressure gauge shall be installed at the pressure switch.

B. A synchronizing function that starts all of the air compressors in a train at the same time shall be provided in the car design.

1. The signal to start may be initiated by any air compressor but shall typically be the compressor with the highest pressure switch cut-in setting.

2. The signal to start shall be utilized in an "OR" fashion so that, in its absence, the compressor will be started by its own pressure switch.

3. Individual start of compressors may be proposed. The algorithm shall provide that the usage of compressors is distributed evenly among all compressors.

12.9.5 Air Filters

A. The intake air filter shall be disposable element type with rating of 10 microns or less, unless otherwise Approved.

B. It shall be sized such that elements shall not need replacement more frequently than once every 30,000 miles, or every 184 days, whichever is longer.

C. The filter shall be arranged for easy one-man replacement, and positioned so that any dust displaced during filter changing shall not fall into the downstream portion of the filter housing.

12.9.6 Air Dryer

A. A regenerating-type, dual chamber air dryer shall be provided, integrally mounted to the air compressor unit.

B. The capacity of the air dryer system shall be sufficient to ensure that the dew point depression is a minimum of 25^{o}F (13.9^{o}C) throughout the entire operating cycle of the air supply system for ambient temperatures up to 100^{o}F (37.8^{o}C).

C. The air dryer must be capable of operating efficiently during periods of continuous air compressor operation without reaching saturation of the desiccant material.

D. The air dryer inlet shall be fitted with a coalescing filter, which shall protect the desiccant element from oil contamination. Discharge of the coalesced liquids shall be accomplished by a drain valve, which shall cycle at regularly timed intervals during air compressor operation.

E. The air dryer shall include a memory feature that will return the air dryer at air compressor start-up to the point in the dryer cycle which it was at when the air compressor shut down.

F. The air dryer shall operate only when the air compressor is operating and shall consume a maximum of 20 percent of the nominal output of the air compressor unit.

12.9.7 Automatic Drain Valve

A. An automatic drain valve shall be applied directly to the air dryer sump reservoir and shall operate satisfactorily under all pressure conditions.

B. The valve shall be actuated by a device to ensure its frequent activation whenever the air compressor is operating continuously to prevent the accumulation of moisture.

C. All drain valves shall be provided with a muffler and a thermostatically controlled protective heater powered from the low voltage power supply.

D. The drain valve shall discharge air at a sufficient rate to prevent the air compressor motor from stalling due to rapid compressor restarting.

E. Shields shall be used on drains to keep liquids off adjacent equipment.

12.10 Reservoirs

A. Each car shall have a main reservoir and check valve protected supply reservoirs for each brake cylinder control system, meeting the requirements of Section 16, Materials and Workmanship.

B. The brake supply reservoir shall have the volumetric capacity capable of supplying all pneumatic systems with sufficient air volume for a combination of 5 full service and 3 emergency brake applications.

C. The main reservoir system shall be used to supply all air used on the car, except for the brake cylinder requirements.

D. The main reservoir shall be protected against air line failure between the air compressor and the main reservoir by means of a check valve.

E. The main reservoirs of all cars in a train shall be connected together through the couplers by means of a Main Reservoir trainline of 1 inch diameter in accordance with Section 16, Materials and Workmanship.

F. Pneumatically isolated supply reservoirs shall be used to supply air to the brake cylinders.

G. An analysis of air usage along with reservoir sizing calculations demonstrating suitability and compliance with this specification shall be provided. The analysis shall consider worst-case temperature conditions, system leakage and duty cycle requirements. **(CDRL 12-12, Air Consumption and Reservoir Sizing)**

H. All reservoirs shall be provided with a manual, self-locking drain cock, and shall be installed with a downward slope toward the drain end to permit gravity draining. The drain cocks shall be protected against damage from wayside debris. Drain valve operation shall be from the side of the car.

I. The main reservoir shall be tested and certified as conforming to the requirements of 49 CFR Part 229.31(c). The supply reservoirs shall comply with all appropriate ASME BPVC, Section VIII-1 requirements, and shall include telltale holes as defined in 49 CFR Part 229.31 (c)).

12.11 Cutout Cocks

A. Cutout cocks shall be provided as necessary to allow pneumatic equipment to be isolated for maintenance and to allow failed equipment to be cutout or bypassed.

B. Unless otherwise specified, cutout cocks shall be aligned on the same side of the vehicle.

C. All cutout cock handles, except for the brake pipe end cocks which shall conform to AAR standards, shall be arranged so that when the cutout cock is open the handle is perpendicular to the pipe, and when the cutout cock is closed the handle is parallel to the pipe. The following cutout cocks shall be provided as a minimum:

1. EP Brake Cutout Cock

    a. An EP brake cutout cock shall be provided for each car to cut out service friction braking while leaving emergency brakes in operation. The cutout cock shall be operable from the side of the car. Handle color shall be white. An alternate solution to a physical cutout may be provided for Approval.

2. Brake Cylinder Cutout Cock:

    a. A vented brake cylinder cutout cock shall be provided in the brake cylinder line for each truck to cut out all friction braking on the truck. The cutout cock shall be operable from the side of the car. The vent shall be positioned to vent air to the trucks. The status of the Brake Cylinder

Cutout shall be transmitted to the Monitoring and Diagnostics system for use on the operators display. Handle color shall be red.

3. Brake Pipe Cutout Cock

    a. A cutout cock shall be provided at both ends of each car to allow the brake pipe to be closed off between cars. The cutout cock shall be operable from the side of the car. Handle color shall be yellow.

4. Main Reservoir Pipe Cutout Cock:

    a. A cutout cock shall be provided at each end of each car to allow the main reservoir pipe to be closed off between cars. The cutout cock shall be operable from the side of the car. Handle color shall be yellow.

5. Air Suspension Cutout Cock:

    a. A cutout cock shall be provided in the air supply lines to the leveling valves on each truck to allow a ruptured air spring to be isolated. The cutout cock shall be operable from the side of the car. Handle color shall be white.

6. Horn Cutout Cock:

    a. A cutout cock shall be provided in the air supply line to the horn control valve located in the floor and shall be easily reached by the Operator in each cab, per Section 5, Operator's Cab. Handle color shall be yellow.

7. Parking Brake:

    a. An annunciated, vented cutout cock shall be provided to isolate the air supply to the parking brake calipers. The cutout shall be operable from the side of the car. The handle shall be yellow.

8. Emergency Magnet Valve Cutout Cock

    a. An annunciated cutout cock shall be provided to block exhaust of the Emergency Magnet valve to allow the EMV to be isolated in case of failure or towing. The cutout shall be wire sealed, inside the car, accessible by crew, and not be accessible by passengers. The handle shall be red.

9. The handles for operating the main reservoir pipe and the brake pipe cutout cocks shall both be located on the same side of the car. Cutout cocks shall be self-locking so that the valve handle will not move to opposite of normal safe operating position by gravity or vibration. All multiple cutout cocks on the car serving the same function (such as the two brake cylinder cutout cocks) shall have an identical arrangement to minimize Operator confusion.

12.12 Air Suspension

A. Main reservoir air pressure shall be supplied to the air suspension leveling valves on each truck through a check valve, choke, and cutout cock in each supply line. The air spring pressure from each truck shall be supplied from a transducer to the friction brake controls for the associated car and the car monitoring system.

12.13 Brake Applied Indicators

A. To indicate when friction brakes are applied on a per-truck basis, each truck shall have a brake cylinder pressure switch installed downstream of the last pneumatic component that controls the brake cylinder pressure, for use by the friction brake controls or propulsion logic in reporting brake application status for the associated truck. The integration and logic of the indicator shall include a means to filter nuisance toggling of indication during wheel-slide activity. All pressure switches shall be equipped with pressure test fittings. The exterior of each car shall have brake applied and brake released indicator LEDs arranged on a per-truck basis, one at each end of the car on both sides. This shall include the status of the parking brake. **(CDRL 12-13, Brake Indicator Design and Integration)** .

B. Indicators status stall be transmitted to the vehicle monitoring system.

12.14 Arrangement of Components

12.14.1 General

A. All friction braking apparatus must have sufficient clearance for easy removal of any portion of a complete component without the need for removing adjacent equipment and be readily accessible for maintenance.

B. All valves in the friction brake control system shall be muffled to reduce noise to a minimum and exclude dirt.

1. Particularly noisy valves shall be mounted in baffled enclosures if simpler techniques are not effective. Exceptions to this requirement will only be granted by SEPTA when a demonstrated impairment of function exists, using commonly available hardware.

C. All pneumatic valves and control devices shall be manifold mounted except as Approved otherwise.

1. Manifolds shall be protected from corrosion, including internal passageways, as Approved.

2. Valve electrical connections to manifolds on car wiring shall be through connectors meeting all requirements of Section 16, Materials and Workmanship.

3. Readily accessible unions and quick disconnects shall be used for any pneumatic devices not manifold mounted. Pneumatic connections, unless otherwise permitted for moving or vibrating devices, shall be metallic tubing or piping.

D. All check valves in the brake system shall be provided with sufficient unions and piping for easy replacement, with the unions arranged to prevent incorrect installation.

E. All safety valves shall be of a heavy-duty design capable of repeated use without drifting of their initial setting.

F. In general, pneumatic piping should be routed along the centerline of the car, and not along the side sill area.

G. Only one hose connection for friction braking control shall be used between each truck and the carbody.

H. Transducers shall be low drift, shall not require adjustment, be of the highest quality with high cycle life, and shall be temperature compensated. Accuracy shall be such that system performance requirements are met under all operating conditions. Magnet valve response times shall be consistent with the overall friction brake system response time requirements.

12.14.2 Component Fastening

Air brake components such as valves, reservoirs and cutouts shall be secured to pipe brackets or manifolds with standard fasteners in accordance with Section 16, Materials and Workmanship. Self-locking nuts shall be used except for retaining serviceable valve portions or other such assemblies which require periodic disassembly for maintenance. Pipe and other components shall be protected from chafing by suitable means as necessary.

12.14.3 Test Fittings

A. Test fittings shall be Staubli RBE type or Approved equal, suitable for use in railway environment.

B. Each air gauge, pressure switch and pressure transducer shall be equipped with Approved test fittings applied as close to the device as practical. Placement of test fittings shall be submitted. **(CDRL 12-14, Test Fitting Types and Locations)** .

12.14.4 Drain Valves

A. All air reservoirs, sumps and any other location which may collect moisture shall be equipped with an approved type of guarded self-locking manual drain valve. They shall be metallically shielded to protect them from damage from flying debris.

12.14.5 Convenience And Safety Features

A. The design of the air system and the monitoring thereof shall be such that placing any cutout cock in a position that might have impact on train safety shall be self-annunciating to the Operator in some obvious manner and recorded by the VMDS. Details shall be submitted. **(CDRL 12-01)**

B. Cutout cocks shall be provided throughout the brake system to release pressure so that valves and sensors may be conveniently removed and replaced.

C. Test fittings shall be applied at all appropriate points in the pneumatic system so that system operation and calibration can be checked, and adjustments can be made.

D. Where there is a need to calibrate or test a device, an inline injectable type test fitting shall be applied.

E. All pneumatic test fittings shall be the same throughout all systems regardless of supplier.

F. Metal protective caps shall be fitted with metal retainer chains, cables, or lanyards.

12.14.6 Wiring And Enclosures

A. All wiring shall meet the applicable requirements of Section 16, Materials and Workmanship. Wires shall be securely cleated, shall not pass over any sharp edges or be stretched and shall be protected from debris. Drip loops shall be provided at entrances to enclosures. All control boxes shall be watertight and meet the requirements of Section 3, Carbody. All cable connections with the control box shall be by sealed connectors meeting the requirements of Section 16, Materials and Workmanship. Wiring shall be suitably keyed where necessary to prevent incorrect assembly of connectors or of adjacent devices.

12.15 System Operation

12.15.1 Trainline Commands

A. The Operator's cab shall command the operation of the friction brake system, and all cars shall respond to discrete trainline commands as specified below, at a minimum, based upon the lead car in command of the train:

Trainline	Description
Brake Demand Trainline (P-wire)	A DC current loop trainline (P-wire) that transmits the braking effort command
Braking Enabled	The leading cab Brake Controller Handle is in the Minimum brake position or beyond

Trainline	Description
Emergency Brake	Brake pipe is charged and no condition or command exists to initiate an emergency brake
Brake Applied Indication	Brake cylinder pressure is applied to at least AW0 suppression value
Parking Applied Light	Any parking brake in the train is applied
Snow Brake	Provide light application of friction braking to prevent icing.
Wheel Slide Enable in Emergency	Enables wheel slide protection during emergency brake conditions when certain pre-requisites are met.

B. Final trainline architecture shall be subject to Approval per Section 17, Network and Trainline Control.

C. Network based brake demand signals and trainlines shall not be accepted.

12.15.2 Locomotive-Hauled Status

A. The friction brake system shall be suitable for use when moving Silverliner VI cars with a locomotive, with compressed air being supplied by the locomotive solely by a brake pipe both in the presence or absence of power.

B. The brake system shall provide both service and emergency braking.

C. The system shall be compatible with normal locomotive brake systems such as 26L, and MU systems such as 26R and PS 68.

D. When in locomotive-haulage mode, it shall be possible to initiate an emergency brake application by operation of any Conductor's valve, by an undesired uncoupling, or by any rapid loss of brake pipe pressure.

E. A standard AAR coupling hose and angle cock connected to the brake pipe shall be provided at each cab end of a car to permit coupling to locomotives. A standard dummy coupling shall be provided to keep the hose coupling closed and supported when not in use.

F. The air brake system design shall be such that if SEPTA moves the equipment on any North American freight railroad, it will be possible to:

1. Convert the service brake from a graduated release to direct release (temporary replacement of a valve portion would be acceptable).

12.15.3 Dead In Tow

A. Apparatus shall be provided on each car to charge the main reservoir from the brake pipe. The rate of main reservoir charging shall be limited to prevent brake pipe pressure from dropping rapidly enough to cause an emergency brake application.

12.15.4 Initiating Emergency Braking

A. Means of initiating emergency braking shall include the following:

1. The Emergency Brake position of the brake controller;

2. Conductor's valve operation;

3. Un-commanded uncoupling;

4. Parting or rupture of the brake pipe system; or

5. Any other condition resulting in de-energization of the emergency brake trainline.

12.15.5 Priority Over Service Braking

A. The pneumatic controls shall be configured such that an emergency brake command takes precedence over any service friction brake command then in effect.

12.15.6 Wheel Slide Protection In Emergency

A. Wheel slip protection shall be deactivated in emergency braking but means shall be provided to activate wheel slip protection in emergency using the deadman system (stepping on switch provides wheel slide protection, and removing foot from switch provides no wheel slide protection).

12.15.7 Independence

A. Emergency brake application shall be independent of the proper functioning of either the propulsion control logic or the friction brake electronic control system.

12.16 Brake Pipe

A. Nominal brake pipe operating pressure shall be 110 psi.

12.16.1 Charging

A. Charging of the brake pipe from main reservoir shall be initiated from an active cab via a combination of a pushbutton, the brake controller position and train status. In order to initiate charging, the brake controller must be in the Full Service position. The train must also be at rest (No Motion is true).

B. The brake pipe control unit shall have a delivery that is as rapid as possible, but insufficient to recharge against the open position of any of the venting apparatus.

C. The charging pushbutton must be held until brake pipe is charged to a level to be self-maintaining and shall be submitted. **(CDRL 12-01)**

D. If charging is cancelled at a pressure below the maintaining changeover threshold, the brake pipe shall be fully vented.

12.16.2 Maintaining

A. Upon initial charge, the brake pipe pressure shall be maintained at the nominal specified pressure by the charge maintaining feature.

B. Pneumatic components shall be provided to maintain the brake pipe pressure at the nominal level against leakage or other causes of pressure change, provided that the brake pipe is not vented, and to cut off brake pipe charging during an emergency brake application.

C. The maintaining feature shall become active once the brake pipe has been charged to a specified minimum pressure and shall be cancelled upon initiation of an emergency brake application.

D. Brake pipe maintaining shall be disabled when charging from an external source, such as when charging from a towing locomotive.

12.16.3 Venting

A. An electrically-actuated, normally energized emergency magnet valve (EMV) shall be provided on each car to vent the brake pipe when de-energized in order to initiate an emergency brake application. The EMV shall be powered through double-break interlocking (i.e., switching both the positive and negative supply) under the control of the local cab. Any of the following conditions shall result in de-energization of the emergency brake trainline:

1. Movement of the brake controller to the Emergency Brake position;

2. Opening of the Brake Pipe Pressure Switch;

3. De-activation of the operating cab;

4. Any other condition causing de-energization of the emergency brake trainline circuit

12.16.4 Propulsion Interlocking

A. Brake pipe pressure sensing shall be provided to inhibit propulsion whenever the brake pipe pressure drops below that required for transitioning to an emergency brake application.

12.16.5 Status Messages

A. The brake system shall include operational status conditions to indicate if operator action is necessary to properly condition the brake system to charge. For example, the system shall indicate if the brake controller handle needs to first be placed in Full Service in order to enable the brake pipe to charge.

12.17 Valve

A. Conductor's valves shall be provided at each end of each car: near the A-end body end door, on the engineer's side of the cab, on the observer's side of the cab, and in the passenger compartment right outside of the cab.

B. The Conductor's valve arrangements shall conform to APTA Standard SS-M-007-98, Standard for Conductor's Valve, and all valves on the car shall be identical.

C. Each Conductor's valve shall be connected to the brake pipe such that operation of the valve shall cause an emergency brake application.

D. Once operated, it shall be necessary to reset the Conductor's valve manually at the valve location in order to recharge the brake pipe.

E. Valve and handle arrangements shall be submitted. **(CDRL 12-01)**

F. Operation of the conductor's valve shall be indicated to the vehicle monitoring system.

G. Conductor's valves shall be electrically annunciated on the TOD.

12.18 Snow Brake

A. A snow brake function shall be provided to allow the Operator to maintain a light application of the friction brakes at all times at a level sufficient to prevent icing of friction materials in cold weather.

B. Snow brake operation shall be a trainlined function and shall be actuated by operation of a console-mounted control functional only in the controlling cab. The control shall permit snow braking to be activated and deactivated.

C. An active snow brake command shall be canceled once the operating cab is shut down and deactivated. It shall be required to activate the snow brake again the next time a cab is activated.

D. The snow brake system shall not thermally damage any discs, wheels, or brake shoes. It shall incorporate a periodic release feature to allow automatic slack adjustment during snow brake operation.

E. Snow brake application pressure shall not be affected by load weighing.

F. Snow braking shall not be designed to impart braking force. The service braking rates shall not be affected by a snow brake application.

12.19 Parking Brake

A. A spring applied air release parking brake system shall be provided, conforming to APTA Standard PR-M-S-006-98, Standard for Parking Brakes for New Passenger Locomotives and Cars.

B. Local control of cars without power shall be provided through manual controls accessible from inside the car, located behind locked access cover or integrated into existing cabinets.

C. Each parking brake shall be equipped with a manual release feature allowing the spring applied feature to be released. Air pressure application shall be used to reset the manual release feature.

D. Manual release devices shall be truck mounted and suitably protected against contamination and corrosion, including from wheel-spray.

E. Manual release shall be operable from either side of the vehicle, and actuation of release from either side of the car shall release all parking brakes from the respective truck.

1. The force to operate the manual release by hand shall not exceed 15 pounds.

F. Parking brake release air status shall be indicated on the side of the car. Parking brake status will be indicated on the TOD.

G. Application of any cars parking brake shall affect the status of the brakes release trainline.

H. The parking brake system shall be equipped with an anti-compounding feature to prevent superposition of parking brake and service/emergency brake forces. The changeover between service and parking brake shall not result in an inadmissible reduction in force during transition.

12.20 Wheel Slide Protection System

12.20.1 General

A. A wheel slide protection (WSP) system shall be provided and shall operate on a per-truck basis.

B. Wheel spin protection will be performed by the propulsion control electronics. A combined system may be proposed for Approval.

C. The WSP shall detect all slides (braking) whether they are random or synchronous.

D. The design of the WSP shall be focused on the achievement of the shortest practical braking distance, and not solely upon wheel protection.

E. The design of the system shall be coordinated with the propulsion system control.

F. The WSP shall correct for wheel slide up to the limits of available adhesion during deceleration of the car and shall prevent flat-spotting and other damage to the wheel treads under all adhesion conditions at all speeds in propulsion; and at all speeds above 3 miles/hour in braking, provided that the coefficient of sliding friction exceeds 5 percent.

1. The WSP shall utilize an adaptive or selective algorithm that is capable of automatically discerning between different adhesion conditions to optimize WSP performance to fulfill UIC 541-5.

2. The WSP shall function properly with wheel diameter differences of up to 0.25 inches in diameter among the wheels on a truck, and differences of up to 3 inches in diameter among the wheels of a car.

3. Detection of a wheel slide during dynamic or blended braking shall result in the modulated reduction of dynamic braking on the affected truck.

4. The WSP shall prioritize slip correction via the propulsion system however a selectable timeout to default to full friction control shall be implemented. The time period shall be software adjustable with the PTU with password protection.

5. If the slide is not corrected during the allocated time period, dynamic braking shall be removed, and the friction brake control shall take the responsibility for braking until the slide is corrected. After the slide has been corrected, braking shall be reapplied automatically at a rate consistent with obtaining the maximum performance without exceeding the specified jerk limit.

6. The design shall also seek to minimize damage to wheel treads during braking below 5 miles/hour.

7. The WSP shall minimize compressed air usage during slide correction in friction braking.

8. The WSP system shall maximize braking and minimize slide to industry standards at a minimum.

    a. Testing of the WSP system shall be performed in accordance with Section 15, Test Program.

9. Detection of WSP activity shall be indicated on the TOD.

12.20.2 Control

A. Modulation of brake cylinder pressure for wheel slide control shall be controlled on an individual truck basis at a minimum.

B. Slide control in emergency braking shall be as previously specified.

C. No single or combination of WSP component failures shall prevent the car from accelerating or braking. The failure mode of the control shall be such as to render the WSP scheme ineffective while allowing the friction brake to remain applied during a wheel slide sequence.

D. During slide correction, friction brake blending controls shall recognize that slide correction is occurring and shall not increase the friction brake effort to make up for the electric braking effort reduction resulting from the slide condition.

E. Wheel slide protection shall be inoperative below a specified low speed threshold which shall be software adjustable with password protection, and initially set to 3 miles/hour.

F. The WSP shall include a watchdog function to prevent triggering of the WSP valves if venting continues uninterrupted for a length of time that shall be proposed for Approval. WSP watchdog timeout activity shall be reported as an event.

G. The WSP shall include an automatic normalization feature, which normalizes wheel speeds to compensate for wheel diameter differences. Differences in wheel diameter shall not interfere with correct operation of the WSP.

H. The WSP shall utilize only one speed sensor per axle.

I. The Contractor shall submit a description of WSP operation. The description shall include system block diagrams, description of detection and correction algorithms, axle speed differential and rate of change thresholds, and friction brake system interface details. **(CDRL 12-15, WSP Operation Description)**

J. The Contractor shall also perform a FMECA for the WSP demonstrating compliance with the safety requirements for the timeout function.

12.20.3 Wheel Slide Control Valves

A. Comply with the following:

1. Provide wheel slide magnet-valves for each truck to modulate brake cylinder pressure at the request of the WSP for wheel slip-slide detection/correction control.

2. Timing of the valves shall be accomplished electrically and shall be independent of brake cylinder applied pressure.

3. Arrange valves so that they will function regardless of the amount of brake cylinder pressure at the time the wheel slide correction is actuated.

4. Electronic components incorporated into the brake control valves shall be located so as to be accessible without removal or disassembly of the air-containing portions of the valves. Required adjustments shall be possible without removal of the valves from the car.

5. Control systems shall be designed to allow a smooth transition between dynamic and friction braking.

6. Design of BCP control valves shall be such that air flow through the valves ceases when air is not flowing in or out of the brake cylinder.

12.20.4 Electronic Control Unit

A. Harness wiring shall be used to the maximum extent practicable for wiring these control items together.

B. The control modules shall be mounted on a metal framework within an enclosure with gasketed covers.

C. Fully assemble and test the control package prior to installing in the car and connecting to other car systems.

D. Internal temperatures of modules and components, including power supplies, shall be designed to provide a large thermal margin. No degradation of reliability shall occur during the design life of the equipment when the equipment is operated continuously where the ambient temperature may reach 130°F (54°C).

E. All wheel slide electronic control cards shall be interchangeable between cars without user adjustment.

1. Arrange control components requiring periodic calibration or testing with test points or test fittings so it is not necessary to remove wires or disconnect pipes to perform testing or calibration and locate and arrange so that one person can perform calibration unassisted.

12.20.5 Control Logic

A. WSP control logic shall consist of one or more microcomputers with peripherals necessary to meet the required functions and performance criteria.

1. Control programs shall be stored in non-volatile memory.

2. Provide sufficient non-volatile memory for the purposes of storing, by manual command, significant data that occurred over a period of at least 2 seconds before a fault event, as indicated by any of the WSP fault indicators when the friction brake system is last turned off.

a. These data shall be held until a reset command is received from a PTU, or a reset pushbutton on the control logic monitoring panel is pushed.

b. These data shall be addressable by the PTU for troubleshooting purposes and by the set of built-in troubleshooting displays.

3. Control logic cabinet(s) on each car shall include LEDs for indicating system states and faults.

4. The friction brake controller shall have a comprehensive diagnostic system capable of diagnosing failed components. The level of fault reporting shall be sufficiently detailed to allow operating and maintenance personnel to uniquely identify common faults.

5. Fault data shall be recorded in a structured format so that statistical analysis may be conducted after download.

6. Data shall be timed, dated, and recorded in local time as appropriate and shall be adjustable as specified in Section 18, Monitoring and Diagnostics.

7. The fault logging system shall also record a sufficient amount of trace data, sampling data at a rate no slower than 100 ms and recording relevant data for 3 seconds before and 2 seconds after the fault.

8. Trace data shall be triggered by major system faults.

9. All data shall be downloaded in a common, spreadsheet-style format that can be directly loaded into Microsoft Excel. No data conversion shall be required.

10. The system shall also be capable of downloading data via the wireless Train-to-Wayside Data Transfer (TWDT) system, as specified in Section 18, Monitoring and Diagnostics.

11. The system shall incorporate a self-test to verify that all system components are working normally within predefined limits, and to check and troubleshoot the integrity of the system.

    a. The system shall initiate a self-test upon startup.

    b. It shall be possible to initiate a test-on-demand from the VMDS or by PTU.

    c. Failure conditions from the electronics self-tests or tests-on-demand shall be communicated to the VMDS and shall be downloadable as part of the fault log by the PTU.

    d. Submit documentation for WSP Self-Test and Test-on-Demand Capability. **(CDRL 12-16, WSP Self-Test and Test-on-Demand Capability)**

12. System shall have sufficient memory capacity to store collected data and fault traces for a minimum of 120 days without loss of data or overwrites. The memory data shall not be lost when the main power is cut off.

13. Provide log file validation and replacement within the control algorithm to ensure against file corruption during file creation.

14. Make provision within the system and any other data storage device to take advantage of higher capacity media as it becomes available to prevent obsolescence constraints.

15. Submit documentation for WSP Brake Diagnostic System. **(CDRL 12-17, WSP Brake Diagnostic System)**

16. Control logic and signals from the friction brake system shall be easily accessed from a PTU.

    a. Both analog and digital data shall be readily accessible and shall have the ability to address logic signals significant to analysis and diagnosis, including signals to and from relays and external inputs and outputs.

    b. Unless otherwise specifically Approved, the control logic shall have the capability of supplying a sufficient number of channels available as analog outputs to a high impedance chart recorder for real-time recording of control signal data.

    c. The PTU for the friction brake system shall comply with the requirements of this Section and the PTU requirements of Section 27, Special Tools and Test Equipment. The interface to the PTU shall be an addressable output using an RJ45 Ethernet-connector.

17. A WSP active signal output shall be provided by the system, for use of the operator's display, to indicate when the WSP system is actively attempting to correct a slide.

12.21 Rollback Protection

A. The friction brake system shall incorporate rollback protection functionality as specified in Section 10, Propulsion and High Voltage System. Rollback functionality shall be coordinated with the propulsion system.

12.22 Diagnostics

A. The brake system diagnostic features shall include the following at a minimum, all faults shall be transmitted to the vehicle monitoring system as described in Section 18, Monitoring and Diagnostics:

    1. Brake Cylinder pressure control fault

2. Main Reservoir pressure control fault
3. Propulsion Interface fault
4. Internal self-diagnostics and failure reporting, both friction brake and WSP
5. WSP speed sensor circuit self-test and failure detection
6. WSP speed sensor circuit failures communicated to the monitoring system
7. WSP timeout events

12.23 Event Recorder Interface

A. The friction brake system shall include interface to the Event Recorder described in Section 20, Automatic Train Control and Positive Train Control. The proposed brake system data to be transmitted to the Event Recorder shall be submitted **(CDRL 12-18, Event Recorder Interface)** and shall at a minimum contain the following:

1. Brake Cylinder Pressure
2. Brake Pipe Pressure
3. Main Reservoir Pressure
4. Brake Applied Trainline
5. WSP active
6. Brake Demand Trainline
7. Emergency Brake Trainline
8. Penalty Brake Trainline
9. Engineering Initiated Emergency (EIE) Brake
10. Deadman

B. The MSDS shall record WSP activated on a per truck basis.

12.24 Contract Deliverable Requirements List (CDRL)

The following contract deliverables have been identified in this section; however, the Contractor is responsible for providing and submitting anything necessary to fulfill the requirements of this contract, including those not identified by CDRL number.

CDRL 12-01, Brake System Component and Design Description 12-2
CDRL 12-02, Brake System Piping Diagram 12-2
CDRL 12-03, Brake System Wiring Diagram 12-2

CDRL 12-04, Layout for Brake System....12-5
CDRL 12-05, Brake Calculation....12-6
CDRL 12-06, Thermal Calculation....12-6
CDRL 12-07, Foundation Brake Equipment Design Description....12-7
CDRL 12-08, Friction Brake Self-Test and Test-on-Demand Capability....12-10
CDRL 12-09, Friction Brake Diagnostic System....12-11
CDRL 12-10, Compressor Duty Cycle....12-13
CDRL 12-11, Compressor Lubricating Oil Details....12-13
CDRL 12-12, Air Consumption and Reservoir Sizing....12-16
CDRL 12-13, Brake Indicator Design and Integration....12-18
CDRL 12-14, Test Fitting Types and Locations....12-19
CDRL 12-15, WSPS Operation Description....12-27
CDRL 12-16, WSPS Self-Test and Test-on-Demand Capability....12-29
CDRL 12-17, WSPS Brake Diagnostic System....12-30
CDRL 12-18, Event Recorder Interface....12-31

12.25 CDRL Details

This section lists the expected content for each CDRL required above. The lists provided for each CDRL are an outline only and should not be considered exhaustive, all CDRLs are subject to SEPTA review and approval.

CDRL 12-01 Brake System Component and Functional Description (SFD)

1. Detail the architecture of the brake system.
2. Describe in detail each functionality performed by the brake system.
3. Describe in detail each component utilized within the brake system.
4. Describe the blending functionality and scheme.
5. Describe the towing functionality.
6. Display of cutout statuses.
7. Brake pipe charging functionality and timing.
8. It shall be submitted as part of each design review meeting (CDR, PDR, FDR).

CDRL 12-02 Brake System Piping Diagram

1. Detail the pneumatic layout and connections of the brake system.
2. Detail the piping requirements of the friction brake system.
3. It shall be submitted as part of each design review meeting (CDR, PDR, FDR).

CDRL 12-03 Brake System Wiring Diagram

1. Detail the electrical connections of the brake system.
2. Detail the wiring requirements of the friction brake system.
3. It shall be submitted as part of each design review meeting (CDR, PDR, FDR).

CDRL 12-04 Layout for Brake System

1. Provide details of the friction brake controls, locations of equipment and system integration.
2. Location and accessibility of each brake system cutout.
3. It shall be submitted as part of PDR and FDR.

CDRL 12-05 Brake Calculation

1. Brake performance calculation showing sufficient detail to allow review for conformance with Specifications, including emergency, service, and parking brake cases.
2. Revise and submit calculations, as a minimum, at each design review (CDR, PDR, FDR) and FAI to reflect the latest physical properties and weights of the vehicles.

CDRL 12-06 Thermal Calculation

1. Thermal capacity calculation showing sufficient detail to allow for review for conformance with Specifications.
2. Analysis of thermal capacity.
3. Revise and submit calculations, as a minimum, at each design review (CDR, PDR, FDR) and FAI to reflect the latest physical properties and weights of the vehicles.

CDRL 12-07 Foundation Brake Equipment Design Description

1. Submit detail of foundation brake equipment including design descriptions and clearance envelope studies, including:
    a. Static any dynamic clearance envelope studies.
    b. Friction material position with respect to the wheel/disc under all static and dynamic loads ensuring no unacceptable overhang/override under any condition per CFR and supplier requirements.
    c. Brake pad retaining latch and locking pin arrangement.
    d. Use of spacers between disc and hub, if proposed.

CDRL 12-08 Friction Brake Self-Test and Test-on-Demand Capability

1. Define the capabilities of all friction brake self-test and Test-On-Demand functions.

CDRL 12-09 Friction Brake Diagnostic System

1. Define the capabilities of the friction brake diagnostic system including the following:
    a. Functional description of the fault logic
    b. List of faults
    c. Functional description of the data logging system
    d. List of triggering faults.

CDRL 12-10 Compressor Duty Cycle

1. Submit calculations demonstrating the duty cycle of the compressor under the specified operating conditions including:
    a. Minimum, nominal, and worst case conditions
    b. Dead car pump-up time
    c. Operational recharge time.
2. Revise and submit calculations, as a minimum, at each design review (CDR, PDR, FDR) and FAI to reflect the latest vehicle configurations.
3. Sufficient detail shall be provided to satisfy 49 CFR 238.303 (17)ii.

CDRL 12-11 Compressor Lubricating Oil Details

1. Submit details to demonstrate suitability of lubricating oil for use in the compressor for year-round operation.
2. Submit lubricating oil data sheet.

CDRL 12-12 Air Consumption and Reservoir Sizing

1. Submit calculations showing sufficient detail of vehicle air consumption over minimum, nominal, and worst case conditions.
2. Submit calculations substantiating that sufficient reservoir capacity is chosen to satisfy the specified functional capacities for the brake system.
3. Revise and submit calculations, as a minimum, at each design review and FAI to reflect the latest vehicle configurations.

CDRL 12-13 Brake Indicator Design and Integration

1. Submit details of the brake indicator design.
2. Submit details of the logic of the indicator, including filtering of indication during wheel-slide activity.

CDRL 12-14 Test Fitting Types and Locations

1. Submit details of the location and type of the test fittings within the pneumatic circuit diagrams and location on the vehicle for accessibility.

CDRL 12-15 WSP Operation Description

1. Submit a detailed description of the WSP operation.
2. Submit block diagrams, algorithm details, and interface details:
    a. Watchdog timers shall be detailed.

CDRL 12-16 WSP Self-Test and Test-on-Demand Capability

1. Define the capabilities of all WSP self-test and Test-On-Demand functions.

CDRL 12-17 WSP Brake Diagnostic System

1. Define the capabilities of the WSP diagnostic system including the following:
    a. Functional description of the fault logic
    b. List of faults
    c. Functional description of the data logging system
    d. List of triggering faults.

CDRL 12-18 Event Recorder Interface

1. Define the signals, interface, and characteristics for the brake system data to be transmitted to the event recorder interface.

12.26 Referenced Standards

The following standards are referenced in this Section:

49 CFR 229.31	Main reservoir tests
49 CFR 229.49	Main reservoir system

49 CFR 238.303	Exterior calendar day mechanical inspection of passenger equipment
APTA SS-M-007-98	Standard for Conductor's Valve-New Passenger Car/MU Locomotives
APTA PR-M-S-006-98	Parking Brakes for Passenger Locomotives and Cars
APTA PR-M-S-011-99	Compressed Air Quality for Passenger Locomotive and Car Equipment
ASME BPVC, Section VIII-1	Boiler and Pressure Vessel Code, Boiler and Pressure Vessel Code, Rules for Construction of Pressure Vessels Division 1
NEMA MG1	Motors and Generators
UIC 541-3	Brakes – Disc brakes and their application – General conditions for the approval of brake pads
UIC 541-5	Brakes – Specifications for the construction of various brake parts – Wheel Slide Protection device (WSP)

SECTION 13
COMMUNICATIONS

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13.1 General

A. The Contractor shall supply, install, test and commission all communications equipment necessary to meet the requirements of this Section. The Contractor shall demonstrate compliance with the requirements contained within this section through the submission of a communication system design and integration package. **(CDRL 13-01, Communication System Design and Integration Package)**

13.2 Communication System Capabilities

A. Communications capabilities shall include the following:

1. Public Address (PA)

   a. The public address system shall allow one-way voice announcements from the Operator in the cab, the train crew at the side doorway locations, and from the Control Center train dispatcher (via the TWDT) to interior and exterior speakers.

   b. The system shall also make automatic digitized voice and visual announcements throughout the operation of the vehicle as configured and controlled by SEPTA.

2. Assistive Listening Systems

   a. Inductive Audio Loop

   b. Bluetooth Auracast Broadcast Audio

3. Passenger Information System

   a. Interior Messaging Signs

   b. Dynamic Route Map Displays

   c. Exterior Display Signs

      (1) An exterior sign system shall be supplied which includes an exterior front display sign at each cab end, and exterior signs on each side at each of the four side doorway locations.

   d. Signs shall be coordinated with the public address system to display route, destination, car type (e.g., out of service, or other type configured by SEPTA) and next stop information. The destination sign system shall utilize Global Positioning System (GPS) technology to provide location information, with fall back to dead-reckoning via speed sensors when GPS is degraded utilizing an internal configurable model of SEPTA's system.

4. Crew Intercom (IC)

a. A crew intercom system shall be installed to permit train crew members to communicate privately between cabs and each side doorway communication station when selected.

5. Passenger Emergency Intercom (PEI)

a. A passenger emergency intercom system shall be installed to permit passengers to communicate with any key-activated cab and any key-activated side doorway communication station of the train.

6. Automatic Passenger Counting System

a. Provide an Infodev automatic passenger counting (APC) system or Approved equal for each car.

7. Video Surveillance System

a. A Gatekeeper Ethernet TCP/IP-based Locomotive Image and Audio Recording Device / Video Surveillance System (VSS) consisting of Gatekeeper color cameras, Gatekeeper Network Video Record (NVR), Crash-Hardened Memory Module, and other ancillary equipment.

8. Communicating Buzzer System

a. A communicating buzzer system, with a pushbutton and concealed buzzer, shall be located as per the requirements of TS 13.14.

9. Radio

a. The radio shall allow the Operator to communicate with the Control Center train dispatcher and other wayside and mobile units.

b. The radio equipment shall be fully compatible with SEPTA's railroad division voice radio network.

10. Expansion Provisions

11. Provisions for Passenger Wi-Fi

12. Content Lab.

13.3 General Requirements

A. Comply with the following:

1. The Communications system shall provide the passengers and crew with visual, audible, and digital information as configured and programmed by SEPTA such as the train destination, present station, next station, pre-set messages, train consist arrangement including passenger counts, car and consist information, emergency messages and visual graphics, including advertising.

2. The information shall be provided through the interior and exterior signs, through interior and exterior speakers, through the inductive audio loop system, through Bluetooth LE Auracast broadcasts, Bluetooth LE beacon advertisements, and through other digital networked connections.

3. This design shall be based on modern state of the art technologies and shall be built with an open and extensible architecture that shall both interface with systems that may already be in use in any existing rolling stock and in SEPTA's existing wayside environment, as well as support on-board systems, rolling stock, and wayside systems that may be added in the future.

4. Short circuits on the audio trainlines shall not damage any communication equipment.

5. No proprietary designs or components, including radio and data transmission protocols, shall be used. As required by Section 17, Network and Trainline Controls, and Section 25, Program Management and Commissioning, the complete and unambiguous Network Interface Control Documents and Interface Control Documents shall be submitted for all components.

6. SEPTA shall be able to make future changes, additions or revisions to the communications systems being supplied under this Contract without the need to pay any fees, licenses or other costs or any restrictions on implementation.

7. The system shall implement secure APIs exposed to SEPTA that allow for simultaneous voice, textual, graphical, diagnostic and test message control of passenger facing communication system displays via the 4G/5G cellular connection.

8. The APIs shall include the capability for SEPTA to update, control, and trigger content throughout the communication system, including to select trains, cars, or individual screens/audio zones based on live feeds of information from on-board and wayside sources, which shall be configurable by SEPTA. These feeds shall enable a variety of uses, including, but not limited to:

    a. Live News

    b. Live weather

    c. Consist status

    d. Connecting bus and train information

    e. Advertising

    f. Anticipated platform berthing

    g. Station updates.

9. The network and software architecture, design, and configuration of the equipment identified in this Section shall be extensible by SEPTA, facilitating the addition or replacement of additional vehicle switches and end devices throughout the life of the vehicle through exposed APIs implemented at each device supplied as a part of these requirements, which shall facilitate the interaction with Contractor supplied communication components.

10. Maintainability

    a. Removal and installation of any component shall not require the removal of any other equipment.

    b. Replacement of any Communication system component of the same type shall not require manual re-configuration. This shall be implemented through car-side coding connectors, dynamic assignment of IP addressing from car network switches, or other Approved method.

    c. Heat generating equipment shall have suitable heat sinks located on external surfaces of the enclosures and be cooled by natural airflow.

        (1) Cooling fans are not acceptable.

11. Cellular Device Compatibility

    a. The Contractor shall ensure that mobile cellular telephones can operate reliably inside all cars within each car, under all on-board equipment operating conditions and at all locations along the SEPTA regional rail network, provided that the necessary external facilities have been installed by others.

    b. The Contractor shall include appropriate considerations taken as a part of the carbody design and/or window design to limit the impacts on cellular reception inside the vehicles from car construction, and from electrical and electronic equipment integrated into the vehicle.

    c. At PDR, the Contractor shall submit for Approval a plan for minimizing the attenuation based on car construction, such as using etched window coatings in vehicle glazing, RF transparent car-body components, or other Approved approach.

    d. The Contractor shall submit a plan identifying the approach to reducing the attenuation of the car-body, on-board equipment, and glazing impact on cellular telephone reception prior to PDR. **(CDRL 13-02, Passenger Cellular Device Compatibility Plan)**

12. Fault Tolerance

    a. The car and train level components of the system shall be fault tolerant, so that failure of one item shall not impair normal operation of the remainder of the system, and that any single point of failure does not

result in good cause (such as the impairment of PA, IC, PEI, PIS, VSS) to remove the train from continued revenue service.

b. To accomplish this, it is expected that multiple communications controllers per consist will be required, and that multiple PA Amplifiers will be required per car, and that diagnostic reporting to the Monitoring and Diagnostic system will be available through multiple controllers.

c. The Contractor shall identify the fault tolerance capabilities, recovery time, and user interaction required to maintain system operation. **(CDRL 13-03, Communication System Fault Tolerance Capabilities)**

d. Momentary power outages shall not cause the system to require any reset, and upon the loss of power for any reason while executing a journey, the system shall return to its previous route and location without re-programming or reconfiguration by train staff.

e. The system and its software shall be designed to reliably operate when the car and its systems remain powered on for extended durations.

13.4 Power Requirements

A. All communications apparatus shall be powered from the low voltage power supply with automatic backup by the battery in the event of power loss and shall have sufficient capacity to meet all peak power requirements.

B. Devices including the PA/IC Control Stations, Automatic Passenger Counting sensors, video surveillance cameras, and Passenger Emergency Intercoms may be powered by Power over Ethernet connections provided by Vehicle Switches powered by the low voltage power supply with automatic backup by the battery.

1. Separate circuit breakers located in the low voltage circuit breaker panel shall be provided for specific communication system functions, to limit overall system impact with the failure of one device.

2. Power conversion and power conditioning devices shall be integral to the communication system components. As Approved, the use of other sources of power supply voltage (e.g., other than car battery levels), may be implemented by dedicated current-limited, self-resetting, DC/DC isolated outputs provided by the associated subsystem controller.

3. The Contractor shall provide all wiring, connectors, enclosures, and suitable installation hardware for all communications equipment.

13.5 Diagnostic and Reporting Requirements

A. The subsystem controllers shall have a comprehensive diagnostic subsystem capable of diagnosing failed components.

1. The system shall incorporate automatic and guided self-tests to verify that all subsystem components are working normally within predefined limits, and to check and troubleshoot the integrity of the system and its components.

    a. An automatic self-test shall be initiated at each component startup. In the event of a startup during revenue service, the automatic self-tests shall not interrupt or interfere with the display or indication of an active route program.

    b. A guided one-person self-test shall be capable of being initiated by the Vehicle Monitoring and Diagnostic System (VMDS), from a communication control panel, and by Portable Test Unit (PTU). This test shall facilitate an efficient one-person confirmation of system functionality of all Communication System components throughout a coupled consist.

    c. Failure conditions from the electronics self-tests shall be communicated to the VMDS, shall be downloadable as a part of the fault log by the PTU, and shall be communicated to the wayside via the TWDT.

        (1) Upon failure of a guided self-test request, the end-user shall be capable of executing only the failed tests again or executing the entirety of the test again.

    d. The self-test shall include options for train crew to perform:

        (1) Automated verification that each PEI works, including microphone and speaker transmission.

        (2) Automated verification that individual PA Amplifiers and the speakers zones they power are functional.

        (3) Automated verification that the assistive listening systems are functioning, including that each hearing loop has continuity, and that current is flowing when audio is sent to the hearing loop amplifier.

        (4) Automated verification that all displays, including interior and exterior displays, are connected and addressable and operating within expected boundaries, with auto-dimming functioning, with the capability for the maintainer to validate a test pattern to confirm display operation.

        (5) Automated verification that all control units are addressable and functioning.

        (6) Automated verification that all APC equipment is functioning.

        (7) Automated verification that all VSS equipment is functioning.

(8) Other communication components as required to validate suitability for entrance into revenue service.

e. At the conclusion of the self-test, a report shall be recorded and displayed on screen that indicates the systems tested and the results of the test.

f. The contractor shall submit documentation defining the capabilities of the self-test functions. **(CDRL 13-04, Communication System Self-Test Capabilities)**

2. The classification of failed components shall be sufficient to determine the failed lowest line replaceable unit.

3. The faults generated by subsystem controllers shall take into consideration the operational impact of the fault and collection of faults, providing the ability for the VMDS to display appropriate information to onboard and remote staff. Specifically, faults should specifically consider:

a. The impact of a failed component which may have a redundant backup.

b. The impact to operations when multiple redundant items fail, resulting in a total loss of one or more services (such as PA, PEI, IC, or signage).

c. The impact to regulatory compliance, such as the failure of one or more regulatory required Video Surveillance components, such as the Forward Facing Camera, Cab Cameras, NVR, or Crash Hardened Memory Module.

B. Through one or more datagrams, the subsystem controllers shall provide status of all variables to VMDS in sufficient resolution to recreate events for maintenance, diagnostic, and engineering purposes and to support trace data generation on the VMDS.

1. The controllers shall provide the status of all inputs, outputs, and internal variables, including those of associated peripherals.

2. The system shall transmit datagrams at intervals not exceeding 100 milliseconds.

13.6 Communication Controls

A. Controls shall be provided in each cab for the operator, in a convenient location adjacent to each cab for conductor use, and at each doorway area to permit operation of various sections of the communications system by the train crew.

1. General Requirements

a. The communications controls and panels shall be designed such that when any microphone is in use, there shall be no feedback or

interference from any adjacent speakers, which shall be automatically cut out when necessary.

b. Control panels shall use connectors for ease of maintenance and shall be ergonomically designed for efficient operation.

2. Cab Controls:

a. Each cab shall have a communications control panel and radio located based on the requirements for the cab design in Section 5, Operator's Cab.

b. Each cab shall have communication controls which provide full system functionality.

c. The cab communications controls shall be active whenever its cab has been activated by the train engineer, or when a communication key switch has been activated by train crew (e.g., to permit system use in the cab from a trailing cab, or to configure the train's route prior to cab activation).

d. The arrangement of all controls (using separate, spring returned, momentary contact switches) for control of the PA, IC, PEI and buzzer, and all indicator LEDs to signal activation of the PA, IC, PEI, and radio transmit functions, along with the radio itself, shall be submitted for Approval.

e. To permit use by the Operator's right hand, a radio transmit pushbutton shall be located at the right side of the center cab console, per Section 5, Operator's Cab.

f. A speaker shall be provided in accordance with the PA, PEI, and IC functions, with a volume control adjustable from 10 percent to 100 percent of full volume.

g. Control of the communication system by Operator, including selection and display of current route, current location, adjustments to route, and activation of special announcements shall be through the Train Operator Display located in the cab.

h. A high-quality microphone shall be provided for use with the PA, IC, PEI, and radio.

i. A three-position speaker selection switch for interior speakers, exterior speakers or both shall be provided.

j. A key switch operated by the standard key shall also be included in the cab to allow Conductor or train crew use of the radio, public address, PEI, and crew intercom in a trailing cab.

3. Conductor's controls shall:

    a. Be located adjacent to the cab, on the rear wall of an Observer's cab, mounted on the equipment locker, or other Approved location.

    b. The control panel shall include a flush mounted high-resolution touchscreen display, with a size a minimum of 15 inch diagonal size, for the communication system for use by the Conductor and train maintainers.

    c. Its location shall allow ergonomic access by a Conductor during typical revenue service.

4. The Cab and Conductor’s Communication Controls shall:

    a. Allow full control over the communication system components, including making and receiving PA, PEI, and IC calls, selection of route information for automatic next stop announcements and destination sign displays, public relations messages and any other required communications control function.

    b. The unit shall display details regarding the selected route, the current messages, and future messages.

    c. The Communication Control capabilities of each control panel (including TOD in cab, and Conductor's controls) on a train shall support full control over the communication system, once unlocked by Authorized staff.

        (1) Initial unlocking shall be with a crew key in a crew key switch adjacent to the control panel, or through activation of the cab in the case of the cab control panel.

        (2) Certain functionality (such as adjustments to messages, triggering of self-tests, or other control features), to be proposed by the Contractor and Approved, shall be through the use of a personalized pin code through a software screen lock.

5. Doorway Communication Control Panels shall:

    a. Be located at each doorway shall provide PA, PEI, IC, and buzzer functions.

    b. The control panel shall be Ethernet based, with the exception of the communicating buzzer function, which shall be available at all times low voltage or battery power is available, including in the event of complete network failure.

    c. The Conductor's communications control panel shall be active only when the standard key has been inserted into the door control panel, except for the buzzer functionality which shall be always available.

d. Each Conductor's doorway communication control panel shall have separate momentary contact switches and indicator LEDs for control of the PA, IC, and PEI functions.

e. The panel shall include a low profile, noise canceling microphone, and an IC speaker, both behind a perforated grille.

f. A communicating buzzer and push button shall also be included.

13.7 Public Address Equipment

13.7.1 General Requirements

A. Comply with the following:

1. Each car in the trainset shall be equipped with a fully digital, IP Ethernet based Public Address (PA) system.

2. The system shall permit the train crew to provide a manual PA announcement to the passengers and allow it to be directed to loudspeakers on only the local car interior, to the interior of all cars in the train and/or to the exterior speakers of all cars in the train.

3. The system shall also be interconnected to the destination sign and vehicle location systems to make automatic voice stop announcements and public relations messages.

4. The PA system shall provide SEPTA's operations center with the capability to control the Public Address System, including making coordinated audio, visual, video, and graphical announcements for emergencies, service disruptions, and otherwise as commanded by authorized SEPTA personnel.

5. The system shall operate with uniform audio quality in a car, shall inhibit audio feedback, and shall be muted when not in use.

6. The public address system shall measure the local ambient noise level between use and automatically compensate gain accordingly and instantly just prior to every announcement.

   The peak sound level shall be easily adjustable through configuration of the amplifier by SEPTA through engineering-level PTU access, and by authorized users via the wayside systems.

13.7.2 Manual Mode

A. The Operator's communication panel shall be equipped with a condenser microphone.

1. A push-to-talk button shall be located at a convenient location on the cab console to permit manual announcements to be made.

2. A speaker selector switch shall be provided to direct the manual announcement to only the interior speakers, only the exterior speakers, or all speakers.

3. Any manual announcement shall also be trainlined to all Silverliner VI cars in the train, being routed to interior or exterior speakers as appropriate.

4. The Conductor shall also be able to make manual announcements by use of a spring-loaded momentary contact pushbutton switch and flush microphone grille located at each Conductor's control panel at each doorway.

5. Any manual mode announcement by the train crew shall override any automatic announcement which may be taking place.

13.7.3 Automatic Announcements

A. Coordinated preprogrammed text, graphical, and voice announcements shall be automatically issued by the public address system.

1. These shall consist of stop, next stop, high or low level door use identification based on individual stations, emergency, and public relations announcements to the interior of the car, and destination announcements to the exterior speakers when stopped at a station or normal boarding location.

B. The system shall be programmable to make announcements throughout the train trips based on signals received from the Train Network, including in order to provide current stop announcements when stopped at a station and a door open command is triggered, next stop announcements upon departure from a station, arrival stations when approaching a station, as well as preprogrammed and manually controlled public relation and route-related information.

C. The Contractor shall provide a web-based content management dashboard that provides SEPTA with the full capabilities to make initial and future announcement changes to the content associated with all Communication System capabilities.

D. The Automatic Announcement system shall incorporate text-to-speech software, to facilitate, as configured, the automatic digitization of text-based prompts.

1. The text-to-speech software, including available voices, shall be submitted for Approval.

2. The text-to-speech software shall either convert the text to speech in the application, or text prompt files shall be transmitted to the onboard Communication System and converted onboard. In either scenario, the output of the text-to-speech software shall be handled seamlessly between the text-to-speech software and the onboard Communication System without any other required conversions.

3. The text-to-speech software shall function for the languages configured by SEPTA, initially English, Spanish, and Mandarin, any of which may be enabled

and/or disabled by SEPTA through future configuration updates. Configuration updates shall be possible through PTU and through the MDS and its connection with wayside systems via the TWDT.

E. All required licenses required to permit SEPTA to operate, maintain and modify the system for the lifetime of the car shall be included at no additional cost to SEPTA.

13.7.4 Power Amplifier

A. At least two power amplifiers shall be provided per car with speakers distributed between each amplifier such that the failure of any one amplifier does not impact all interior speakers of a single car.

B. The public address system amplifier and associated components shall be mounted together in a dustproof enclosure behind an access cover secured by heavy duty hardware.

C. The amplifier shall be digital and receive audio from the onboard Ethernet Train Backbone via the Ethernet Consist Network.

1. Amplifier gain controls and noise compensation algorithm shall be adjustable by SEPTA through provided software, including through a password-protected configuration screen, PTU application, and via parameter synchronization through the onboard Diagnostic system and via the wayside TWDT.

2. Complete test and adjustment procedures shall be provided in the appropriate maintenance publication.

3. The amplifiers and their mounting shall be submitted for Approval.

D. The power amplifier shall be capable of delivering 35 watts at not more than 1 percent total harmonic distortion in the range of 100 to 8,000 Hz within the voltage operating range specified in Section 9, Auxiliary Power.

E. The output circuit and power supply shall include short circuit protection without the use of fuses.

F. Design, materials and workmanship shall be of first-class quality in accordance with Section 16, Materials and Workmanship, and suitable for the intended use.

G. With speech or pre-recorded input, the amplifier shall operate continuously with full output at rated input voltage without damage to any components.

13.7.5 Speakers

A. A minimum of twelve public address speakers shall be installed on each car.

1. Six internal speakers shall be located in the ceiling of the passenger area, evenly spaced longitudinally and alternately mounted on opposite sides of the car, two per seating section of the car.

2. A speaker shall be centered in each doorway area.

3. Weather-resistant exterior speakers shall be located on each exterior side of the car, one at each side doorway.

B. The speakers shall be transportation grade, vandal resistant, direct radiating, permanent magnet field type capable of handling the required audio power.

1. The frequency response with proper enclosure shall be plus or minus 5 dB from 100 to 8,000 Hz.

2. The nominal axial sensitivity shall be at least 87 dB at 4 feet with 1 watt input, and the speakers shall have a wide dispersion characteristic.

3. The entire loudspeaker shall be designed and constructed to tolerate frequent exposure to moisture.

C. The speakers shall be phased so that when the primary is connected to the distribution network, all speaker cones shall move in the same direction at the same time.

D. There shall be no feedback between car speakers and the control station when the public address system is in use.

E. During public address announcements the speakers shall be properly balanced for equal sound level distribution throughout the car interior and eliminate feedback noise to the microphone in use.

F. Each interior speaker shall be protected by a stainless steel or plastic enclosure designed to adequately protect the speaker from the effects of dust, moisture, ferrous materials, or other foreign objects.

1. The enclosure shall include knockouts and gaskets for the dust tight entrance of the speaker connection leads and shall prevent mechanical resonances or vibrations from occurring.

2. The speakers shall be mounted behind an Approved flush baffle of stainless-steel satin finished metal or integrally colored plastic material, matching the decorative treatment of the car.

a. Matching tamper-resistant stainless steel mounting hardware shall be used.

3. The mounting of the interior speakers shall be aesthetically pleasing and allow easy removal of the speaker for repair or replacement.

4. Interior speakers shall be rated minimum IP54 for dust and moisture ingress.

G. The exterior speakers shall be mounted behind a strong stainless-steel grille resistant to thrown objects.

1. They shall be a waterproof, dynamic reflex horn, or Approved alternative, designed for extreme outdoor environmental conditions, and the front surface of the horn shall have a gasketed flange for flush mounting into the carbody.

2. The mounting of the external speakers shall not allow water to leak into the carbody, shall be aesthetically pleasing and allow easy removal of the speaker for repair or replacement.

3. The speaker locations and grilles shall not violate the outline limits defined in this Specification.

4. The exterior speakers shall be immune to the chemicals and detergents normally used during vehicle washing and shall not interfere with or damage the mechanical car wash components.

5. Mounting of exterior speakers and routing of speaker wires shall be designed to a minimum of IP66.

13.7.6 Performance

A. Comply with the following:

1. Messages shall be intelligible and acoustically pleasing under all operating conditions.

2. Frequency response: Measured from signal origin to output signal at the speaker, shall be 150 Hz to 10 kHz, +/- 1 dB at all power levels.

3. Total harmonic distortion: For all circuits, without compression circuits, shall not exceed 1% at 1 kHz, full output.

4. Output volume and audio quality: Same from each speaker.

5. Speech peaks: Limited to approximately 5 dB above the average input level.

6. Intelligibility:

a. When tested according to IEC 60268-16, the PA subsystem shall have measured speech transmission index (STI) from the input of the microphone, or audio messages from the APIS, to the output of the speakers as follows:

(1) No measurements below 0.5 STI at 80 dB background ambient noise with positions tested throughout the car.

b. Use test signal recommended by manufacturer of STI measuring instrument.

7. Announcements shall be synchronized, and speakers shall be balanced, to ensure passengers do not hear announcements out of sync from multiple speakers.

13.8 Assistive Listening Systems

13.8.1 Inductive Loop

A. Each car shall be equipped with an audio inductive loop antenna and transmitter system, to allow receipt of announcements by passengers wearing hearing aids.

1. The system shall be integrated with the PA system to broadcast interior public messages that are broadcasted in the area of the inductive loop.

2. The system shall be ruggedized for the railroad environment and shall be a high output current design (no less than 10 Amps RMS), feature a high frequency gain potentiometer, feature metal loss correction, operate on vehicle nominal DC voltage, and include status LEDs for status information.

3. The solution shall meet all appropriate certifications for both Rail and Hearing Loop technology including, but not limited to EN-50155, EN-50121-3-2, IEC-60118-4, and IEC-62489.

4. The solution design and implementation plan should align with -IEC TR 63079 and testing should be completed to verify that:

a. Background magnetic noise is minimized.

b. Magnetic Field is strong enough to provide full car coverage while minimizing interference with RF on the train (Wi-Fi, Mobile Voice and Data, etc.)

c. Frequency Response is appropriate to T-Switch capable equipment.

5. The inductive loop shall cover all areas of the passenger compartments.

6. Appropriate latching diagnostics shall be provided to alert maintenance personnel when the inductive loop is open, shorted, or otherwise not delivering the appropriate current when an input is received.

7. The interior messaging signs shall be configurable by SEPTA to display an appropriate graphical icon that indicates when the inductive loop system in that car is broadcasting.

13.8.2 Bluetooth LE Broadcast

A. Each car shall be equipped with the capability to broadcast audio and pertinent passenger train information via Bluetooth based transmitters.

1. All interior audio messages shall be broadcast via Bluetooth Auracast technology.

2. The communication system shall be programmable with alternative audio tracks synchronized to be played back based on the configured content database - that shall be broadcast on additional Auracast channels.

3. These additional program channels, to be named by SEPTA via configuration of the content database, may be used to provide additional translations for audio announcements.

4. Bluetooth LE data channels shall enable broadcasting of a selection of triggers of passenger announcements to facilitate applications running on passenger devices to receive train information and relay information that is displayed on the interior displays.

5. The Bluetooth LE broadcasts in each car shall enable beacon technology to facilitate micro-location within a train consist and train car.

6. SEPTA shall have the capability to adjust all beacon messaging.

7. The Contractor shall demonstrate that enough beacons have been installed in each car and on each level to provide positioning within 8 feet when using triangulation techniques on consumer handsets.

13.9 Passenger Information System (PIS)

13.9.1 General PIS Requirements

A. The Contractor shall furnish and install a solid-state passenger information system, including front, side, interior, and dynamic route map display signs, and a passenger information system controller that is compliant with the following:

1. The signs shall meet all applicable the Americans with Disabilities Act (ADA) regulations and requirements, and the ADA Accessibility Guidelines (ADAAG) for Transportation Vehicles, including Subpart F.

2. The sign modules shall be configured in a way that allows their removal for service and repair without disruption to other vehicle electronic systems.

3. The screen area at each location shall be maximized for the space available to provide readability for the greatest number of passengers in the car. The Contractor shall provide a proposal that balances the requirement for large screen size, availability of commercially available display sizes, and the number of individual screen sizes required throughout the vehicle.

4. All displays shall have a readability at a 65-degree angle on either side of a line perpendicular to the center of the mean plane of the display.

5. Cycling input power to the information signs shall not cause the sign to display a fault mode or indicate a self-test mode.

6. The sign shall automatically resume normal display without crew intervention.

7. Each sign assembly shall be placed in dustproof, water-resistant housing. Displays shall be protected from vandalism.

8. The housing shall allow easy access to all routine maintenance functions including the cleaning of the display face(s) of the unit.

9. When not commanded to display, all signs shall perform a configurable action, configurable on a display-by-display basis by SEPTA through content updates. Configurable actions shall include:

    a. Turning the display / LED / backlight off

    b. Displaying a programmed graphic, image, or video

    c. Displaying a text message

10. Control of the sign system shall be by TOD and through a dedicated communications control panel located adjacent to the Operator's side of the cab.

    a. The Conductor shall use the control panel in any cab of a train, once it has been made active by the Conductor, to adjust all signs.

    b. The control system methodology shall be simple to understand and use, and provide the capability for a Conductor to:

        (1) Perform initial setting at the beginning of a trip, including current route and follow-on routes.

        (2) Make changes during a trip, such as skipping normal stops, adjusting the current and future routes, and

11. The Contractor shall provide all interface control documents and database description files for all messaging signs, to allow SEPTA to implement alternative designs for on-board equipment, and to allow SEPTA to implement alternative designs for wayside database maintenance tools. The Contractor shall disclose to SEPTA all required methods, software, tools, and associated equipment necessary to ensure the successful operation and replacement of the system.

12. All required licenses or other fees required to permit SEPTA to operate, maintain and modify the system for the lifetime of the car shall be included at no additional cost to SEPTA.

13. Interchangeability: The screens shall be as interchangeable with other commercially available screens as possible and shall not require any proprietary interfaces. Provide a detailed Interface Control Document physical and data interfaces, and testing requirements, for the screens.

14. The displays shall be designed to be easily removed and replaced over the lifetime of the fleet.

15. All details of the destination sign system and operation of the control system shall be presented to SEPTA for Approval.

B. In addition to the on-board system, the Contractor shall supply a complete Wayside Communication System capable of managing all aspects of the onboard Communication Systems via the TWDT channel.

1. The wayside elements shall include a web-based server software installed on-premises through SEPTA's existing virtualized environment detailed in Section 16, Materials and Workmanship.

2. The web-based content management system supplied shall provide the capability to control existing trips by system, line, and train, such as:

a. Initiating routes

b. Adjusting destinations

c. Configuring stations to be skipped

d. Setting special service messages

3. The system shall support updates to all on-board content, including:

a. Audio messaging

b. Text messaging

c. Visual messaging

d. Content templates

e. Content feed sources and configuration

13.9.2 Interior Messaging Signs

A. Each section of the car interior shall have an interior destination sign having an impact-resistant screen.

B. Displays shall be of a 16:9 aspect ratio and minimum 1920x1080p resolution, with minimum of 27-inch viewing area, brightness of 500 cd/m^2, 60 Hz refresh rate with no detectable flicker.

C. The screen shall be mounted at the front end of each section (e.g., change of direction of passenger seating) to allow maximum visibility to passengers.

1. At least 8 interior signs shall be provided for the purpose of passenger information system messaging, located as Approved. Each seated passenger must have the ability to view at least one passenger information system messaging sign.

2. The interior signs shall automatically display next station stop information when under control of the automatic GPS vehicle location system, or as selected by the Operator.

3. The signs shall be full-color LCD / TFT displays with connections to controllers through the Ethernet Consist Network.

4. The interior graphical display message signs shall be 32 inches measured diagonally or larger, using a backlit full color LCD (using high intensity LED backlighting), or other Approved equivalent full color display, and have the capability of displaying video, graphics, images, and text.

5. The interior signs shall have the capacity to scroll or page large messages, as configured by SEPTA on a message by message basis in the content database.

6. An additional 4 interior messaging signs, initially configured by SEPTA to display dedicated advertising content, shall be included in addition to the 8 displays for passenger information.

13.9.3 Transverse Display

A. Modern high-resolution LCD displays shall be provided at the transition between ceiling heights at each end of each car.

1. These displays shall be sized to provide readability for seated passengers located throughout the passenger compartment.

2. The displays shall be controllable based on SEPTA's programming of the content database, nominally configured to provide a text representation of audible announcements.

3. Pixel pitch of the transverse displays shall be 5mm or smaller.

13.9.4 Dynamic Route Map Displays

A. Dynamic Route Map Displays shall be provided in two areas of each car, aimed at providing detailed context-specific wayfinding information for the entire SEPTA system.

1. Dynamic route / system information display shall be provided in at least two areas of each car.

2. Display shall have a minimum 40-inch viewing area.

3. Display shall have the ability to display a variety of information as configured by SEPTA and shall include the capability to digitally display the information currently present in SEPTA's paper-based Regional Rail & Rail Transit map in a similar aspect, while highlighting the current line/route, the current train location, the next stations, the previous stations, and the next station.

4. Based on SEPTA configuration, the Dynamic Route Map Display shall be capable of automatic cycling through a variety of displays to highlight pertinent passenger information. Displays shall include:

    a. Overall Regional Rail & Rail Transit map

    b. Abbreviated Route Map, showing past, current, and future stations for current line.

    c. Connections Map, showing available connections and connection status at the next station.

    d. Station maps, showing arrival information, accessibility details, and wayfinding support for connections to common destinations such as Amtrak/NJT, the Broad Street Line, Market-Frankford Line, the Sports & Entertainment Complex and Airport

    e. Other displays as configured by SEPTA.

5. The Dynamic Route Map Display shall be configurable to accept feeds of information, such as from SEPTA's Real Time data feeds, GTFSRT feed, and others, to display the location of relevant connecting information (such as the location of connecting buses and vehicles in proximity to next stations, and their anticipated departure times).

13.9.5 Exterior Display Signs

A. The exterior destination sign message shall be sufficiently sized (minimum height of 2.5 inches) to allow a person with normal vision to identify the following:

    1. the destination text on the front exterior sign at a minimum distance of 150 feet

    2. Each side exterior sign at 50 feet

B. Each cab end of every car shall have one exterior end destination sign above the Operator's windshield or other Approved location.

C. Every car shall also have an exterior side destination sign located at each side, for a total of 4 per car.

    1. These exterior signs shall display route identifier, service type, destination information, as well as public relations messages, all under the control of the Operator, train crew, and SEPTA wayside systems.

D. All exterior signs shall include full RGB color capabilities, allowing SEPTA to configure pixel-by-pixel elements of the signs at any location as configured by the content database. This will be used for sign elements such as color-coded route displays, color-coded indication of service level (Express, Limited, Local, SilverLine), and special characters (e.g., Airplane)

1. The exterior signs shall be either a backlit full color LCD (using high intensity LED backlighting), RGB high intensity LED, or other Approved equivalent full color display.

2. The exterior signs shall be capable of displaying a minimum of 26 characters.

3. The front (cab end) text sign may use two rows of 13 characters each, provided the route number is nearly twice the character height.

    a. Longer character strings shall be accommodated using characters of lesser heights and/or closer spacing, subject to Approval.

4. Longer character strings shall be accommodated using the following techniques, as configured in the content database:

    a. Characters of lesser heights and/or closer spacing

    b. Scrolling messages

    c. Paged display

13.9.6 Display Capabilities

A. A comprehensive templating system shall be provided to provide complete control over all displays on each car. The system shall include the following capabilities:

1. Through Contractor supplied content database tools, SEPTA experienced programmers shall be provided the capability to reference and display train mission variables based on a variety of contexts (for example, in-service at origin station, in-service at a station, in-service between stations, in-service at a terminal station, in-service at the Center City Commuter tunnel, transition between train numbers, under daily test, and under maintenance).

2. The system shall be based on an open standards templating system, through the use of HTML, JavaScript, and similar technologies.

3. Through a template system, to be Approved, displays shall be capable of being programmed to accept and display on-board variables. The list of on-board variables shall be submitted. **(CDRL 13-01)** The variables shall include at a minimum:

    a. Velocity

    b. GPS Location

c. Line Map with Current Location, direction of travel, intermediate stops, and destination in a variety of scales

d. Origin, Current, Next (including full sequence) and Final stops.

e. Date & Time

f. Status of PA, IC, and PEI system, including status of audio broadcast, functioning of hearing loop, PEI call information, and intercom status.

g. Smoke detector status

h. Automatic Passenger Counting status for each car of the train.

i. Car in-service status, as configured through the TOD and Communication Control Panel (e.g., to indicate a car is not accepting new passengers)

j. Relevant maintenance information – including onboard system status – which could be incorporated into a special workshop display templates to facilitate maintenance and operations staff during daily, scheduled, and unscheduled maintenance activities.

k. Planned and actual door opening, including override of planned doors based on conductor and/or wayside modification, as well as identification of high or low level doors to be opened at next stop.

4. The Communication System template shall also include the capability to make use of data pushes and pulls from wayside ground-based systems in near real-time to facilitate weather updates, news, service updates, connecting information, and other feeds as configured by SEPTA.

5. To accommodate period of outages of wireless connectivity, the onboard systems shall be capable of storing data for replay, contingent upon a configured data validity and expiration.

6. The on-board experience shall be configured based on an event-driven fashion which will generate a new or additional screen based on pre-programmed triggers, including:

a. Mission start and end.

b. Geolocation with geofences to trigger events.

c. Time since hitting a geofence, or time projected prior to reaching a geofence.

d. State of operations, including start of movement, emergency brake, door status, arrival at a station

e. Manual operation by operator, train crew, or SEPTA wayside control center.

7. Displays and display controllers shall support the playback of a wide variety of content formats, including MP4, AVI, MOV, WMV, MPEG, MKV, WebM video formats and JPEG, PNG, GIF, BMP, TIFF, SVG, and WebP image formats.

13.9.7 Journey Logging

A. A comprehensive set of logs shall be captured on each car and be collected and organized per consist for each journey initiated by SEPTA crew or systems.

1. The log shall include the set of system inputs and triggers received by the on-board systems necessary to recreate system performance in the Content Lab for the purpose of troubleshooting a journey configuration, further content development, and other uses.

2. The log shall include a summary of system operations and outputs, including actions taken per display screen, audio announcements made per car and per audio zone, and general status of communication equipment.

3. The system shall be capable of maintaining journey logs for a minimum of 30 days.

4. Log offload shall be enabled through the TWDT on a scheduled or on-demand basis as configured by SEPTA.

13.10 Crew Intercom (IC)

A. Each cab and Conductor's doorway control panel shall have an intercommunications system to allow communications between any cabs of a train and any active Conductor's control panels, whenever any cab or control panel has been activated.

1. Any Operator, Conductor, or other train crew on a train shall be able to send a message over the intercommunications system at any time.

2. Depressing the "IC" switch in any cab or Conductor’s communication control panel shall initiate an Intercom request.

3. A unique tone shall play over the interior speakers indicating an IC request, and a configurable icon shall indicate the car and cab/control panel location that the IC request is initiating from on the interior display screens.

4. Additional train crew shall be able to respond and join the requested intercom call from any cab or conductor control panel throughout the train consist.

5. The system shall use the cab microphone and a cab speaker with volume control.

6. A speaker with volume control shall also be built into the Conductor’s communication control panel for use with the intercom.

7. The system shall allow simultaneous communication between any number or combination of cab and active Conductor's control panels.

8. Intercom audio and control signals shall be transmitted over the Ethernet Consist Network and Ethernet Train Backbone.

9. The system shall have a frequency response of 300 to 8,000 Hertz plus or minus 3 dB, with a balanced and shielded impedance of 600 ohms.

10. Trainline signal level shall be minus 5 dBm and noise shall be 35 dB below the output level.

11. The system shall be free from interference from audio signals and switching transients from all other electrical equipment.

12. The trainline shall have a minimum signal to noise ratio of 40 dB.

13. An automatic gain control or compressor system shall be used to compensate for level changes.

14. The intercommunications system may be a part of the public address amplifier assembly.

    a. If not, it shall be mounted adjacent to it, and the same mounting requirements shall apply.

13.11 Passenger Emergency Intercom

A. A Passenger Emergency Intercom (PEI) system which conforms to 49 CFR Section 238.121 shall be installed in each car, to permit emergency communication between passengers and the Crew.

1. Each passenger compartment shall be equipped with three passenger emergency intercom (PEI) stations in Approved locations, with at least one installed at each half of the car.

2. One each shall be installed at the two mobility device locations.

3. The location of each PEI station intended for passenger use shall be conspicuously marked "Emergency Intercom" with luminescent material and legible and understandable operating instructions shall be posted at or near each such intercom. Instructions shall include an indication that the calls may be recorded.

4. The passenger emergency intercom station shall be equipped with a heavy-duty red pushbutton with a raised collar guard to prevent accidental activation, a speaker for both talking and listening, and a heavy duty faceplate which retains the speaker and pushbutton.

5. The unit shall be vandal resistant.

6. The car number shall be permanently and legibly applied to the car immediately above each passenger emergency intercom unit.

7. When a passenger activates the PEI, a visual indicator on the PEI shall flash. Once an Operator or train crew acknowledges the call, the annunciator on the PEI shall constantly illuminate.

    a. The annunciator shall be large enough for crew members to easily identify an active PEI station.

    b. Activating the PEI station shall notify the crew of the car number audibly in all cars via the PA system and location of the active PEI station visually on each communication control panel, and through the passenger information displays in all cars.

8. Each cab shall be equipped with two passenger emergency intercom system momentary contact pushbuttons or rocker switches, identified as "Passenger Intercom Push to Talk" and "Passenger Intercom Reset."

9. The reset switch shall also be illuminated.

    a. When a passenger presses the pushbutton on the passenger emergency intercom, it shall cause the "reset" switch in the active cab of the train to illuminate and sound a distinct chime signal to alert the Operator.

    b. It shall also cause the passenger intercom station to latch on, allowing the passenger to both speak to and hear the Operator without having to continue to depress the pushbutton.

    c. The Operator shall use the "Press To Talk" button in the console area in conjunction with either the Operator communication panel’s internal condenser microphone to talk to the passenger, and shall hear the passenger over the monitor speaker.

    d. When communication with the passenger has concluded, the Operator shall depress the "Reset" pushbutton to reset (unlatch) all energized passenger emergency intercom stations; when this occurs, the indicator within the "Reset" pushbutton shall be extinguished.

10. Simultaneous activation of all passenger intercom stations of a train shall be possible. Operators and train crew, through control stations, shall be capable of placing calls on hold, canceling calls, communicating with all active PEIs (party call), as well as selecting calls for one-to-one communication.

11. Train crew utilizing different control stations shall be able to communicate with different PEI stations or join in existing PEI sessions.

12. PEIs shall trigger event recording on the Video Surveillance System to mark the section of video recordings relevant to the PEI call.

13. SEPTA, through a configurable setting, shall be provided with the ability to enable or disable NVR recording of the two-way audio calls synchronized with the video of the closest camera to the PEI.

14. PEI calls shall be configurable to be annunciated by PA tone, through crew-app notification, and on display screens that include passenger graphical displays, communication control terminal displays, and remotely. The annunciation shall be configurable to include car number, road number, relative position in train based on display location, and location in the vehicle.

15. PEIs shall be full-duplex, Ethernet based devices which transmit and receive digital audio.

16. The design of the system shall be submitted for Approval.

13.12 Automatic Passenger Counting System

13.12.1 General

A. Provide an Infodev automatic passenger counting (APC) system or Approved equal for each car.

1. The subsystem shall count the passengers that enter and exit the car at each station and record the passenger count, location, time, and car number in an onboard database for remote processing at a later time.

2. The subsystem shall monitor and report real time passenger loading of each car, including movements between the car end doors.

3. Provide a comprehensive Automatic Passenger Counting System design and integration package. **(CDRL 13-05, Automatic Passenger Counting System Design)**

13.12.2 System Requirements

A. Comply with the following requirements:

1. Memory: Sufficient to hold 180 days of data, assuming worst case schedule and count.

2. Software:

a. Provide software necessary for the car and wayside.

b. Provide PTU software to maintain the subsystem, download data, and analyze data. The PTU shall be as specified in Section 27, Special Tools and Test Equipment.

c. Provide licenses as necessary for SEPTA to use the software for the design life of the vehicles.

3. The APC System shall time stamp the boarding and alighting data collected every time the passenger side doors are open with the station name (including station latitude/longitude), car number, time, date, train/trip number and train composition (all other individual cars in the consist). There shall be no required crew interface with the APC system.

4. An event shall be identified as every time a car door (or doors) opens or closes. Events also occur at system startup and shutdown. Every APC event shall be recorded. Every event that has been recorded shall be uploaded automatically when a connection is available, and at any time a wayside request for APC data is initiated (i.e. at the yard or the end of line).

13.12.3 APC Accuracy

A. The system shall be designed to meet National Transit Database (NTD) reporting requirements, and accurately determine the number of alighting and boarding passengers per station, passenger miles traveled, and unlinked passenger trips. The system shall be designed to accurately determine the station stop on SEPTA's regional rail network 99.9% of the time when compared to manual observation. The accumulated count of alighting passengers shall be within 5% for each 1,000 consecutive boarding and alighting passengers, and the accumulated count of boarding passengers shall be within 5% for each 1000 consecutive boarding and alighting passengers.

B. Use the following formula for generating accurate passenger accumulated count data:

C. $x_{rel} = \frac{|P_a - P_m|}{P_m} \times 100\% \leq 5\%$

D. Where the following apply:

1. P_a = automatic counted passenger (each separate for in and out)

2. P_m = manual counted passenger (each separate for in and out)

3. Sample size is minimum 1000 passengers (P_m > 1000)

E. Accuracy requirements shall be maintained between stops.

F. The supplier shall support SEPTA in developing the required tools, procedures, and certification plans required for certification of the delivered APC system based on the Federal Transit Administrations' requirements for NTD reporting and APC system certification. The documentation submitted by the Contractor shall include initial certification of the system as well as plans for performing follow-on re-certification activities.

13.12.4 APC Doorway Equipment

A. Each doorway of the car shall be equipped with multiple sensors and associated logic unit to sense passengers entering and exiting the car, including through the end-doors.

1. The combination of sensors and logic shall properly detect and indicate the correct passenger count and real time passenger loading regardless of whether single or multiple persons are simultaneously entering or exiting a doorway, or any simultaneous or overlapping combination of boarding and alighting persons.

2. The APC doorway equipment shall function accurately regardless of the size of the passenger, from small child to large adult and shall not interfere with operation of the doors.

3. Direct connections shall be used to communicate between APC sensors and the APC doorway logic unit.

4. Communication between the APC doorway logic units and the central logic unit shall be transferred over the ECN as specified in Section 17, Network and Trainline Control.

13.12.5 APC Logic Unit

A. Provide an Infodev APC Logic Unit or Approved equal to collect, process, and store the data from the APC doorway equipment:

1. It shall determine the position of the car by a combination of the following:

2. Logic shall process the door and location data and store it in non-volatile memory with sufficient capacity to comply with the memory capacity specified.

3. The memory shall be maintained in a circular buffer.

4. The APC Logic Unit shall contain logic to detect subsystem faults and receive fault data from the APC doorway equipment.

a. A fault log shall be maintained in the APC Logic Unit and made available along with APC data reports to facilitate wayside systems making appropriate adjustments.

b. In addition to functioning with the PTU to permit manipulation and display of this data, the subsystem shall communicate with the VMDS to transmit the fault log and permit manipulation and display of the passenger count data via the VMDS specified in Section 18, Monitoring and Diagnostics.

13.12.6 APC Data Downloading

A. Comply with the following:

1. The data shall be available for downloading via PTU and for automatic downloading via wireless communication from the car to the wayside via the TWDT subsystem as specified in Section 18, Monitoring and Diagnostics.

2. Offloaded APC data shall be in a format compatible with SEPTA's existing Infodev APC subsystem see Appendix VIII for disaggregated APC schema.

3. Server requirements for the wayside server collecting APC data are specified in Section 18, Monitoring and Diagnostics.

4. Real time passenger load data shall be transmitted to the wayside within 2 minutes of each event.

13.13 Video Surveillance System

13.13.1 General VSS Requirements

A. Comply with the following:

1. Provide each car with a Gatekeeper Ethernet TCP/IP-based Locomotive Image and Audio Recording Device / Video Surveillance System (VSS) consisting of Gatekeeper color cameras, Gatekeeper Network Video Record (NVR), Crash-Hardened Memory Module, dedicated Network Switch, and other ancillary equipment, as required.

2. The system shall be fully compliant with the Code of Federal Regulations, including 49 CFR Parts 217, 218, 229, and 299 as amended November 13, 2023.

3. The Crash-Hardened Memory Module shall support all required video streams and be Certified per Appendix D to 49 CFR Part 229. The Contractor shall provide the test procedure and test report. **(CDRL 13-06, Video Surveillance System CHMM Test Procedure and Report)**

4. The VSS network and the NVR shall have sufficient bandwidth to record all cameras at the highest defined camera resolutions and frame rates without network contention or loss of data.

5. The vehicle level shutdown functionality shall be coordinated with the VSS to protect from corruption – such as by using a vehicle-level delayed shutdown, additional super-capacitor or uninterruptible power supply dedicated to the NVR.

6. The car VSS network shall be capable of forwarding VSS subsystem fault conditions to the MDS through discrete I/O, as well as receiving trigger inputs from the MDS and other subsystems through discrete I/O.

7. The VSS subsystem shall use the TWDT subsystem for communication to the wayside, as specified in Section 18, Monitoring and Diagnostics. VSS subsystems shall be connected using the VSS network specified in Section 17, Network and Trainline Control. However, VSS subsystem video shall be handled on a per-car basis, including the connection between VSS and the TWDT subsystem.

8. Provide a comprehensive Video Surveillance System design and integration package, including camera coverage plan. **(CDRL 13-07, Video Surveillance System Design)**

13.13.2 Cameras

A. Comply with the following:

1. Camera installation and arrangement shall support identification based on the EN 62676-4:2015 International Standard of a minimum of 250 ppm (pixels per meter) or higher to identify individuals at the following locations:

   a. At each door

   b. Throughout the passenger areas

   c. Forward facing out the windshield, in the sweep of the

   d. Operators cab area

   e. Operator

   f. Observer's cab

   g. Pantograph area

2. Each camera shall:

   a. Be installed as required to meet visibility requirements. Only fixed cameras supplied by Gatekeeper are permitted; panoramic fisheye cameras are prohibited.

   b. Power source: PoE, IEEE 802.3af or 802.3at from network switch.

   c. Minimum dynamic range: 120 dB.

   d. Low-light sensitivity: 0.2 lux or better (when measured at 1/30 second, F 1.4, IRE 30). Demonstrate that the camera does not "white out" when operating at night.

   e. Colors: Minimum 16-bit color depth.

   f. Compression: Cameras shall support both H.264 and H.265 codecs, but H.265 shall be used for all recording and live viewing.

   g. Frame rate: Minimum 30 fps.

   h. Control: Frame rate and bandwidth for each camera shall be remotely controllable using the wayside VSS system.

i. Interior cameras, including the passenger area and cab cameras, shall support audio recording. Audio recording shall be enabled for cab cameras, but audio recording of passenger compartments shall be enabled only after Approval as part of design review. The audio recording configuration shall be configurable by SEPTA through an Approved method. Space shall be reserved as part of requirements in Section 14, Interior and Exterior Appointments, for signage to notify passengers that audio recording is active.

13.13.3 Camera Enclosures

A. Comply with the following:

1. Each camera enclosure shall be appropriate for the given camera location.

2. Camera enclosures for interior cameras shall be vandal resistant, IK10 impact rated, and of industrial/rail grade.

3. Exterior camera enclosures shall:

a. Be designed to IP68.

b. Be supplied with heating elements for defrosting and de-fogging, with control such that clear view for exterior cameras are available within 10 minutes of the activation of any cab, and is maintained while any cab is active.

c. The design shall prevent snagging of carwash brushes or debris.

d. The view port shall be constructed of tempered glass.

e. The exterior camera enclosure shall be removeable without effecting camera adjustment.

13.13.4 Interior/Exterior Camera Locations

A. Each car shall include the following surveillance cameras:

1. Interior Passenger Surveillance Cameras

a. A sufficient quantity of car interior cameras shall be provided to provide complete coverage of all passenger areas, including from all door openings looking out to the platform with a clear view of the entire door sweep area.

b. These cameras shall be active when a cab is active in the train. An adjustable timer (by default, turned off) shall be configurable to turn off the cameras when there is no longer an active cab in the train, and there is no motion detected.

2. Exterior Cameras

a. Pantograph monitoring camera: each pantograph equipped car shall be equipped with a camera to provide complete coverage of the pantograph and the contacting catenary wire.

3. Inward-facing cameras for operator and observer surveillance

a. Each cab shall be outfitted with a sufficient number of inward-facing cameras in order to meet the requirements of 49 CFR 229.136 (c). The camera shall be mounted to capture controls located in the cab desk and the Operator's face. These cameras shall be recorded at 30 frames per second and shall record audio but be capable of being configured by SEPTA to disable audio recording functionality.

b. Additional inward-facing cameras shall be located in each Observer area.

c. The Operator surveillance camera shall be active at all times power is applied to the Video Surveillance system.

4. Outward-facing camera

a. Each cab shall be outfitted with a camera that meets the requirements of 49 CFR 229.136 (b) that is recorded at 30 frames per second.

13.13.5 VSS Workstation

A. Comply with the following:

1. Provide VSS Workstation software for installation on personal computers with a Windows Operating System (OS), with OS version compatibility based on the requirements in Section 19, Software Engineering:

a. Using a network port on the NVR, the software shall permit uploading operating parameters (such as frame rates, bitrates, and resolution), viewing all or selected cameras in real time, downloading and viewing of video data from the NVR, verification of authenticity, image and video enhancement, and similar processes.

b. The software shall be web-browser based, and compatible with common Internet web browsers, including Google Chrome, Microsoft Edge, Safari, and Mozilla Firefox.

c. The software shall enable access to recorded video data that has been downloaded from the car, on storage devices which have been removed from the car, and video which has been transferred to SEPTA's server.

d. The workstation software shall include provision to connect to SEPTA's server and facilitate browsing of stored data by car number and date range, and display on the workstation.

2. Provide network-connected equipment (utilizing a standard Ethernet interface) that will accept each storage device which contains video as a simple plug-in to facilitate access to the video on storage devices that have been removed from an NVR. Chain-of-custody shall be capable of being demonstrated when utilizing this device.

3. The software shall implement the required features of 49 CFR 229.136 (d).

13.13.6 Video Surveillance System Network Video Recorder (NVR)

13.13.6.1 General

A. Provide one or more Gatekeeper NVRs paired with Certified Crash Hardened Memory Module (Certified per Appendix D to 49 CFR Part 229) in each car as appropriate:

1. Camera quantity supported: Sufficient for the quantity of cameras to be recorded in each car, plus two spares.

2. Capacity: Sufficient to record all cameras in use at one time.

3. Authentication: The recording method shall include a process to detect any alteration of the data after recording.

4. Location: Place the NVR(s) behind a panel with a lock that can be opened only with the maintenance key specified in Section 14, Interior and Exterior Appointments.

13.13.6.2 Recording

A. Provide for recording the cameras described above as follows:

1. Interior Passenger Surveillance Cameras

2. Exterior Cameras

3. Inward-facing cameras for operator and observer surveillance

13.13.6.3 Stream Information

A. The NVR shall automatically include accurate car ID and date/time stamp on all recordings:

1. The Car ID, as received from the MDS.

2. Camera location

3. Date and time: maintained by an internal clock which is synchronized to GPS time provided by the MDS as specified in Section 18, Monitoring and Diagnostics. Date and time shall be recorded and indicated as UTC.

13.13.6.4 NVR Data Storage Capacity

A. Provide the NVR with hot-swappable non-volatile memory storage in addition to a minimum of 72-hours of Certified Crash Hardened Memory (Certified per Appendix D to 49 CFR Part 229):

1. Storage capacity: minimum of 30 days of surveillance video, computed using a minimum of 20 hours of operation per day, maximum camera resolution, quality, and bandwidth, at 30 fps, and audio recording.

2. Recording durations shall be configurable by SEPTA, from one day to full capacity.

3. Full capacity recording duration shall result in a circular buffer, having the oldest recordings rewritten by new recordings.

4. Devices shall be solid state drives (SSD), providing a minimum of 5-year life at the specified recording rates.

   a. The Contractor shall provide a calculation and confirmation of the predicted lifespan based on manufacturer parameters.

5. The memory storage devices shall be secured via a keyed lock.

13.13.7 VSS Remote Workstations

A. The VSS Remote viewing workstation will be existing SEPTA workstations interfacing with SEPTA's wayside Video Management System.

13.13.7.1 Remote Live Viewing

A. Comply with the following:

1. The VSS subsystem shall permit remote live viewing of VSS cameras from designated facilities and workstations within SEPTA IT infrastructure via the TWDT wireless data connection.

2. The subsystem shall stream remote live footage at reduced resolution and frame rate such as to not overwhelm available network bandwidth. To support this functionality, cameras shall be configured with a minimum of two streaming profiles: one for recording and a second profile for live viewing.

3. Remote live viewing shall occur from existing SEPTA Gatekeeper Video Management System workstations via a federated architecture.

4. The video shall have the car number available in metadata or other appropriate means, so that the viewer knows the car from which the data is being streamed.

13.13.7.2 Wireless Video Offload

A. The CCTV subsystem shall automatically offload flagged video footage (e.g., activation of emergency brake at speed, activation of door obstruction during passenger service, activation of PEIs) to wayside video storage.

1. Wireless video offload shall interface with SEPTA's existing wayside Gatekeeper CCTV infrastructure.

2. Offloaded video shall have the car number available in metadata or other appropriate means, so that the viewer knows the car from which the data is being offloaded.

13.14 Communicating Buzzer System

A. A communicating buzzer system shall be provided on all cars, which shall also be discretely trainlined to all Silverliner VI cars in the train.

B. The signal buzzer trainline shall be energized by momentary contact pushbuttons located as follows:

1. One at each Conductor's doorway control panel, both upper and lower panels, for a total of 8.

2. One in each cab

3. One located at each end of the car, adjacent to the body end door, for a total of 2.

4. One located on the car exterior at each low-level doorway, easily reached when standing on a low-level station platform, for a total of 4.

5. One located on the car exterior on each side of the end of the car, at each cab end of a car, easily reached when standing on the car during car coupling/uncoupling, for a total of 2 per car.

C. All interior pushbuttons shall be flush mounted to prevent accidental contact.

D. All exterior pushbuttons shall be of weather resistant design and be capable of exposure to car washer cleaners.

E. Pushbutton locations shall be Approved.

F. An Approved electronic signal buzzer shall be in each cab, and at each side doorway.

1. For ease of train crew recognition, the signal shall mimic the sound and tone quality of the buzzer system currently in use on the Silverliner V cars.

2. Whenever any pushbutton has been activated in a Silverliner VI car, all buzzers on each car shall sound.

3. The buzzers shall have a tone and volume sufficient to be readily audible under high noise level conditions.

4. The acoustic level shall be 85 dBA at 5 feet from the buzzer.

13.15 Radio

13.15.1 General Radio Requirements

A. Each cab of a car shall be equipped with an individual Ritron RCCR 151 Clean Cab railroad radio or Approved equal, arranged for operation on the existing SEPTA radio channels in the frequency range between 150 MHz and 174 MHz and capable of 6.25kHz very narrowband, 12.5 kHz narrow band and 25 kHz wideband operation.

B. SEPTA shall supply the required radio frequency information and channel configuration to the Contractor during Design Review.

C. The radio equipment in each cab shall be operable when the cab has been activated by the Operator.

D. The Contractor shall

1. Be responsible for radio purchase, programming, and integration into the vehicle.

2. Be responsible for integration of all new and existing radio subsystems and equipment.

3. Demonstrate full and complete operational performance of the overall radio system as described in relevant parts of this Section.

E. Special attention shall be paid by the Contractor to the suppression of conducted and radiated electromagnetic interference effects on radio equipment operation from other car subsystems and on car control subsystems from radio transmissions.

F. All equipment must meet or exceed the standards of the Electronic Industries Association and the rules and regulations of the Federal Communications Commission in addition to those specified herein.

G. The radio system components and design shall be submitted. **(CDRL 13-01)**

13.15.2 Equipment

A. Each cab shall be equipped with a complete set of radio equipment consisting of a radio control unit and radio transceiver, rooftop antenna, interconnecting wiring, and miscellaneous items described below.

1. The radio system shall be powered by the radio power supply using individual circuit breakers and suitable interference suppression line filters.

13.15.3 Arrangement

A. It is intended that the radio control head be flush mounted in the left side cab console panel as identified in Section 5, Operator's Cab.

1. Sufficient cable slack shall be provided for ease of servicing or replacement.

2. The radio transmit control shall be by means of a dedicated pushbutton located on the right side of the cab center console outboard of the brake controller, arranged for ease of Operator use by the right hand.

3. All other control over the radio transceiver shall be performed by use of the radio faceplate controls and indicators.

4. If possible, the radio faceplate transmit pushbutton should also be kept functional, for redundant/left hand operation.

B. Remote mounting of the radio control head from the radio transceiver is permitted to optimize installation design.

C. The radio faceplate shall meet the following requirements:

1. The radio faceplate shall consist of a compact, low-profile assembly of control buttons and alphanumeric visual displays.

2. Lighting devices shall permit the Operator to identify all controls and to read the visual display under all lighting conditions.

3. The radio faceplate as installed shall be orientated to the Operator to permit convenient operation of controls and clear observation of the displays.

4. The radio shall switch received audio to the car public address system when SEPTA Control Center train dispatchers operates a control function on their radio control console.

5. The housing, faceplate, controls, and displays shall be highly resistant to impact, abrasion, and water intrusion.

13.15.4 Transceiver

A. The radio transceiver shall be of a digitally synthesized, programmable design which employs monolithic integrated circuits for most electronic functions.

B. An Ethernet interface port on the transceiver shall permit programming of radio channels and control functions with a PC compatible computer.

C. The transceiver shall be provided with a threaded RF input/output connector for interconnection to the car roof antenna.

D. A rugged, vibration resistant, environmentally protected, multi-pin connector on the transceiver shall be used for interconnections to the radio power supply.

E. The radio transceiver unit shall be enclosed in a durable, impact resistant, water resistant, and corrosion resistant housing and shall be capable of withstanding the severe environmental conditions encountered in continuous rail car service.

1. The housing shall have no unsealed openings or gaps between housing segments (e.g., case and cover), and all controls and connectors shall be fully gasketed or otherwise sealed to protect the interior of the radio from dust and moisture intrusion.

2. The radio transceiver shall withstand the environmental tolerance testing described for land transportation vehicles in Military Standard MIL-STD-810F for mechanical vibration and shock.

F. The transceiver power input circuitry shall be provided with protective devices to avoid damage from

1. Reverse polarity and

2. Transient overvoltage

G. The electrical power input of the transceiver shall also be provided with an overcurrent protection device, such as a circuit breaker, to minimize damage to the transceiver and to the vehicular electrical system, in the event of a short circuit in the transceiver.

H. The transmitter circuitry shall be provided with a programmable automatic time-out function which shall cause the transmitter to cease transmitting after a specific period of time after the transmit switch has been operated.

1. The period of time that the transmitter remains enabled shall be PC programmable over a minimum range of 30 to 90 seconds, and shall be initially set to 60 seconds.

2. The transceiver circuitry and the PC programming software shall permit the disabling of the automatic time-out function at any time by SEPTA.

3. At the end of the programmed time-out period, the radio transceiver shall emit an audible tone from the transceiver's loudspeaker, to warn the Operator that the unit is no longer transmitting.

4. The automatic time-out circuitry shall automatically reset when the Operator releases the transceiver transmit switch.

13.15.5 Antenna

A. Comply with the following:

1. A low-profile mobile antenna shall be installed at each cab and connected to the adjacent radio transceiver.

2. Orientation shall be to avoid damage from mechanical car wash brushes, and to also maximize signal strength.

3. The antenna shall be designed for severe environmental conditions.

4. The antenna shall be a Sinclair Radio Laboratories, Inc. model 221, or Approved equal.

5. The antenna shall be adjusted, if necessary, for maximum signal strength in the 160.800 MHz range prior to car delivery.

6. The antenna cable shall be run in conduit between the antenna and the radio with its length and use of connectors minimized in order to maximize received signal.

7. All antennas shall be identical.

13.15.6 Programming Equipment

A. Comply with the following:

1. Five complete sets of radio programming equipment shall be supplied for setup and maintenance of the car radio transceivers by SEPTA.

2. Each set of programming equipment shall include a standard laptop PC computer that meets the requirements of the Portable Test Units (see Section 27, Special Tools and Equipment), but also includes all required radio programming interface and software to be specifically used by the radio maintainers at SEPTA.

3. Interface adapters shall include all necessary cables required to interface with all components of the radio equipment.

4. The radio interface unit shall be provided with connectors and cables which are compatible with the radio and the computer.

5. The software shall include the latest version of Microsoft Windows and radio programming application software. SEPTA shall be provided a site license for the programming application software.

6. The radio programming software shall permit adjustment of all programmable radio operational parameters.

7. SEPTA shall be entitled to free supplier upgrades of the radio programming software for the duration of the vehicle warranty.

13.16 Automatic Vehicle Location System

A. The Contractor shall supply a complete system to have the interior destination signs display information identifying the next regular stop on the selected route.

1. This shall consist of the interior signs giving visual identification of the next stop (using several screens if necessary), with a simultaneous automatic public address announcement using the interior speakers of the next stop along with connecting transit routes and points of interest.

2. Upon arrival at the stop, the exterior speakers shall announce the vehicle route and destination and the interior speaker shall announce the stop as configured through the content database.

3. The system shall also allow the additional display without voice announcement of up to 500 supplementary emergency or public relations messages, searchable on each control terminal, and capable of being triggered via the wayside communication system.

4. The signs shall alternate between display of the supplemental message and station stop information when configured to in the content database. Selection of automatic announcements and supplementary messages shall be under the control of the Operator, train crew, and authorized remote SEPTA workers through the wayside communication system.

5. All interior and exterior voice announcements shall simultaneously announce on all cars of the train through the PA.

6. The current local time shall be displayed on the interior signs at least once between each station stop, based on programming in the supplied templating system.

7. A switch to disable exterior announcements during the trip shall be provided.

    a. In addition, the system shall be capable of being programmed by SEPTA personnel to disable exterior announcements at select stations or during selected hours of the day.

8. In order to synchronize the sign displays and voice announcements to the proper location, the Contractor shall provide an Automatic Vehicle Location System (AVL) system.

    a. The system shall use a Global Positioning Satellite System (GPS) enhanced by utilizing the Wide Area Augmentation System (WAAS), and a Dead Reckoning system for operation within the 1.5-mile Center City Commuter Connector tunnel and other instances when GPS may not be available, which will provide the geographical location of the vehicle.

    b. The system shall use satellite ranging to determine position on a geographic coordinate system.

    c. The position information shall be correlated to a database containing the various routes, location triggers, announcements, and other required information.

9. The Control Terminals shall include the following features:

    a. When the Operator activates the train, the Conductor or Operator will enter the route number and train number into the Vehicle Location Control Panel, as well as provisions for entry of an employee ID number.

b. The system shall use this information for next stop announcements and to determine schedule adherence.

c. A status page available via the Control Terminal shall include the selected route and current location in SEPTA's Railroad Division terminology shall be displayed along with train speed, current local time, estimated time to destination, estimated arrival time at the destination or Center City terminal location and schedule adherence information.

d. The system shall be configured to recognize various types of triggers to be used for vehicle location, stop, next stop and public relations announcements along the route.

10. A method to disable GPS synchronization of the destination signs and automatic announcements shall be provided. This shall allow for the manual operation of the destination sign displays during out-of-service conditions (test trains, dead heads, etc.).

11. Updates to the location database and system software shall be by the use of a PTU laptop via the Ethernet Consist Network and Ethernet Train Backbone, and remotely through the wayside content management system.

12. Application software and hardware shall be supplied so that updates and changes can be made to the Automatic Vehicle Location database.

13. Changes to the voice announcements made along the routes shall be by converting text to speech to form a voice message that can be saved to a new database for eventual downloading to each car.

    a. The sound quality of the converted message shall be the same as a pre-recorded voice message.

    b. The software shall have adjustable sound parameters and characteristics to adjust the sound quality, all messages shall sound as if from the same voice.

    c. The system shall allow the addition of new location triggers with the accompanying voice announcement and sign displays.

    d. Updates to the database shall also allow independent updates to, and the addition of new, interior and exterior sign displays.

    e. The system for updating the database and system software shall be user friendly and intuitive.

    f. Updates to content and content database shall include effectivity dates, such that content may be pre-loaded on the system and made effective on a certain date and time. The system shall support a minimum of five pre-loaded content databases, each with different effectivity dates.

14. The system shall include a simulator mode which shall make it possible to view and enter routes or locations and simulate the operation of the train along the route via the Control Terminal and/or PTU laptop.

    a. It shall be possible to play any voice message or display any sign message.

15. SEPTA, in defining certain features, shall permit the Contractor to offer various plans and/or methods of achieving the overall outcome and specific configuration of the system. The Approval process shall be systems oriented.

16. SEPTA shall provide to the Contractor listings of all station stops for all routes in the SEPTA Railroad Division system.

    a. The Contractor shall prepare all mapping and survey work (location database) necessary to establish trigger points for all announcements, and prepare all software and databases for complete operation.

    b. All mapping and survey work performed pursuant to this Contract shall be the property of SEPTA and shall be delivered to SEPTA in a format that is transportable and/or convertible in furtherance of SEPTA's interests.

    c. The Contractor shall supply all required software and special equipment to SEPTA by a site license agreement as part of this Contract.

    d. The Contractor shall provide all source codes, mapping software and hardware to SEPTA which is required to make initial and future announcement changes, shall prepare and install all updates and revisions to the cars for the basic warranty period for each car, and shall disclose to SEPTA all required proprietary methods, software, tools and associated equipment necessary to ensure the successful operation of the system.

    e. All required licenses required to permit SEPTA to operate, maintain and modify the system for the lifetime of the car shall be included at no additional cost to SEPTA.

    f. There shall be no additional or reoccurring costs incurred by SEPTA for any software, documentation, or special equipment required to operate, program, update, change displays and/or announcements and maintain the system as delivered.

    g. This shall include all software and hardware necessary to incorporate future changes and revisions in routes, destination displays, announcements, public relations messages and so forth.

17. The system in all operating modes shall indicate vehicle location to within 3 meters horizontally at 95% probability and the WAAS-enabled GPS system shall provide an accuracy sufficient for track identification.

a. The Contractor shall provide all source codes, mapping software and hardware to SEPTA along with a complete bill of material.

b. The Contractor shall disclose to SEPTA all required proprietary methods, software, tools, and associated equipment necessary to ensure the successful operation of the system.

c. All aspects of the system shall comply with the Americans with Disabilities Act as amended.

18. The system shall include a digital, crystal controlled clock which shall permit periodic synchronization from the Global Positioning System provided by the Monitoring and Diagnostic system and used for the communication system components.

13.17 Onboard Dynamic Advertising System

A. The vehicle graphical interior messaging signs, including Interior Messaging Signs and Dynamic Route Map Displays, shall include dynamic advertising capabilities and integrate in with existing digital signage servers used for the SEPTA fleet. As programmed through SEPTA configured playlists and SEPTA configured templates, a mix of advertising and editorial / infotainment message shall be displayed in configured sections of the display screens (including up to the entire display for certain configured display types), for configurable periods based on the journey status. The following provides the general set of requirements for the onboard dynamic advertising system capabilities:

13.17.1 General Requirements

A. The Advertising system shall support a minimum of 4 hours' worth of video programming per display.

B. The onboard dynamic advertisement system shall be capable of playing a variety of content, including MP4, AVI, MOV, WMV, MPEG, MKV, WebM video formats and JPEG, PNG, GIF, BMP, TIFF, SVG, and WebP image formats.

C. The contractor shall provide a comprehensive Onboard Dynamic Advertising System design and integration package. **(CDRL 13-08, Onboard Dynamic Advertising System Design)**

13.17.2 Advertising Content Playback

A. The advertising system shall implement the following playback capabilities:

1. Content Loop – the vehicle graphical message signs shall be capable of playing a content loop to be provided by the wayside digital signage server.

2. When the pre-programmed passenger information system are configured to play in the same space which the advertising and editorial content is targeted,

playback of advertising and editorial content provided via the content loop should be paused.

a. Ad/editorial content should playback from the beginning of the last message interrupted or continue playback with the next item if no interruption was required.

3. Content loop shall be based on playlists which shall be configurable based on system, route, train number, and specific car.

4. Content items shall have start times and end time attributes, as well as start dates and expiration dates.

5. Content items shall be able to be played at specific times and based on configurable time intervals.

6. Content items shall be able to be played based on geographical location.

7. Content items shall be capable of being assigned to SEPTA defined groups of screens, including specific screens and specific areas of specific screens.

8. The content loop shall be able to play a playlist:

a. In order

b. Random

13.17.3 Dynamic Data

A. The onboard dynamic advertising system shall include the ability to connect to external sources via the TWDT in order to incorporate feed based dynamic data. The capabilities shall include:

1. News/Sports/Other Feeds – various types of data feeds employing RSS or other sources. Data shall be able to flow into configured sections of SEPTA designed templates.

2. Ability to connect to and display external content such as sports scores and weather reports through RSS feeds, XML, JSON, and flat file manipulation.

3. If data is stale (based on configurable expiration date) or unavailable, the message should not play. If the data source is inaccessible, an alert should be raised.

13.17.4 Logging Capabilities

A. The onboard dynamic advertising system shall include the ability to track system operation and ad execution:

1. General – logs shall be recorded in flat files, CSV, or other format that is easily digestible in a database based server environment.

2. Play – player will report log play activity. Play log shall be provided in detail, including asset played, date and time of start and stop, car number, display unit identifiers, train location, route, destination, display status, and other information as is typically required by advertisers for audit and billing purposes.

3. Status – player will log system status for the following:

    a. Current settings

    b. Link health

    c. Uptime

    d. Transfer status

    e. Content versions

    f. Software/firmware versions

13.17.5 Advertising System Communication

A. The onboard dynamic advertising system shall communicate with the wayside digital signage server utilizing the TWDT.

1. The system shall perform the following key tasks:

    a. Move content to players

    b. Move advertising schedules

    c. Move data to players

    d. Fetch/modify player attributes

    e. Transmit logs to server.

2. The onboard dynamic advertising system shall implement the data encryption methods utilized by the wayside dynamic advertising server.

13.18 Expansion Provisions

A. The Communication System shall be implemented through an open architecture provide for future expansions and upgrades to the system.

1. The system shall be designed to easily add new functions and upgrades from different equipment manufacturers and suppliers.

2. The Contractor shall provide on-board APIs that facilitate secure access to communication system functions that enable the development of handheld device applications that interface with or receive information from the onboard communication system.

3. The intended use for on-board APIs include:

    a. Crew applications, which, through the Contractor-supplied API, shall be capable of the command and control of the communication system functions including:

    b. Setting and adjusting routes

    c. Making manual PA announcements (including graphics visual, text, and audio)

    d. Selecting pre-loaded special messages to play

    e. Answering PEI calls

    f. Making and receiving intercom calls, including general calls, calls to specific intercom clients, and call to specific cars.

    g. Viewing system, car, and train status and diagnostic information

    h. Other system functions identified by SEPTA during the design review process.

4. Passenger applications, which, through the Contractor-supplied secured API, shall support:

    a. The capability to display and playback onboard announcements and current train.

    b. The capability to display route information.

    c. The capability to display the consist configuration, individual car passenger counts, and current location in a car and train.

    d. Other system features identified by SEPTA during the design review process.

5. The method of communication and control shall be secure, with configuration and security considerations identified during the design review.

13.19 Passenger Wi-Fi Provisions

A. The Contractor shall supply provisions for a future Passenger Wi-Fi system which meets the followings requirements:

1. General

    a. Provisions shall be provided in order to support the installation of a future Passenger Wi-Fi system. Provisions shall include all cabling, connectors, antenna mounting locations, circuit breakers, power, for a high-capacity multi-modem aggregation passenger Wi-Fi system.

2. Provisions for Passenger Wi-Fi Hardware shall consider the following devices:

    a. A passenger Wi-Fi Ethernet Train Backbone network switch, with connections to hardware on the car, as well as trainlined connections to other cars in the consist.

    b. Two Wi-Fi Access Points with integrated antennas for passenger internet access in each car, with CAT-6A cabling to the passenger Wi-Fi network switch.

    c. A Mobile Access Router on each married pair

    d. Four 4x4 multiple-input multiple-output (MIMO) exterior antennas, with two of the antennas also supporting GPS and Wi-Fi capabilities on each car outfitted with a Mobile Access Router.

    e. Ethernet, RF, and power cabling to support the equipment.

3. Ethernet Cabling

    a. Ethernet cables shall be CAT-6A cables supporting 10Gbps throughput, terminated with 8-pin M12 X-coded male connectors.

    b. After installation on each car, each Ethernet channel shall be certified to ISO/IEC 11801-1 - Class F for each copper cable.

    c. Test results shall confirm channel suitability for IEEE 802.3an-2006 10GBASE-T for each copper channel.

    d. The Contractor shall submit the test procedure to SEPTA for review and Approval.

    e. The certification results for each cable shall be submitted to SEPTA as part of the Car History Book.

4. RF Cabling

    a. Home-run RF cables, minimally 400 series antenna cabling, shall be installed between the location of each Antenna input and the Mobile Access Router

    b. Contractor shall test Cellular RF cables across 617MHz to 3.98GHz (the 4x4 MIMO cables). Wi-Fi RF cables shall be tested from 2400 – 2483MHz and 5150 – 7125MHz. GPS cables shall be tested from 1164 MHz to 1610 MHz.

    c. All VSWR results shall be 1.4 or less. All cable runs shall be tested when the cables are installed.

    d. Contractor shall measure the insertion loss of all RF cables. The insertion loss for each cable shall not exceed 2dB.

5. Power

    a. Contractor shall provide a Wireless Internet circuit of no less than 650w per car, connected to a single 10-amp circuit breaker.

    b. Power shall be brought to the area provisioned for each component via WAGO blocks or Approved alternative.

    c. Contractor shall provide sense power cabling to Mobile Access Router location to support post-run delay timer implementations (not required if located in load-shed circuit).

13.20 Content Lab

A. SEPTA must be able to simulate and validate the complete customer experience prior to loading the programming to the Silverliner VI cars, and to diagnose issues identified in the field with communication system operation, including content playback.

B. The Contractor shall deliver a turn-key content management lab which shall include the full complement of onboard equipment necessary to fully simulate the on-board communication system operation.

C. All Communication System equipment necessary to simulate all car types shall be supplied as a part of the off-board customer experience simulation lab.

D. For clarity, this includes minimally the following equipment:

1. All types of displays, of type and quantity necessary to simulate all car types
2. PA/IC controllers
3. PEI units
4. Amplifiers
5. Speakers
6. Communication Controls
7. TWDT / data communication system
8. Control units which make up the Communication System
9. Necessary simulators to provide inputs to the Communication System, such as from the MDS.
10. The Contractor shall also deliver ancillary hardware which provides the capability to perform automated, semi-automated, and manual route simulations.

E. The system shall support mission simulation with playback of telemetry and events from a recorded from actual on-board journeys, and through manually prepared journeys.

F. The system shall support:

1. Interfacing with the same production systems used for the revenue fleet that facilitate the upload of programming and content, such that the same APIs as production are used.

2. Playback of telemetry and event logs to animate the simulation in real-time, accelerated, and slow modes.

3. Simulation of customer experience for samples of all interaction types (all display types, audio)

G. The simulation shall incorporate the capability to simulate end user interaction with the on- and off-board system during all stages of the train's operation, including:

1. Train staff operation of the on-board HMIs, including authentication, and operation of system integrations with the Public Address System, Passenger Information System, Assistive Listening Systems, Intercom System, Attendant Call, and PEI.

2. Train staff operation of SEPTA electronic devices, and their interaction with the onboard equipment.

H. The Off-Board Customer Experience simulation lab shall be implemented in a modular and extensible fashion, allowing future modifications and upgrades which will occur on the vehicles to be implemented in the lab.

I. The Contractor shall be responsible for delivery and setup support to a location specified by SEPTA.

1. The detailed system description, functionality, and infrastructure requirements shall be submitted. **(CDRL 13-09, Communication System Content Lab Design)**

13.21 Contract Deliverable Requirements List (CDRL)

The following contract deliverables have been identified in this section; however, the Contractor is responsible for providing and submitting anything necessary to fulfill the requirements of this contract, including those not identified by CDRL number.

CDRL 13-01, Communication System Design and Integration Package 13-1
CDRL 13-02, Passenger Cellular Device Compatibility Plan 13-4
CDRL 13-03, Communication System Fault Tolerance Capabilities 13-5
CDRL 13-04, Communication System Self-Test Capabilities 13-7
CDRL 13-05, Automatic Passenger Counting System Design 13-26
CDRL 13-06, Video Surveillance System CHMM Test Procedure and Report 13-29
CDRL 13-07, Video Surveillance System Design 13-30

CDRL 13-08, Onboard Dynamic Advertising System Design.....13-43
CDRL 13-09, Communication System Content Lab Design.....13-49

13.22 CDRL Details

This section lists the expected content for each CDRL required above. The lists provided for each CDRL are an outline only and should not be considered exhaustive, all CDRLs are subject to SEPTA review and Approval.

CDRL 13-01 Communication System Design and Integration Package

1. It shall be submitted as part of each design review meeting (CDR, PDR, FDR).
2. It shall include the following:
    a. Integration of passenger information, audio announcement, and video surveillance with car subsystems.
    b. User interface and user experience design details.
    c. Data sheets and specification sheets for all subsystem components and network hardware/software.
    d. Functional descriptions and block diagrams of the communications components.

CDRL 13-02 Passenger Cellular Device Compatibility Plan

1. Provide details as to how compatibility with passenger cellular devices will be maintained through the design of the carbody, windows, and other aspects of the vehicle design which may impact cellular device performance.

CDRL 13-03 Communication System Fault Tolerance Capabilities

1. Provide details of all communication system fault tolerance capabilities, demonstrating approach to compliance of the fault tolerance requirements.

CDRL 13-04 Communication System Self-Test Capabilities

1. Provide details of all communication system self-test functionality.

CDRL 13-05 Automatic Passenger Counting System Design

1. Provide details that demonstrate compliance with all requirements related to the Automatic Passenger Counting System, including integration with the existing SEPTA wayside systems, and sharing of APCS in real-time and report basis for on-board and off-board uses.

CDRL 13-06 Video Surveillance System CHMM Test Procedure and Report

1. Submission of the test procedure and test report for demonstrating compliance with Appendix D to 49 CFR Part 229.

CDRL 13-07 Video Surveillance System Design

1. It shall be submitted as part of each design review meeting (CDR, PDR, FDR).
2. The design shall include complete details of all components of the Video Surveillance system, including functional descriptions and drawings.
3. A camera coverage diagram shall be submitted demonstrating compliance with the requirements of the specification.

CDRL 13-08 Onboard Dynamic Advertising System Design

1. It shall be submitted as part of each design review meeting (CDR, PDR, FDR).
2. Demonstrate compliance with the requirements related to the onboard dynamic advertising system.

CDRL 13-09 Communication System Content Lab Design

1. It shall be submitted as part of each design review meeting (CDR, PDR, FDR).
2. Demonstration of approach for supplying content lab for SEPTA, including:
   a. Design and capabilities of the simulation software to be supplied.
   b. Approach to simulating all display types found on the vehicle.
   c. Equipment arrangement and bill of materials.
3. Design shall include requirements for installation, such as power, space, and connectivity.

13.23 Referenced Standards

The following standards are referenced in this Section:

IEEE Std 802.3	Ethernet Working Group Standards
49 CFR Part 217	Railroad Operating Rules
49 CFR Part 218	Railroad Operating Practices
49 CFR Part 229	Railroad Locomotive Safety Standards

49 CFR Part 238	Passenger Equipment Safety Standards
49 CFR Part 299	Texas Central Railroad High-Speed Rail Safety Standards
EN-50155	Railway applications - Rolling stock - Electronic equipment
EN-50121-3-2	Railway applications - Electromagnetic compatibility - Part 3-2: Rolling stock – Apparatus
EN 62676-4	Video surveillance systems for use in security applications – Application guidelines
IEC-60118-4	Electroacoustics - Hearing aids - Part 4: Induction-loop systems for hearing aid purposes - System performance requirements
IEC-60268-16	Sound system equipment – Part 16: Objective rating of speech intelligibility by speech transmission index
IEC-62489	Electroacoustics. Audio-frequency induction loop systems for assisted hearing
IEC TR 63079	Code of practice for hearing-loop systems (HLS)ISO/IEC 11801-1 Generic cabling for customer premises Part 1: General requirements
MIL-STD-810F	Environmental Engineering Considerations and Laboratory Tests

SECTION 14
INTERIOR AND EXTERIOR APPOINTMENTS

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14.1 Interior Finish and Structure

14.1.1 General

A. All interior arrangements shall by designed by the Contractor with SEPTA input and submitted. **(CDRL 14-01, Interior Arrangements)**

1. The Contractor shall participate in a series of meetings with SEPTA's designated stakeholders to gather SEPTA's input and feedback with regards to seating arrangement, vehicle appearance, and electronic and physical signage. The Contractor and Industrial Designer shall account for SEPTA's input in their proposals.

B. Each car shall be designated as either a Standard Car or an Airport Car. Specific references to Airport Cars can be found within this specification. Provisions shall be provided to convert back and forth between a Standard Car and an Airport Car.

C. The design and attachment of all interior fittings shall comply with the requirements of 49 CFR Part 238.233 and APTA PR-CS-S-006-98 Standard for Attachment Strength of Interior Fittings for Passenger Railroad Equipment. The interior of all car types shall be designed and constructed for maximum safety, comfort, convenience and service to the passenger and train crew, and shall be fully ADA compliant.

D. The interior of the car shall be pleasing in appearance, shall be modular in design, and shall be free of sharp corners or edges to eliminate the possibility of injury to passengers, train crew and maintenance personnel in either normal usage or emergencies.

E. Surfaces requiring paint and painted metal trims are not permitted.

F. The interior design, including lining materials, attachment methods, colors, and finishes, shall be as proposed by the Industrial Designer. **(CDRL 14-02, Industrial Design)** Special attention shall be given in the design regarding human factors and ergonomics for train crew and passengers in accordance with the requirements of Section 2, Design and Performance Criteria.

1. The selection of the type of materials to be used, colors and surface finishes shall be Approved prior to any material purchase. **(CDRL 14-03, Materials Samples and Finishes)**

G. The interior shall be designed to allow for industrial cleaning techniques throughout the design life of the car using cleaning agents proposed as per Section 16, Materials and Workmanship.

H. Colors and patterns of interior materials, including interior liner, window mask, ceiling, valence, door pocket and access panels, shall be as Approved. "Speckled" finishes are prohibited.

I. All exposed stainless steel shall be given a 180-grit brush finish.

J. Fiberglass reinforced plastic, coated with DuPont Tedlar composite material shall be used to the extent practical to provide large radius corners, smooth transitions, and minimize molding while providing a graffiti-resistant surface.

1. Non-directional patterns and colors shall be used on the Tedlar composite and colored to minimize the appearance of dirt and graffiti, as well as coordinated with the interior color schemes proposed for the cars.

K. The interior shall be designed to minimize rattles, squeaks, or noise during the operation of the cars.

14.1.2 Interior Fasteners

A. Fasteners shall comply with the following:

1. Fasteners to be concealed whenever possible.

2. Visible fasteners shall be tamper-proof, using a Torx TR15 size, or Approved equivalent.

3. To the maximum extent possible, all interior fasteners of the same diameter shall use the same tool for installation and removal.

4. All fasteners used shall be stainless steel, flush mounted and not visible to passengers. Specific Approval is required for the use of exposed fasteners.

5. Use of bonding or dual lock adhesive fasteners on panels is prohibited except where Approved.

6. Adhere to requirements in Section 16, Materials and Workmanship.

14.1.3 Linings

14.1.3.1 General

A. Design

1. Joints on side linings shall be appropriate to the window placement and located to require the minimum number of seats to be removed for future panel replacement.

2. All linings shall be designed for easy removal and installation. For ease of accident repair or maintenance, all linings shall be individually removable, without the need to remove adjacent linings. The use of "keyed" linings, which must be installed or removed in sequence starting at one end of the car and working to the other end, is prohibited.

3. Interior linings shall be designed with sufficient stiffness for their intended application. Linings shall be so supported as to prevent sagging and drumming. An interior panel as installed in the car shall not deflect more than 1 percent of its short span length when separately subjected to a uniform load of 30 pounds/ square foot (146.5 kilogram per square meter), or a centrally applied load of 50 pounds (22.7 kg) on a contact area of 4 square inches (25.7 square cm).

4. The longitudinal dimension of any piece of lining material shall not exceed 8 feet.

5. All joints exposed to passenger view shall be covered by moldings or be trimmed or configured in a finished manner to result in a pleasing appearance.

6. Wall linings shall not have joint lines running through a side window.

B. Installation:

1. Interior linings shall be applied and mechanically fastened to their supporting surfaces in an Approved manner. The mounting shall be designed to accommodate the dynamics of car movement without transmitting stress to the liners.

2. The transitions between components and linings shall be designed to eliminate inside corners to enhance cleanability.

3. "Anti-squeak" neoprene (chloroprene) or cork elastomer tape shall be used between linings and any structure to which they are attached or with which they come in contact.

4. All trim used to conceal joints, inside or outside corners shall be standardized sizes of satin finished stainless steel or other materials proposed by the Industrial Designer and Approved.

5. All holes in linings or carbody structure for mounting trim shall permit complete interchangeability of parts.

14.1.3.2 Window Masks

A. Window masks shall be compression molded FRP, or Approved equal, with a duct for the floor heater to side window vent. A stainless steel scuff guard with rounded corners shall be provided in the area of the luggage racks to protect the wall linings.

B. If the warm air discharge outlet holes are used, they shall have a maximum diameter of 0.2 in (5 mm).

1. If the window masks are made of FRP material, the discharge outlet holes shall be on a stainless-steel plate permanently attached to the mask.

C. If the window glazing and mounting arrangement will not permit discharge outlet holes, the outlet holes shall be located in the vertical lining surface, if required.

14.1.3.3 Side and End Wall Linings

A. The side and end wall linings shall extend from the top of the floor coving, heater guard or kick panels up to the ceiling with an appropriate cutout to form the window mask where required.

1. The linings at either end of the car for transitions into the end wall shall be provided with smoothly rounded corners and be generally formed and assembled to prevent dirt collection and build-up in crevices, joints, projections, or corners.

2. Access panels must be provided in liners where applicable to ensure easy access to equipment for inspection, service, and repair.

3.

14.1.4 Door Pockets

A. Door pockets shall be constructed, from floor to ceiling, with sufficient strength and support to the main structure to bear passenger load under the most extreme conditions. The door pocket shall not sag, drum, or vibrate. Door pocket material shall be Approved.

B. The passenger compartment facing side shall continue, without joints, to junctions with the window mask, the lining panel, and the windscreen.

C. Door pocket panels shall withstand the forces of attached seat loads for the design life of the car. There shall be no distortion to interfere with the operation of the side doors.

D. Door pocket shall be provided with door guiding channels coordinated with the door system as specified in Section 6, Passenger Doors. Guiding channels shall not impede operation of the side doors at all car loading conditions and shall be subject to Approval.

E. The area above the side doors to the ceiling shall be provided with a hinged access panel of an Approved design and material and offer easy and sufficient access to all door system components and assemblies. Latching of this panel shall be keyed, and the panel able to be kept open when desired.

F. A flush access panel shall be provided at the bottom of each door pocket panel near the floor. The panel shall be large enough to allow for access to door seals, heaters, guiding channel, and other equipment in this area.

14.1.5 Cab Partition Wall

A. The "F" end cab partition wall shall separate the Operator's cab end from the passenger interior.

B. The cab partition wall shall be full width and fully enclosed to prevent unauthorized access. Both sides of the wall will be passenger facing depending on the configuration of the Operator's Cab Door.

C. A hinged cab door shall provide access to the cab as described in Section 5 Operator's Cab.

1. When the car is configured for active cab, the cab door shall lock to the cab partition wall.

2. When the car is configured for walk through, the cab door shall lock to the Operator's Cab compartment. Passengers will be allowed to access the doorway in the F-end left cab area, and in case of emergency also access the carbody end door.

D. The cab partition wall shall be enclosed by a panel constructed from a rigid, durable, mar-resistant material such as melamine-faced plymetal, honeycomb, or other material as Approved.

E. The cab partition wall shall be attached to the car structure, not to adjacent liners or panels.

F. The cab partition wall shall be designed to resist a load of 200 lbs (890 N) applied to a 6 in x 6 in (152 mm x 152 mm) surface area with no permanent deformation.

G. The cab partition wall may be integrated with electric lockers as described in TS 14.6.2.

H. The cab partition wall shall complement the appearance of the interior lining of the side walls.

I. The cab partition wall shall be provided with smoothly rounded corners and be generally formed and assembled to prevent dirt collection and build-up in crevices, joints, projections, or corners.

14.1.6 Moldings

A. Use of moldings shall be minimized and only as Approved. Moldings shall be a color and gloss matching the adjacent lining.

14.1.7 Ceiling

A. A ceiling shall extend across the entire length of the car:

1. It may also form the bottom of the air distribution duct.

2. Overhead hardware, such as lighting fixtures, air diffusers, public address speakers and the like shall interface and integrate harmoniously with the ceiling

panels, all of which shall be adequately supported from the carbody roof structure.

3. The transition between the ceiling and side walls shall provide maximum space for the luggage racks.

4. Hinged access panels and access covers shall be provided for maintenance access. Ceiling panels for maintenance access shall be hinged, of adequate size to facilitate maintenance and replacement of components and filters and equipped with safety lanyards and adequate spring clips.

5. Ceiling panels shall be designed to be removable with the removal of no more than two adjacent panels.

6. All ceiling panels and air diffusers shall be adequately supported by hangers to prevent sagging and drumming.

14.1.8 Windscreens

A. Windscreens shall be provided at each passenger doorway, separating the entranceways from the seating areas, with the exception of the F-end door which shall utilize a Cab partition wall:

1. The windscreens shall have stainless steel tubular frame, a 180-grit circumferential finish on exposed sides. The windscreens shall also have a solid bottom panel with Tedlar finish, and an upper panel of clear laminated safety glass with a full perimeter frame.

2. The top of the bottom panel shall be at the same height above the floor as the top of the adjacent passenger seat assembly.

3. Partitions which face passenger seats shall be provided with an Approved stainless steel kick plate.

4. Floor coving shall be installed on all exposed base surfaces.

5. All corners and edges of partitions shall be rounded.

6. The partition surfaces and trim shall be identical to or harmonize with the appearance of the car interior.

7. The windscreens adjacent to each passenger side door shall contain a door control panel (see Section 6, Passenger Doors).

B. The windscreen shall incorporate stainless-steel handrails and stanchions, described in more detail in TS 14.1.9.

14.1.9 Stanchions and Handrails

A. Adequate stainless-steel handrails and stanchions meeting the applicable requirements of 49 CFR 38 Subpart E and APTA PR-CS-S-006-98 shall be provided at each doorway to permit ease of ingress and egress when using the lower-level steps.

B. Handrails and stanchions shall not reduce the clear width of the doorway or impede accessibility per Section 2, Design and Performance Criteria.

C. All tubing shall be seamless and polished to a number 180 grit brush finish. Powder coating is prohibited.

D. The tubing shall be terminated with heavy wall, polished or glass bead finished cast aluminum fittings. Welding as a joining method is prohibited.

E. Handholds shall terminate into the wall, ceiling, or seat to prevent passenger clothing or baggage from catching or snagging.

F. Horizontal rails in the windscreen shall be included for assisting passenger ingress and egress of the vehicle.

G. A vertical stanchion shall be located on the aisle side of the windscreen.

H. Vertical handrails shall be provided in the diaphragm space to assist safe passage through the carbody end doors while the train is in motion.

I. A full height vertical handrail shall be located adjacent to the side entrance doorway opening. The handrail design shall be such as to provide minimum interference in the doorways.

J. Windscreens in the mobility device area may be narrower in width to provide adequate maneuvering space per 49 CFR 38.

K. The design and locations of the entire windscreen, stanchion, and handrail system shall be submitted. **(CDRL 14-04, Stanchion and Handrail Arrangement)**

14.1.10 Entrance/Exit Structure

14.1.10.1 Doorways

A. Two types of doorways shall be used for passengers to board the train. Door requirements can be found in Section 6, Passenger Doors.

1. One door type is for high level platforms and allows entry straight from the platform to the car (and vice versa for egress) without the use of steps or ramps.

2. The other door type is for low level platforms and shall have stairs built into the car for passengers to get from the low level of the platform into the car (and vice versa for egress).

14.1.10.2 Stairs

A. Flooring and step wells in the entrance areas shall be slip resistant and comply with the requirements of 49 CFR 38 Subpart E.

1. Stainless steel step wells, consisting of three (3) steps with Approved anti-skid surfaces, shall be located at low level doorways for use at low level platform stations.

   a. The top surface of the lowest step tread shall be 17 inches (431.8 mm) (nominal) above the top of the rail.

   b. The tread depth shall be a minimum of 10 inches (254 mm); riser heights shall be equal.

2. The step wells shall be designed as a modular design for ease of replacement after grade crossing or other strikes. All gaps shall be properly sealed to prevent water or dirt ingress, and minimize noise.

3. The step well shall be designed to minimize water and dirt accumulation, and shall prevent moisture from freezing and resulting in slippery surfaces.

4. Threshold heaters shall be provided per Section 7, HVAC.

B. Samples shall be submitted. **(CDRL 14-05, Passenger Steps Samples)**

14.1.11 Outlet Locations

A. Duplex GFCI protected outlets, as defined in Section 9, Auxiliary Power, shall be installed along the center sidewalls and ends of the car for use during maintenance and cleaning.

14.1.12 Coat Hooks

A. Flush, spring-loaded folding coat hooks of an Approved design shall be provided in the side wall of the car just below the baggage rack elevation.

1. One side wall coat hook should be provided per each row of seats.

2. The hooks shall have rubber bumpers to reduce noise.

3. Coat hooks shall be secured to car body structure.

4. The design shall be as proposed by the Industrial Designer and submitted for Approval.

14.1.13 PEI Locations

A. Passenger Emergency Intercom (PEI) shall be located adjacent to each ADA mobility space.

B. Two additional PEIs shall be added throughout the design process with location to be determined by SEPTA.

14.1.14 PIS Locations

A. Passenger Information Systems (PIS) shall be mounted in locations that allow for maximum passenger visibility. Refer to Section 13, Communications, for complete information on these systems.

B. The quantity of each of these shall depend on the interior configuration of the car. Locations to be suggested by the Contractor and shall require final Approval from SEPTA.

14.2 Flooring

14.2.1 Floor Panels

A. Floor panels shall be phenolic or epoxy composite construction and meeting the requirements of Section 16, Materials and Workmanship.

B. Floor panels must be engineered to withstand SEPTA's cleaning processes.

C. Floor panels shall be designed to last the life of the car and not require periodic inspection or maintenance.

D. All exposed edges of the individual floor panels shall be machined smooth and free of sharp edges and burrs.

E. Floor panels shall be composed of pieces as large as possible and shall extend the full width of the car. Transverse shiplap joints shall be located over structural members. There shall be no joints in the top or bottom face skins of the panels.

F. Floors shall provide a smooth continuous surface for the floor lining. Installed panels shall have height variations at panel joints no greater than 0.03 in (0.76 mm). Floor flatness shall be better than 0.125 in (3 mm) over any 36 in (914 mm) span.

G. All floor penetrations shall be sealed with Approved fireproof sealant. All connections to the floor shall utilize threaded inserts applied to areas of solid resin.

H. Panels shall be mechanically attached and sealed to the floor beams and sides. It shall be possible to remove, replace, or repair individual panels without damage to surrounding floor panels or structure.

I. The floor and mounting configuration shall not exhibit undesirable mechanical resonance, transmit underfloor equipment noise and vibrations, nor support other disagreeable noise generation.

J. For structural analyses and strain measurement/testing purposes, floor panels shall not be considered part of the carbody structure.

14.2.2 Floor Covering

14.2.2.1 Material

A. The interior floor covering shall be a high-quality, resilient, hard surface, slip resistant transportation grade material designed to last 20 years in service without need for major repairs and meeting the requirements of Section 16, Materials and Workmanship.

B. The flooring shall be available in rolls.

C. The color, gloss and pattern shall be proposed by the Industrial Designer and submitted for Approval.

D. Floor covering to have a consistent and uniform appearance throughout the vehicle, including but not limited to no lumps, gaps, bubbling, misaligned panels, or obvious seams between covers.

E. The floor shall be sufficiently insulated to prevent freezing of standing water under worst case ambient conditions while HVAC system is in layover mode.

F. To provide contrasting colors for passengers of low visual acuity, the floor covering at all door thresholds shall have an integral minimum 3 inch (76.2 mm) yellow stripe visible by people boarding or exiting the vehicle.

G. Floor covering shall be Approved material with a minimum thickness of 0.1 inch (2.5 mm).

H. It shall meet all industry performance and safety standards and provide moisture protection for the underlayment material.

I. Floor coverings shall have a minimum coefficient of friction of 0.6, wet or dry, when tested in accordance with ASTM D2047.

J. The proposed floor covering shall include all technical, safety, maintainability, and life-cycle cost data necessary to thoroughly review the proposed product and its application on the car. The proposed floor covering shall include the service history of the proposed product.

K. The floor shall be flat (flatness) within 0.062 in (1.6mm) in 3 ft (914 mm) in any direction.

14.2.2.2 Installation

A. At doorway areas, it shall be installed transversely from door to door. A single width, one-piece material is preferred, but two widths butted side to side will be acceptable as long as seams are not visible.

B. Under the passenger seats the material shall be one piece in width from the side wall to the joint with the aisle and shall extend as a continuous single piece from the end of the car to the first doorway, and between the two side doorways.

C. In the passenger aisles, the material shall be installed longitudinally, and shall be a single piece from the end of the car to the first doorway, and between the two side doorways. The aisle material width shall be no closer than 3 inches (76.2 mm) from the passenger seat pedestals, to permit aisle sheet removal and replacement without removing the seats or disturbing the smooth floor covering under the passenger seats.

D. The cab flooring shall be a single piece.

E. Where the floor covering reaches walls or partitions, it shall be finished with a suitable 1.5-inch (38.1 mm) radius sanitary cove molding of Approved material, which shall be properly fitted and secured at all corners for ease of maintenance and cleaning. Approved silicone sealants matching the floor color shall be used to seal the floor covering to thresholds, partition joints, and edges along the floor heaters.

F. Floor covering seams shall use materials with a service life that meets or exceeds the service life of the floor covering itself.

G. The door thresholds shall overlap and be sealed to the floor covering at the outboard edge of the floor to prevent the floor covering from "turning up." Any discontinuity between floor covering and threshold trim shall not exceed 0.25 inch (6.35 mm), and the trim shall have approximately a 45-degree sectional transition to the floor covering.

    1. Coving, fittings, and floor angles shall all be applied to form a watertight seal using an Approved method. All screws and hardware shall be stainless steel.

H. Floor covering arrangement, installation, and repair procedures to be submitted. **(CDRL 14-06, Floor Covering Arrangement, Installation and Repair)**

14.3 Windows

14.3.1 General

A. The design, installation and materials used for all windows of the car shall meet the requirements of 49 CFR 223, 49 CFR 238.113 and 49 CFR 238.221.

    1. Windows shall be as large as practical and shall allow maximum visibility for passengers and Operator consistent with practical car design.

    2. All horizontal window lines of similar windows and doorways shall be uniform or harmonize. Tinted glazing shall use a solid gray color tint with a visual light transmission of 12 to 18 percent and shall be Approved.

    3. All windows shall be interchangeable with windows of the same size.

4. Single glazed windows shall be used for all exterior and interior glazing and shall meet the requirements of Section 16, Materials and Workmanship.

   a. The windows shall be leak-free in car operation and be capable of withstanding the external and internal pressure differentials caused by head-on pressures of 150 miles/hour (100 miles/hour car speed and 50 miles/hour wind speed) and passing train speeds of 100 miles/hour.

   b. All glazing shall have all edges and radii ground smooth and must fit without binding. All laminated glass shall have sealed edges. The corners on exterior glazing shall have a minimum radius of 3.5 inches (88.9 mm).

   c. The glazing shall not be affected by any car heating or condensation.

   d. The finished dimensions, layout, and the composition of all glazing shall be Approved.

   e. A summary of glazing types to be used is as follows:

Table 14-1: Window Types

Location	Minimum Thickness	Visible Light Transmission	Type	FRA Type
Carbody End Door Windows	0.46 inch	Untinted	Polycarbonate	Type I
Windshields	0.46 inch	Untinted	Polycarbonate	Type I
Passenger Windows	0.46 inch	Tinted	Polycarbonate	Type II
Emergency Windows	0.46 inch	Tinted	Polycarbonate	Type II
Side Door Windows	0.46 inch	Tinted	Polycarbonate	Type II
Front Destination Sign Windows	0.46 inch	Untinted	Polycarbonate	Type I
Side Destination Sign Windows	0.46 inch	Untinted	Polycarbonate	Type II
Windscreen Partition	0.25 inch	Untinted	Laminated Glass	N/A
Cab Door Window	0.25 inch	Tinted	Laminated Glass	N/A

14.3.2 Mounting

A. All passenger windows, emergency windows, exterior destination sign windows, side door windows shall be mounted in an endless elastomer glazing strip.

   1. All elastomers shall meet the requirements of Section 16, Materials and Workmanship.

2. All elastomer glazing strips shall be endless and shall fit tightly without buckling and shall have rounded corners both inside and out to facilitate car cleaning.

   a. They shall be designed for use with polycarbonate glazing and shall compensate for its expansion rate.

   b. All windows shall use an inward facing zipper strip or flap, with exception of the side destination sign.

   c. The destination sign windows shall use a zipper strip accessible from the exterior of the car.

   d. No sealers or adhesives shall be used for the mounting of any window.

14.3.3 Carbody End Door Windows

A. An FRA Type I window shall be installed in each carbody end door as applicable. At each cab end of car, the vertical dimension shall match that of the adjacent windshields.

1. The carbody end door windows shall be as wide as possible. The window dimensions shall allow for a standing 95th percentile male train crew member to clearly see into the next car in accordance with Section 2, Design and Performance Criteria. The window shall be installed in an anodized aluminum frame.

2. The frame and screw hardware shall be finished with either a black anodized finish or a black powder coat epoxy finish.

3. The interior frame and screw hardware finish color shall be as proposed by the Contractor's Industrial Designer and submitted for Approval.

4. Mounting shall be designed to prevent the glazing from being pushed into the car interior and shall be arranged for replacement from outside the car. A thermal break shall be provided to minimize the transmission of heat through the aluminum window frames.

5. An Approved closed-cell gasket shall be used to seal the frames to the carbody shell. Mounting screws shall make full engagement into the frame.

14.3.4 Passenger Windows

A. Each passenger side window shall be a flat piece of FRA Type II polycarbonate.

1. The passenger side window area shall be maximized, and the window clear opening height shall start from the shoulder height of a seated 5th percentile female passenger and extend upward to the base of the luggage rack supports. (Section 2, Design and Performance Criteria)

2. The window width shall be as large as reasonably possible and align with the passenger seating.

3. They shall be mounted so that flexing or vibration of windows during car operation is not apparent.

B. Windows shall be capable of withstanding external and internal pressure differentials requirements of Section 2, Design and Performance Criteria

14.3.5 Passenger Emergency/Rescue Access Windows

A. Six passenger side windows as designated shall be arranged to function as emergency exit/rescue access windows.

B. Two emergency windows shall be located in each of the vehicle's three sections, on opposite sides of the vehicle.

1. These windows shall be identified and marked as emergency windows, both inside and outside the car, and shall comply with the requirements of 49 CFR 223.9, 49 CFR 238.113, 49 CFR 238.114.

2. The design and location shall be submitted. **(CDRL 14-07, Emergency and Rescue Access Window Design and Arrangement)**

C. Generally, these windows shall operate in the same fashion as those on the SEPTA Silverliner V cars for both exit and access and shall be marked in a similar fashion.

1. A red metallic handle as Approved shall have a reinforced attachment to the interior removable zipper strip portion of the glazing strip, at the upper left corner of the window. The gasket shall be easily removable by pulling the handle, requiring a force not to exceed 40 pounds. The handle shall be imprinted with 0.25-inch-high (6.35 mm) phosphorescent paint letters reading "PULL FOR EMERGENCY EXIT."

2. Beneath the red metallic handle, a red pull handle shall be mechanically fastened to the glazing to facilitate removal of the window. Adhesive bonding is prohibited. The location and size of this handle shall be fully covered by the metallic pull handle. "PULL TO REMOVE" shall be imprinted in phosphorescent paint on the handle in 0.25-inch-high (6.35 mm) letters. This lettering shall normally be hidden from view when the gasket is installed.

   The window shall be removable by 5th percentile female passenger. Sufficient seat clearance shall be provided to allow for emergency window removal, reference Section 2, Design and Performance Criteria.

14.3.6 Side Door Windows

A. Each side door shall have a flat piece of FRA Type II polycarbonate window glazing, installed as flush as possible to the inside face of the door leaf.

1. The bottom of the window shall match the adjacent passenger side windows and shall be as high and as wide as possible.

2. The window dimensions shall permit a standing train crew member in accordance with Section 2, Design and Performance Criteria, to clearly see outside the car.

14.3.7 Destination Sign Windows

A. Each destination sign shall have a flat piece of un-tinted polycarbonate window glazing, of sufficient size to prevent masking the display.

1. Front destination signs shall use FRA Type I

2. Side destination signs shall use FRA Type II.

14.3.8 Windscreen and Cab Door Window Arrangement

A. Windscreen and Cab Door Window Frames

1. All interior windscreen partition glazing and cab door window glazing shall be mounted in a metal frame and cushioned by a neoprene elastomer channel which shall allow easy replacement.

2. The cab door window mounting hardware shall face the interior of the cab and shall be hidden from passenger view to the maximum extent possible.

B. Windscreen and Cab Door Windows

1. All interior windscreen partition glazing shall be a flat piece of laminated glass. All partitions shall be of identical size.

2. The cab door windows shall be a flat piece of polycarbonate. See Section 5 Operator's Cab for additional information.

14.4 Seats

14.4.1 General

A. The seats shall be designed to provide maximum width and knee room, and the seat spacing shall be arranged to provide maximum passenger room and shall coordinate with the side window spacing, especially in regards to the emergency windows.

B. Details of the design, construction, installation, and arrangement of the passenger seats shall be submitted for review and Approval.

1. Prior to placing quantity orders of any seat type, furnish to SEPTA one complete passenger seat of each type, constructed in accordance with the design provisions specified above. The seats will be used by SEPTA for evaluation of the comfort, interchangeability, and aesthetic aspects of the seats prior to FAI.

14.4.2 Seating Configuration

A. Fixed 3+2 passenger transverse seating shall be provided outboard of the quarter point doorways towards the F-end and A-end of the car.

B. Generally, fixed 2+2 passenger transverse seating shall be provided between the quarter point passenger side doorways. . The seating configuration will also include:

1. Triple flip-down longitudinal seats on either side of the aisle in the center section near the high-level doors.

C. In the Airport Car, the fixed 2 + 2 passenger transverse seating at four locations in the center of the car shall be replaced by luggage stacks.

1. All seat mounting arrangements for the replaced seats shall remain, to allow SEPTA the ability to remove a luggage stack in the future and install seats in its location.

D. Passenger seats facing the Cab partition wall may be proposed for Approval as flip-down type to enhance the maintainability of equipment on the wall when located in front of a maintenance access point such as a Cab partition wall or electric locker.

E. Fixed single seats shall also be used to take advantage of any available space where multiple passenger bench seats cannot be installed and shall be used to enhance passenger flow aspects for approaching and exiting the seating area.

F. Seating direction shall be split in half in married pairs from the location where two separate cars meet to form the married pair. Seats nearest Cab partition walls may face either the Cab partition wall or be turned to face the center of the car depending on which direction achieves maximum foot space and leg room.

G. All main seating area transverse seats shall follow the aisle and seat width minimums to provide an aisle of 32 inches (812.8 mm) where there is 2x2 seating and an aisle of 21.5 inches (546.1 mm) where there is 3x2 seating.

H. The Contractor shall submit detailed drawings of the seats, seat installations (including pedestal placement dimensions and wall connections), with respect to the interior arrangement for each car configuration. **(CDRL 14-08, Seat Design and Installation)**

I. A minimum seat pitch of 32.875 inches (835 mm) shall be maintained throughout the carbody based on seat assemblies with a seat back tilt greater than fifteen (15) degrees unless otherwise Approved.

J. Once the pedestal location is determined for the narrower two-seat unit in a 3x2 seating arrangement, it shall serve as the standard pedestal location for all seats.

14.4.3 Seat Construction

A. The seating shall generally be similar to the design of the seats installed on the SEPTA Silverliner V cars.

1. Each passenger seat position shall have an extended height headrest approximately 12 inches (304.8 mm) wide incorporated as part of the seat back cushion, with a sloped transition between headrests of approximately 8 inches (203.2 mm) high.

2. The design of the seats shall maximize passenger knee room by having the minimum possible thickness for the seat back assembly. In addition, the seat shall have the maximum possible width per passenger, measured as the clear width between the sidewall and the inside edge of the armrest.

3. The armrest on the aisle side shall be of an open tubular loop design, so as to maximize available hip room. No armrest shall be provided on the side wall side of the seat.

4. A cushion seat width of 3 feet 6 inches (1066.8 mm) shall be provided on the 2 + 2 seats in the middle of the car in the full width zone between door pockets. Transverse 2 + 2 seats with cushion width of 3 feet 3 inches (990.6 mm) may be used at the door pockets.

   a. At the outboard ends of the car, a cushion seat width of 4 feet 10.5 inches (1485.9 mm) shall be provided on the 3-passenger seat, and a cushion seat width of 3 feet 3 inches (990.6 mm) shall be provided on the 2-passenger seat.

   b. All seating positions shall have a back cushion height of 3 feet 9 inches (1143 mm) from the floor to the top of the extended height headrest. Seat bottom cushion depth, measured from the face of the back cushion, shall be 1 foot 6 inches (457.2 mm).

5. Deviations from the specified dimensions shall be submitted for Approval.

6. All seats and their attachments shall comply with the requirements of 49 CFR Part 238.233. In addition, the passenger seating shall comply with the requirements of APTA PR-CS-S-016-99 Standard for Passenger Seats in Passenger Railcars, which shall include structural testing of seating and seating attachments.

7. The seats shall reflect high quality, comfort, and appearance standards.

a. The Contractor shall identify specific procedures for periodic cleaning, maintenance, and particular soiling conditions for the seats, including types of chemicals and equipment to be used.

b. Emphasis shall be placed on human factors in the design of the seating contour, shape, and cushion firmness, as well as an attractive appearance which enhances the interior of the car.

c. Equipment storage under any seats is prohibited.

8. The details and colors of the seating design shall be as proposed by the Industrial Designer and submitted for Approval. The Industrial Designer shall consider utilizing darker colors in areas that tend to accumulate dirt and stains, such as the head rests and the armrest caps.

a. As part of the Design Review efforts, the Contractor shall present an ergonomic analysis and report of the seating system. The Contractor is to submit alternate seat designs which include superior or unique design concepts for the intended service if available.

b. One sample seat of each seat type and mounting configuration shall be submitted by the Contractor for Approval following successful completion of testing.

14.4.4 Seat Installation

A. Seats not mounted on Cab partition wall enclosures shall be installed by use of a brush-finished stainless steel fully enclosed pedestal on the aisle side, and attachment to integral floor heating supports on the wall side, similar to the existing SEPTA Silverliner V cars.

1. The seat supporting structure shall not obstruct the foot area of seated passengers.

B. Seats mounted against Cab partition walls may be mounted on under seat enclosures.

C. Seat assemblies shall be installed to allow ready access to heater elements and other similar items.

D. Where the seat attaches to the floor, the floor covering shall be counterbored, and a hardened washer which is the thickness of the floor covering shall be inserted to ensure that the seat fasteners bear fully on the floor tapping rail and not on the floor covering.

E. The attachment shall be sealed watertight in accordance with Approved procedure and materials.

14.4.5 Framing And Shroud

A. Each seat shall consist of a welded steel supporting frame with upholstered cushions.

1. The seat frames shall be constructed of square and tubular painted carbon steel, and AISI number 3 finished stainless steel where exposed to passengers. All frames shall have sealed tube ends to prevent the entry of vermin and shall have metal reinforced drain holes as required.

   a. The side wall attachments shall be designed to discourage the accumulation of dust or debris and shall not interfere with heater enclosures or other equipment.

   b. Each seat frame shall have an armrest only on the aisle side of the frame.

   c. All welding performed shall meet the requirements of Section 16, Materials and Workmanship. Seat frame welding shall be done in appropriately designed and constructed weld fixtures which shall ensure dimensional consistency of all frames for interchangeability.

2. The back of the seat shall have a shroud manufactured from compression molded, fiberglass reinforced plastic (FRP) in accordance with Section 16, Materials and Workmanship, or other Approved and equally durable material. The shroud design shall be recessed to maximize all possible passenger leg room.

   a. The minimum inside radius of all corners shall be 0.375 inch.

   b. The FRP shall be covered with DuPont Tedlar composite laminate, or Approved equal, during the compression molding process to provide a colored graffiti resistant surface.

   c. The shroud shall closely match the shape of the support frame to prevent any buckling or poor fitting when assembled and prevent cracking while in service. It shall not be possible for a passenger to pull the shroud away from the support frame.

14.4.6 Cushions

A. Seat cushions shall consist of a seat bottom cushion and a seat back cushion, covered with a vinyl or synthetic leather seat upholstery.

   1. Each cushion shall be a one-piece assembly interchangeable with all other seat bottom or seat back cushions of the same type.

   2. They shall fit against each other and the seat frame when installed without visible gaps or misalignment.

   3. To delineate the seat area for each passenger, decorative treatment including contrasting upholstery coloring, upholstery seams and extended headrests shall be used to support this effect.

4. No bolstering of the bottom cushion or seat back cushion shall be provided. All upholstery material shall fit tightly, with no visible wrinkles, sags, or other defects.

5. The seat back cushion shall be designed to be easily removed and replaced for maintenance as a single unit. It shall provide passenger comfort with the thinnest possible back and incorporate a headrest.

   a. The cushion assembly shall consist of a heavy duty aluminum pan with a Dutch roll lip on the perimeter, and a one-piece molded or fabricated beveled back cushion, combination of chloroprene latex and polyurethane foam designed for long-term transit service durability.

   b. The foam shall have an IFD firmness rating of 35 to 40, and be of an Approved thickness, with additional foam thickness in the upper corners, or wherever required to improve appearance.

   c. The back cushion assembly shall be mechanically secured to the support frame.

6. The vinyl upholstery covering material shall be a non-expanded transportation grade vinyl seating material, to be Approved, with previous rail car application experience.

7. All upholstery seams shall have high mechanical strength, and transverse seams in the area of the front upper edge of the seat cushion are to be avoided. The covers shall be sewn with number 69 nylon thread. The thread color shall match the vinyl color in all visible areas. All stitching shall be a minimum of 6 lock stitches per inch.

8. Pull tabs shall be double stitched to the stiffeners, 1 inch of each end of stiffeners shall be double stitched.

9. All cushion assemblies shall be properly vented to prevent ballooning.

14.4.7 Armrest

A. An armrest shall be provided only at the aisle side of each transverse seat.

B. It shall be on an open stainless steel loop structure fitted with a cushion pad.

C. The armrest structure shall be formed and finished in a manner compatible with the seat design and interior scheme.

14.4.8 Seat Handhold

A. Each seat shall have an energy-absorbing handhold installed on the seat back and shall not protrude into the aisle further than the armrest.

B. The handhold shall be suitable to provide support and balance with proper ergonomics for a standing passenger, without inconveniencing the seated passenger adjacent to it.

C. The design shall be a metallic frame covered with a textured, energy-absorbing, rounded-corner elastomer. There shall be no sharp edges, gaps, dirt collecting crevices or seams, or exposed metal surfaces on the handhold or its interface with the seat back.

D. Handholds shall be designed to prevent passenger clothing or baggage from catching.

14.4.9 Ticket Holder

A. Each seat shall be provided with Approved holders for fare cards in use by SEPTA.

B. The ticket holders shall be of a design that is free of all hazards to the passengers, crews, or their clothing.

14.4.10 Flip-down Seats

A. Flip-down seats shall be provided in locations described in Section 14.4.2..

1. Each flip down seat shall hold 1-3 passengers depending on the location. Each flip-down seat shall operate independently. No armrest shall be provided.

2. The general appearance, colors, comfort, and strength of the flip-down seat shall match the standard seat. All surfaces, including the bottom of the seat bottom cushion, shall be finished in a manner to be Approved.

3. When in use, the seat shall have the same sloping backrest angle as the standard passenger seat.

4. The underside of the bottom cushion of the flip-down seat shall be considered visible.

5. The seat bottom cushion shall be hinged to fold up and stay in the up position until lowered by means of springs and/or counterbalances without the need for a latch.

   a. The seat back cushion shall be hinged to the bottom cushion with pivoting linkage and shall move upward when the bottom cushion is folded up to provide the maximum clearance for parking of passenger mobility devices in the accessible area. When berthed, the mobility device shall not impede into the accessible aisle space.

   b. Access to all side doors, emergency equipment or locker mounted controls shall not be blocked.

   c. Each folding seat shall revert to the up position when not in use. The force required to operate the seat shall not exceed 10 pounds throughout the full

range of motion. Movement shall be dampened to prevent "free fall" dropping when the bottom cushion is lowered.

6. Flip-down seat assemblies shall be securely wall mounted in conjunction with pedestal supports, if needed, located toward the wall to allow open floor space for mobility devices, and luggage when the seat is in the flipped up position.

7. The design of the seat back shall consider the location and size of the passenger side windows and in no way limit emergency ingress/egress or passenger visibility out of any window unless otherwise Approved.

14.4.11 Fire Resistance

A. The armrests, seat cushions, covering materials, and any other materials used in the seat shall meet the fire resistance, smoke emission, and toxicity requirements of Section 16, Materials and Workmanship, Section 23, System Safety and Security, and 49 CFR 238, Appendix B.

14.4.12 Seat Mock-Up

A. Mock-ups of each seat type, as defined in Section 25 Program Management and Commissioning, shall be provided. The mock-up seats shall be developed in conjunction with and to supplement the design drawings Approved by SEPTA.

B. In addition, one sample seat of each type and mounting configuration shall be submitted by the Contractor for public review and comment and for Approval.

C. Approval of both the design drawings and the mock-up seats shall be required prior to proceeding with production.

14.5 Multiuse Areas

14.5.1 Accessibility/Mobility Aid Parking

A. Each car shall have provisions for the parking of two (2) mobility aid devices. The accessibility spaces and signage shall meet the requirements of 49 CFR 38 Subpart E.

B. Wheeled mobility device parking areas shall have a clear approach by the device with ample room to maneuver. Space shall be provided using areas associated to flip-down seats.

C. The international wheelchair symbol and "Passengers with Disabilities" decals shall be applied adjacent to each designated area.

D. A bench of three independently operated flip-down seats shall be located in each ADA accessible seating position for wheeled mobility devices.

14.5.2 Bicycle Racks

A. Provide bicycle stowing racks:

1. Type, locations, and overall size of bicycle storage rack shall be approved during Design Review.

2. Each Bicycle Rack will be designed to accommodate a 29-inch bicycle model with 23 to 64 mm wide wheels.

3. Bicycle Racks shall be round, tubular, brushed stainless-steel construction to match luggage racks.

4. Mounting:

   a. Bicycle Racks shall be located as close to the interior sidewall as possible, to minimize bicycles protruding into the passenger aisle.

   b. Bicycle retention equipment and bracketry shall in no way hinder or impede accessibility requirements of the interior.

   c. The device shall not impede passenger flow in the stored position.

   d. Mounting shall be designed to limit bicycles from being damaged and excessive rattling while vehicle is in motion.

5. Strength:

   a. Assume the weight of a stowed bicycle is at minimum 23 kg (50 lb).

   b. Each single bicycle bracket and its respective mountings and supports shall withstand, without permanent deformation, the following individually applied design static load factor's action on the mass of the bicycle stowed, combined with the mass of the bicycle bracket (hook):

      - Longitudinal: 8g
      - Vertical / Lateral: 4g

14.6 Interior Lockers and Access Panels

14.6.1 General

A. Any equipment that requires periodic maintenance shall be located within equipment lockers or behind access panels. It shall not be necessary to remove any linings or moldings to inspect or clean any equipment requiring periodic inspection or maintenance.

B. All hinges, latches, and locks shall be designed to last the life of the car.

C. All lockers determined by SEPTA Railroad Division requiring limited access shall be provided with key locks, special keys, or tamper resistant hardware as specified in Section 24, Cybersecurity.

D. All lockers shall have interior lights, as specified in Section 8, Lighting.

E. Access panels shall be hinged and shall incorporate safety lanyards or safety catches to prevent injury or damage when panels are opened.

F. Lockers shall be coated in non-conductive coating as Approved.

G. Locker locations shall be as proposed by the Industrial Designer and submitted. **(CDRL 14-09, Equipment Locker and Access Panel Locations)**

H. Interior lockers and access panels shall either be locked with a standard coach key or with tamper proof fasteners. Locations of locks and respective keys shall be submitted. **(CDRL 14-10, Keys and Locks)**

14.6.2 Lockers And Access Covers

A. Several lockers to be accessed by the Operator, train crew, and maintenance personnel shall be located in each car and shall accommodate electrical and electronic equipment, switch and breaker panels, annunciators, signal equipment, etc.

B. An electrical/ATC equipment locker shall be provided behind each cab.

C. Locker doors shall have a continuous stainless steel hinge and close flush.

1. The door surface shall be a laminated fiberglass with Tedlar surface, or other Approved material, matching the car interior.

2. Doors shall be equipped with a latching lever arrangement in order to remain open while accessing components and equipment.

3. Hinge springs shall be provided to hold each door in a closed position under all conditions when not latched open, including maximum superelevation conditions.

14.6.3 Underseat Enclosures

A. Seats mounted with the seatback against a vertical surface, such as a partition, may be mounted on an underseat enclosure box, as Approved, provided that there is no loss of passenger leg room.

1. The seat enclosures shall be constructed of stainless-steel and be watertight to IP54 or greater.

2. All access covers shall be bottom hinged and be spaced at least 1 inch above the floor to prevent water entry.

3. The front face and aisle side of the enclosure shall be recessed for passenger leg clearance.

14.7 Overhead Luggage Rack

A. A continuous, satin finished, anodized aluminum luggage rack of open construction with transverse rods shall be provided on both sides of the car over the passenger seating areas.

1. Location of the racks shall maximize passenger head room and luggage storage space.

2. Luggage racks shall not be located above multiuse areas.

3. The gap between the rear edge of the luggage rack and the wall lining shall be minimized.

4. A formed bumper pad with contrasting color shall be provided along the bottom front edge of each luggage rack, along the bottom of each mounting bracket, and at the end brackets.

5. The luggage rack shall be designed to provide longitudinal and lateral restraint for stowed articles.

   a. Representative luggage weight may be assumed to be 25 pounds per foot of length.

   b. The luggage racks shall have sufficient strength to support a distributed load of 250 pounds (114 kg) applied midway between adjacent supports without permanent deformation. The luggage shelf shall not have more than 0.25-inch (6.4 mm) deflection at the center.

6. Each luggage rack shall be sufficiently sloped towards the exterior wall to avoid sliding of objects. The front edge and ends of the luggage rack shall have a longitudinal lip to ensure retention of luggage against transverse and longitudinal forces.

   a. A transverse lip shall also be provided at each wall support location to prevent the longitudinal motion of luggage. These safety lips shall be designed to withstand a 300-pound concentrated load without exceeding the yield strength of the luggage rack structure.

7. Details of the design, construction, installation, and arrangement of the luggage racks shall be as proposed by the Industrial Designer and submitted. **(CDRL 14-11, Luggage Rack/Stack Design)**

14.8 Airport Car Luggage Storage

A. Each Airport Car shall have 4 luggage storage stacks in addition to the overhead luggage racks provided.

B. Vertical luggage stacks shall not intrude on the aisle and shall take the space of approximately one 2+2 seat including the required legroom of the seated space..

C. Luggage stack design shall incorporate the following:

1. Luggage stacks shall include 2 shelves which can flip up and lock in place to accommodate larger baggage or bicycle storage within the stack.

2. Luggage stack side support and shelves shall be of round, tubular, brushed stainless-steel construction so that seated passengers can see their bags.

   a. Luggage stack side support may include safety glass sides or be open.

3. Bumper guard shall be mechanically attached to the wall panel within the luggage stack to prevent damage to the walls or luggage.

4. Luggage stacks shall have sufficient strength to support a load of 250 lbs midway between adjacent supports with a deflection not to exceed 0.25 in and without permanent deformation.

5. The shelves shall be inclined upward from the sidewall toward the center of the car at an angle of approximately 3-5 degrees to prevent luggage from sliding off the rack during typical railcar motions while in operation.

6. The overall size of the luggage stack shall be Approved.

7. Luggage stack mounting provisions shall be included in all cars, including the standard vehicles, in order to allow easy conversion by SEPTA from standard to airport service cars in the future.

D. Details of the design, construction, installation, and arrangement of the luggage stack shall be as proposed by the Industrial Designer and submitted. **(CDRL 14-11, Luggage Rack/Stack Design**

14.9 Emergency Equipment

14.9.1 Fire Extinguisher and Pry Bar

A. In accordance with the requirements of 49 CFR Part 239.101, each car shall be equipped with a fire extinguisher and a pry bar.

1. The fire extinguisher shall contain 20 lbs of ABC dry chemical and shall be equipped with a pressure gauge.

a. The extinguisher shall be located in a passenger accessible locker, having an Approved method of securement and access.

b. The extinguisher shall be hydrostatically tested prior to initial filling and have tags indicating the inspection date and the inspector's signature.

c. The extinguisher shall be marked in 2-inch-high letters "Property of SEPTA."

2. A 2-foot-long painted steel prybar shall also be located in the fire extinguisher mounting recess.

a. The prybar shall be permanently marked "SEPTA."

3. The design and location of the fire extinguisher and pry bar installation shall be developed by the Industrial Designer. **(CDRL 14-12, Emergency Equipment Locker)**

B. Safety Appliance placement shall take into account retrofitting of the low level doors to high-level. Any additional safety appliances shall be installed as required. Where installation is not feasible, provisions for installation shall be made.

14.10 Insulation

14.10.1 General

A. Provide thermal and acoustic insulation in the floor, roof, sides, doors, step wells, and ends of the cars, as required to meet the interior noise and air-comfort performance requirements of this section and Section 2 Design and Performance Criteria.

1. All insulation used shall be service proven for rail applications and meet the requirements of Section 16, Materials and Workmanship.

2. All thermal insulation should be retained in position by the use of Approved mechanical fasteners.

B. An analysis of the proposed insulation design and locations shall be submitted. (**CDRL 14-13, Insulation Arrangement)**

14.10.2 Thermal

A. The thermal insulation system shall limit heat transfer of the completed car shall not exceed a maximum of 700 BTU's/hour/^{o}F (372.7 W/°C), measured in accordance with Section 15, Test Program.

1. All insulation shall be protected by a continuous vapor barrier.

2. Thermal breaks shall be provided in locations where it is necessary to interrupt an all-metallic path between the interior of the carbody and the outside of the carbody skin.

14.10.3 Acoustical

A. A vibration and sound damping material shall be applied to inner surfaces of all areas of the carbody structural shell, including subfloor pans, ends, roof, and side frames.

1. The damping material shall be a spray applied, water base, non-asphaltic, silica free, filled polymer in an emulsion form.

2. A protective primer shall be applied as required by the manufacturer's recommendation prior to the application of the sound deadening compound.

14.11 Signage

14.11.1 General

A. All signage, colors, material, and application details shall be Approved. Detailed information on signage appearance and location on the car, as well as renderings of the signage in context of that location shall for provided. **(CDRL 14-14, Signage Design and Arrangement)**

B. The signs and markings used on the cars shall be as proposed by the Industrial Designer and submitted for Approval.

C. All signs and markings shall be provided as required by 49 CFR 223.17, 49 CFR 238 Subpart B, and 49 CFR 239.107.

D. All signs, decals and labels shall have radiused corners.

E. All vinyl film and decals shall suitable for railroad car service with Approved graffiti-resistance protective coating, and have a minimum service life of 15 years.

1. Vinyl film and decals shall be installed on flat surfaces only.

2. Edge sealing methods shall be applied to prevent deterioration from cleaning solutions or peeling.

F. Metallic signs shall be engraved and black epoxy powder coat, or paint-filled stainless-steel plates.

G. All metallic sign mounting rivets shall be self-sealing stainless steel.

14.11.2 Safety Related Signage

A. Interior Safety-Related Signage

1. All emergency exit/access signage systems shall enable passengers, train crew and emergency responders to make positive visual identification of exit/access points without undue hesitation, delay, or confusion.

2. All emergency exit/access signage shall comply with the requirements in 49 CFR 238 Subpart B for exit doors, door releases, windows, and emergency instruction. Emergency Instruction space shall be measured at 20 inches by 28 inches.

3. Interior emergency signs shall include raised lettering and Braille typeface for the visually impaired and shall be Tedlar coated decals.

4. An Approved vinyl sign shall be located at the top of each side door leaf warning passengers to not lean on doors.

5. An Approved vinyl sign shall be located at the top of each carbody end door warning passengers to not pass through doors.

6. A suitable vinyl sign shall identify the location of the fire extinguisher and pry bar in each car.

B. Exterior Safety-Related Signage

1. Emergency Roof Access signage shall comply with the requirements in 49 CFR 238.123 and coordinated with Section 3, Carbody.

2. To enhance grade crossing and operational visibility, the following markings shall be applied using a 4-inch wide highly reflective white vinyl film:

   a. Safety stripe shall be applied in a horizontal straight line centered on the side sills.

   b. Two stripes shall be applied at each cab end of a car, across the bottom and the top of the car end.

3. Each step well shall have engraved stainless steel "Watch Your Step" signs.

14.11.3 Emergency High-Performance Photoluminescent (HPPL) Signage

A. High Performance Photoluminescent (HPPL) and Low-Location Exit Path Markings (LLEPM) used on the car shall comply to requirements in 49 CFR 238 Subpart B and APTA PR-PS-S-006-23, Emergency Egress/Access Signage and Low-Location Exit Path Markings for Passenger Rail Equipment.

1. HPPL markings on the floor are prohibited.

2. All aisleway HPPL markings shall be assemblies that are mechanically fastened to the seats to indicate the pathway for egress in an emergency.

3. HPPL around the doorways, steps, and in vertical locations can be of adhesive type.

14.11.4 Passenger Information Signage

A. A SEPTA logotype shall be located centered in the window deadlight area outboard of the side doorways. A logotype shall also be located at each cab end of a car. Each logotype shall be accompanied with the words "SEPTA" in proportionate height.

B. A no smoking logotype shall be installed at each side doorway.

C. All accessible signage shall comply with the requirements of 49 CFR 38 Subpart E.

D. Each side door shall have a 1-inch high alphanumeric vinyl number sign located on the door side of the windscreen to identify each door leaf.

E. A SEPTA system map, each 1 foot 10 inches (86.3 cm) wide by 1 foot 10 inches (86.3 cm) high, shall be installed using an unobtrusive brushed aluminum or stainless steel frame on the inboard face of a door pocket lining at each doorway.

1. The maps shall be printed on 20-point Rupaco board and subsequently laminated with 8 mil clear vinyl film.

14.11.5 Crew and Maintenance Signage

A. Except as specified or Approved otherwise, exterior non-emergency signs and numbers shall be of exterior-type reflective, UV-protective, decorative vinyl film, Roboto Medium Font, 5-in (127-mm) numbers. Where a logotype is applied to vinyl film, it shall be protected by the final lamination of clear vinyl film.

B. The Contractor's serial number and SEPTA car number shall be stamped into a permanent element of the carbody, per Section 2, Design and Performance Criteria. The "F" end of each car shall be identified using a cast stainless steel or aluminum plate riveted to the side sill on both sides, in accordance with 49 CFR Part 229.11. A cast stainless steel builder's plate shall be riveted to the end of the side sill at the "F" end, below the cab. The plate shall read:

"Silverliner VI"

Built for Southeastern Pennsylvania Transportation Authority by

(Contractor) at *(location)*. Built: *(year)*

C. All underfloor and roof apparatus, control device, valve, cutout cock and test fitting shall be identified in an Approved manner using mechanically fastened permanent identification labels, using engraved stainless-steel signs filled with black enamel paint and having rounded corners to prevent injury.

1. Each equipment or device shall be identified.

2. Each valve or switch shall have the open/closed or normal/cutout positions identified.

3. All major components contained within each enclosure shall be permanently identified in an Approved manner. Each safety catch shall be identified.

4. Signs shall be installed in a horizontal orientation, and where Approved may be installed on the pipe adjacent to a control valve by use of stainless-steel wire.

D. All doors and cover plates guarding electrical equipment with a potential of greater than 150 volts shall be marked "Danger - High Voltage" in accordance with 49 CFR Part 229.85.

E. The car number specified in Section 2, Design and Performance Criteria, shall be located at each end of the car using a riveted, stainless-steel sign with engraved, black filled, 2-inch-high (50.8 mm) numerals. In addition, each cab in a car shall be equipped with a riveted black anodized aluminum sign with engraved, white filled, 1-inch (25.4 mm) minimum height horizontal format numerals.

F. The car number shall be located on the roof in 2-foot-high (61 cm) digits to facilitate airborne identification.

14.11.6 Other Decorative Treatments and Frames

A. A decorative treatment drawing comprising feature stripes, areas or logos as developed by the Industrial Designer shall be submitted for Approval and included in Mockups as described in Section 25, Program Management and Commissioning.

B. An unobtrusive brushed aluminum or stainless-steel frame, located on the outside of the electric locker partition aft of the Operator's cab, shall be designed to retain slide-in special public notices printed on card stock.

1. The card holder shall accept two side by side cards, each 8.5 inches (215.9 mm) wide by 11 (279.4 mm) inches high, and a card 17 inches (431.8 mm) wide by 8.5 inches (215.9 mm) high positioned directly under the two smaller cards.

C. Digital advertisement screens shall be flush mounted to the sidewall liner or partition walls as decided with SEPTA during design review.

14.12 Exterior Accessories

14.12.1 Buffers

A. Hinged walkway plates of an Approved design having a safety tread surface shall be provided at each end of every car to provide a continuous walkway between coupled married pairs. The design of the walkway plate shall be coordinated with the carbody end door threshold. The walkway plate shall rest upon a spring-loaded buffer assembly:

1. The buffer faces shall be free to move in a direction parallel to the length of the car to the extent required for the track curvature identified in Section 2, Design and Performance Criteria.

2. They shall be guided and held against the face plate of a coupled car by a suitable side stem and compression spring arrangement. The side system shall incorporate a means to adjust the face plate to compensate for manufacturing tolerances so that it is parallel within 0.5 degree to a true vertical plane extending from the top of the running rail.

3. The design of the buffer assembly shall minimize noise transmission, and there shall not be any metal-to-metal contact.

4. All combinations of car coupling, and different ride heights shall be evaluated so that the buffer assembly of one car cannot override the other.

5. Buffer pins shall be captive.

6. All buffers shall be identical and interchangeable.

14.12.1.1 Face Plate

A. A stainless steel, spring loaded, buffer vertical face plate shall be provided at both ends of each car:

1. The face plate shall support the foot plate and press against the matching face plate of a coupled car.

2. Materials and dimensions shall be such that the buffers will not bind under any operating condition, including deflated air springs and worn wheels on one car and over-inflated air springs and new wheels on a coupled car.

3. An easily replaceable non-metallic wear plate shall be provided on the contact surface of the buffer face plate. Wear plates shall be designed to last the life of the car.

4. The face plate and side stem shall have replaceable hardened manganese steel bushings and washers at all connection points between the buffer face plate and the side stem.

   a. The side stem rod guides shall operate in a self-lubricating non-metallic brushing and shall be contained in a sound deadening material.

14.12.1.2 Foot Plate

A. A hinged, stainless steel foot plate with a non-skid surface, shall be provided as part of each buffer assembly to provide a walkway for train crew and passengers between married pairs.

1. The foot plate shall rest upon the buffer face plate and shall be readily removable to permit access to the emergency lifting holes in the end sills.

   a. Hinges shall be fabricated from a durable, noise free material requiring no lubrication.

2. The foot plate shall have an Approved sound deadening wear material at all points of contact with the buffer face plate.

14.12.2 Intercar Safety Chains

A. To provide for safe passage between coupled cab ends , every F end cab end of each car shall have a set of integral safety chains installed.

1. Three safety chains shall be furnished on all cab end doorways, located on the left hand (non-cab) side of the body end doorway as seen from inside the car looking out the windshield.

2. All chains shall be stainless steel and shall terminate in a stainless steel rod with hooks to engage stainless steel mounting eyes located on the adjacent car.

3. The rod and chain assembly shall be stored in a small recess in the car end covered by a door when not in use.

4. The door shall be of the same material and exterior shape as the end of the car and painted to match the car end. All chains shall have an Approved covering such as rubber hose to prevent noise.

5. When the cars are coupled, the rod and chain assembly shall be extended from the ends of the adjacent cars and shall fit into the eyes provided on the coupled car by the train crew. The safety chains shall also mate with a Silverliner V car when coupled.

14.12.3 High Platform Between Car Barriers

A. Each car shall be equipped with ADA compliant between-car barriers, located on each corner. The design and finish shall be proposed by the Industrial Designer and Approved. Barriers shall comply with the requirements of 49 CFR 38.109.

1. Between car barriers shall be automatically engaging, spring-loaded, lever arm type gates of an Approved configuration.

   a. The gates shall be constructed of stainless steel and shall be brush finished to match the exterior finish of the car. All components of the gate assembly as well as attaching hardware shall be stainless steel.

b. The gates shall be properly secured into carbody structure.

c. Easily replaceable non-metallic wear plates shall be installed on the vertical contact surfaces of the gates. Wear plates shall be designed to last the life of the car.

2. An Approved strap arrangement shall be provided between the outboard end of the gate and carbody to limit the swing of the gate away from the carbody. The strap length shall be set so that, on level and tangent track, the gates of two coupled cars are in contact.

3. A mechanical keeper latch shall be provided for each gate to retract and secure the gate against the end of the carbody when required. The latch shall be constructed of stainless steel and shall not require a key for operation.

Details of the design, arrangement, and installation of the barrier shall be submitted for review. **(CDRL 14-19, Inter-car Barrier Details)**

14.12.4 Safety Appliances

A. Each car shall be provided with safety appliances (handrails, handholds, ladders, steps) conforming to the requirements of 49 CFR Part 231 and APTA PR-M-S-016-06 Safety Appliances.

1. Safety appliance construction, strength, rigidity, hand clearance, and location arrangement details are defined and detailed in APTA PR-M-S-016-06 Safety Appliances.

B. In addition to the descriptions in APTA PR-M-S-016-06, the Contractor shall comply with the following requirements:

1. Horizontal handholds shall be provided at the bottom edge of each end, on each side of the coupler.

2. A handhold shall also be provided at the end of the roof on all pantograph-equipped cars, aligned with the roof ladder, to assist in climbing to the roof. This handhold shall be concealed by the manual grounding switch handle.

3. A vertical handhold shall be located on each side of the side door, above the side door step, which shall be recessed into the carbody.

4. An Approved ladder constructed of stainless steel shall be furnished at the pantograph end of every pantograph-equipped car to provide access to the roof.

a. Unauthorized use of the ladder shall be physically prevented.

b. The rungs shall be self-cleaning and have an anti-slip upset surface.

c. Non-slip stainless steel handholds shall be provided at both top and bottom of the ladder for ease of maintenance access.

d. The operating handle of the pantograph lockdown and grounding lever (see Section 10, Propulsion and High Voltage System) shall be located at the top of the ladder, arranged to obstruct access to the roof from these steps unless the car and pantograph are grounded.

C. Safety Appliance placement shall take into account retrofitting of the low-level doors to high-level. Any additional ladders or other safety appliances shall be installed. Where installation is not feasible, provisions for installation shall be made.

D. All safety appliances such as steps, handholds, ladders, walkways, etc., shall meet all the requirements of carbody structure equipment supports for that particular piece of equipment, and shall not be fastened to welded bosses whose sole function is to support human weight.

E. An ergonomic evaluation shall be performed by the Industrial Designer and Approved regarding the size, placement, and necessary handholds.

F. The design and installation of all safety appliances shall be submitted. **(CDRL 14-15, Safety Appliance Arrangement)**

G. At least 60 days prior to the shipment of the fully assembled pilot cars, the Contractor via SEPTA shall notify the FRA's Office of Safety Assurance and Compliance that the car is ready for inspection. The Contractor shall then coordinate a sample car inspection with the FRA's designated representative(s). The Contractor shall address all deficiencies found during the sample car inspection to ensure that the car complies with all CFR requirements. See Section 25 Program Management and Commissioning, for further details **(CDRL 14-16, FRA Sample Car Inspection)**

14.12.5 Door Key Switch

A. The key switch for the door shall have a hinged, spring loaded cover, and lock with a crew key.

14.12.6 Underframe Protective Device Arrangement

A. All protective devices on the car that are not specifically required to be located inside the carbody, or to have provisions for resetting from within the carbody, shall be located undercar with access from the side without crawling underneath the car.

B. Provisions shall be made for access to such devices without encroaching upon the car dynamic clearance envelope.

C. Protective Devices shall include air brake cutouts, truck cutouts, circuit breakers, fuses, latching protective relays, and other devices requiring resetting or replacement to move

the car or cause auxiliaries to function. See Section 9 Auxiliary Power, Section 11 Trucks, and Section 12, Friction Brake, for additional information.

D. Locations for all protective devices shall be identified on arrangement and installation design drawings. **(CDRL 14-17, Underframe Protective Device Arrangement)**

14.13 Equipment Enclosures

14.13.1 Equipment Access

A. Apparatus requiring frequent inspection or attention shall be readily accessible and replaceable. Apparatus requiring attention more frequently than every 180 days, or in emergencies, shall be accessible from the side of the car or in an Approved location.

B. All other apparatus shall be arranged to provide ready access from maintenance pits and/or from the side of the car and/or from access panels in interior Approved locations.

C. Large apparatus shall be capable of convenient replacement by a forklift from the side of the car or by overhead crane through appropriately sized roof access panels. The Contractor shall supply, at no additional cost, all special material handling equipment required for car mounted apparatus, such as lifting and storage frames for HVAC units and lifting rigs for air reservoirs.

D. The frequency of required service shall determine the degree of accessibility.

14.13.2 Underfloor Equipment Enclosures

A. Underfloor equipment enclosures shall be welded stainless steel or aluminum with appropriate dissimilar metal arrangement as described in Section 16 Materials and Workmanship. The battery box shall not be aluminum.

B. Enclosures shall be provided with top-hinged doors that have suitable means for ready removal and door hardware that remains captive.

1. All hardware used shall be stainless steel. Access panel covers shall have captive fasteners.

2. Top-hinged doors shall be interchangeable between the corresponding enclosures on different cars.

3. All doors shall be provided with the same quick-release, spring-loaded latch that operates with a toggling type action.

4. A spring-loaded safety catch shall be provided at the center of each equipment enclosure cover. The safety catch shall be designed to retain the cover within the car dynamic clearance envelope at all operating speeds without the door latches engaged.

5. Doors shall have one or more handholds with adequate hand clearances for a person wearing gloves.

6. Doors shall have a “hold open” feature to facilitate inspection and maintenance.

C. The outer vertical faces of enclosures and apparatus mounted along a side sill shall all be equidistant from the longitudinal centerline of the car (i.e., shall all lie in the same vertical plane) unless otherwise Approved.

D. Devices enclosed in underfloor enclosures shall not be fastened directly to the walls, roof, or floor of the enclosure.

E. All underfloor equipment shall be protected from debris strikes.

1. If separately mounted shields are used to provide such protection, they shall not hinder the flow of heated air from underfloor equipment or accumulate snow, ice, or other debris.

F. All underfloor equipment boxes on the exterior which are required to be watertight shall be rated to IP56 or higher, except for condensation drain holes.

1. The drain hole shall have baffling such that rain, snow and dirt cannot enter while the car is in motion. Drain holes shall be fitted with stainless steel cotter keys or other Approved, simple drain clearing mechanisms.

G. All cables shall have sufficient slack for ease of installation and drip loops.

H. The general arrangement of all underframe equipment and enclosures shall be submitted. **(CDRL 14-18, Underframe Equipment and Enclosure Arrangement)**

14.14 Roof Shrouds

A. Shrouds or other Approved aesthetic treatment shall be used to conceal roof mounted equipment, as proposed by the Industrial Designer and submitted for Approval.

B. Shrouds shall be made of the same material as roof sheets, designed to harmonize with the car design, and not interfere with any ventilation requirements of roof mounted equipment or air intakes.

C. All side and end openings in the shrouds shall be screened as required for ventilation, especially for the brake resistor. Perforated stainless steel screening or equivalent, as Approved.

D. All roof arrangements shall prevent accumulation of leaves, water, car wash cleaner, snow, ice, or debris.

14.15 Contract Deliverable Requirements List (CDRL)

The following contract deliverables have been identified in this section; however, the Contractor is responsible for providing and submitting anything necessary to fulfill the requirements of this contract, including those not identified by CDRL number.

CDRL 14-01, Interior Arrangements 14-1
CDRL 14-02, Industrial Design 14-1
CDRL 14-03, Materials Samples and Finishes 14-1
CDRL 14-04, Stanchion and Handrail Arrangement 14-7
CDRL 14-05, Passenger Steps Samples 14-8
CDRL 14-06, Floor Covering Arrangement, Installation and Repair 14-11
CDRL 14-07, Emergency and Rescue Access Window Design and Arrangement 14-14
CDRL 14-08, Seat Design and Installation 14-16
CDRL 14-09, Equipment Locker and Access Panel Locations 14-24
CDRL 14-10, Keys and Locks 14-24
CDRL 14-11, Luggage Rack/Stack Design 14-25
CDRL 14-12, Emergency Equipment Locker 14-27
CDRL 14-13, Insulation Arrangement 14-27
CDRL 14-14, Signage Design and Arrangement 14-28
CDRL 14-19, Inter-car Barrier Details 14-34
CDRL 14-15, Safety Appliance Arrangement 14-35
CDRL 14-16, FRA Sample Car Inspection 14-35
CDRL 14-17, Underframe Protective Device Arrangement 14-36
CDRL 14-18, Underframe Equipment and Enclosure Arrangement 14-37

14.16 CDRL Detail

This section lists the expected content for each CDRL required above. The lists provided for each CDRL are an outline only and should not be considered exhaustive, all CDRLs are subject to SEPTA review and Approval.

CDRL 14-01 Interior Arrangements

1. Submit general arrangement drawing for the interior.
2. Identify locations for all interior equipment including but not limited to dimensions for doorway, aisleway, windscreens, stanchions, handrails, communications system equipment, windows, seats, multiuse areas, and interior lockers.
3. Include design concepts for the seating arrangements.
    a. Submit three different seating arrangements for SEPTA's selection and Approval.

CDRL 14-02 Industrial Design

1. Include renderings to provide examples of the design features including colors, finishes, surface finishes, materials, and other details.

2. Special attention shall be given in the design regarding human factors and ergonomics for train crew and passengers in accordance with the requirements of Section 2, Design and Performance Criteria.

CDRL 14-03 Materials Samples and Finishes

1. Submit samples for all colors, patterns, textures, and surface finishes to be used for each type of base material (stainless steel, aluminum, FRP, thermoplastic, etc.).

2. Include sample HPPL marking assembly that is mechanically fastened to the passenger seats.

CDRL 14-04 Stanchion and Handrail Arrangement

1. Submit dimensioned arrangement layout for all interior stanchions and handrails.

2. Include reference dimensions relative to the top of finished floor, hand clearance, and doorway opening clear width.

CDRL 14-05 Passenger Steps Samples

1. Samples of the step wells shall be provided, including high contrast markings, step tread and anti-slip features.

CDRL 14-06 Floor Covering Arrangement, Installation and Repair

1. Submit floor covering interface details for all joints with walls, partitions, liners, molding, thresholds, etc.

2. Submit sufficient detail for repair and replacement of the floor covering.

CDRL 14-07 Emergency and Rescue Access Window Design and Arrangement

1. Submit emergency window details to show compliance to 49 CFR 223.9, 49 CFR 238.113, 49 CFR 238.114.

2. Include dimensions showing unobstructed clear opening dimensions with complete interior installed.

CDRL 14-08 Seat Design and Installation

1. Submit all seat type dimensions.

2. Submit details for seat frame, seat back, seat bottom, cushioning, and seat pedestals.

3. Include documentation with installation instructions for passenger seats and their attachment to the carbody.

CDRL 14-09 Equipment Locker and Access Panel Locations

1. Identify all equipment that must be accessible for periodic maintenance.
2. Provide a layout for locations of all electrical components in lockers.
3. Submit a drawing that shows all locker doors and access panels in the fully opened position.
4. Identify lockers that require limited access by SEPTA Railroad Division for cybersecurity.

CDRL 14-10 Keys and Locks

1. Provide documentation detailing each type of key and respective lock, as well as their locations on the car.

CDRL 14-11 Luggage Stack Design

1. Provide design details for luggage rack/stack including bumper pad.
2. Provide structural analysis to demonstrate strength requirements.

CDRL 14-12 Emergency Equipment Locker

1. Provide location details for access to fire extinguisher and prybar.
2. Include description for locker door, latches, and signage.

CDRL 14-13 Insulation

1. Identify all areas using thermal and acoustic insulation. Describe each type of insulation used and the amounts used in each area of the car.
2. Attachment methods for each insulation type shall be clearly defined.
3. Provide preliminary calculations to determine the carbody heat transfer value that will be coordinated with the HVAC system.

CDRL 14-14 Signage Design and Arrangement

1. Submit drawings for all signs. Identify material (vinyl or metallic), location (interior, exterior), and attachment method. Include all HPPL signage and markings.
2. Describe the method of edge sealing to be used for each sign where applicable.

CDRL 14-15 Safety Appliances Arrangement

1. Submit dimensioned arrangement drawing for all safety appliance types and locations.
2. Provide details to demonstrate compliance to 49 CFR 231 and APTA PR-M-S-016-06.
3. Provide details for retrofitting safety appliances for future low-level doors to high level door conversion.
4. Provide structural analysis to demonstrate strength requirements.

CDRL 14-16 FRA Sample Car Inspection

1. Documentation of the configuration of the vehicle safety appliances, to which no exception was taken by the FRA.

CDRL 14-17 Underframe Protective Device Arrangement

1. Submit arrangement drawing for underframe layout with all protective devices.
2. Include dimensions from carbody sidewall to each protective device to demonstrate accessibility from the side of the car.

CDRL 14-18 Underframe Equipment and Enclosure Arrangement

1. Submit dimensioned arrangement drawing including all underframe equipment and underframe enclosures.
2. Submit a drawing that shows all enclosure doors unlatched and retained only by the safety catches. Include car dynamic clearance outline to verify compliance.

CDRL 14-19 Inter-car Barrier Details

1. Details of the design, arrangement, and installation of the inter-car barrier shall be provided.

14.17 List of Standards Referenced

49 CFR 38	Americans with Disabilities Act (ADA) Accessibility Specifications for Transportation Vehicles – Commuter Rail Cars and Systems
49 CFR 223	Safety Glazing Standards
49 CFR 229	Railroad Locomotive Safety Standards
49 CFR 231	Railroad Safety Appliance Standards

49 CFR 238	Passenger Equipment Safety Standards
49 CFR 239	Passenger Train Emergency Preparedness
APTA PR-CS-S-006-98	Attachment Strength of Interior Fittings for Passenger Railroad Equipment
APTA PR-CS-S-016-99	Passenger Seats in Passenger Railcars
APTA PR-M-S-016-06	Safety Appliances for Passenger Equipment
APTA PR-PS-S-006-23	Emergency Egress/Access Signage and Low-Location Exit Path Markings for Passenger Rail Equipment
ASTM D2047	Standard Test Method for Static Coefficient of Friction of Polish-Coated Flooring Surfaces as Measured by the James Machine

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TEST PROGRAM

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15.1 Introduction

A. The Contractor shall plan, conduct, and maintain a test program to verify the conformance of components, assemblies, subassemblies, subsystems, cars, and married pairs to Drawings, Specifications, and performance requirements.

1. Prepare a Master Test Plan as specified in TS 15.3.3.1. The Contractor is responsible for designing, scheduling, managing, and executing this test program.

2. The tests specified in this Section contain varying degrees of detail. This Section compiles the tests for the Project. However, in some cases, where necessary to provide the appropriate context, the details of certain tests are specified in other sections of the Specifications.

3. If the Contractor wishes to propose additional or replacement tests to those required in the Specifications for Approval, the proposals for these additional or replacement tests shall be included in all relevant design review packages.

4. The Contractor is also responsible to fulfill all requirements called for by the Federal Railroad Administration for testing passenger equipment which has not been used in revenue service, per the requirements of 49 CFR 238.111(b) for Tier I equipment, for submission by SEPTA to the FRA.

5. The Contractor shall ensure that all test procedures and reports are formally reviewed and approved for validity and reliability by their engineering department prior to their submittal to SEPTA.

15.2 Scope and Responsibilities

15.2.1 General Requirements

A. Comply with the following:

1. Implement a comprehensive test program to perform testing and associated inspection of all items of work required by the Specifications, including those performed by subcontractors or suppliers. The test program shall detail the methods and test procedures to ensure that all design, materials, performance, safety, and completed work conform to the Specifications and other Contractual requirements (e.g., RAMS).

2. Perform comprehensive testing, as necessary, on all equipment, subsystems, individual cars, married pairs, and trains to meet the performance requirements set forth in the Specifications.

3. Submit test procedures and corresponding test reports for Approval. The test documentation must verify and confirm that all functions identified in the design documentation are tested and the test results confirm compliance with the design requirements.

4. All tests shall be conducted to the Approved test procedures.

5. All costs associated with testing shall be borne by the Contractor, including tests that have failed and/or require retesting. For such re-test costs, the contractor shall reimburse SEPTA costs, such as the provision of test support staff.

6. Provide all calibrated instruments, personnel, and apparatus required for testing.

7. Perform a complete retest of the subject item to demonstrate compliance to the Specifications if the design of an item is changed after a test is conducted.

15.2.2 Contractor Responsibilities

15.2.2.1 Witnessing and Notification

A. Arrange all specified tests to facilitate witnessing and verification by SEPTA. The FRA shall also be invited to witness tests.

1. Furnish at least 45 days written notice to SEPTA prior to the start of each specified test. A copy of the plan will be submitted to FRA at least 30 days before testing the equipment and include with that submission notification of the times and places of the pre-revenue service tests to permit FRA observation of such tests.

2. Ensure that the status of all tests is tracked and updated in the Master Program Schedule as specified in Section 25, Program Management and Commissioning.

3. Furnish a monthly test schedule of all testing activities and associated work on SEPTA property. If there are changes to the schedule, give at least 48-hour notice to SEPTA.

15.2.2.2 Staffing

A. Ensure appropriate staffing levels are provided to support all the test activities under this Contract.

1. Furnish a resource labor profile showing proposed completion dates for tests and inspections in the timeframe allocated in the schedule. The staff scheduling and coordination of all testing shall match the type of test and pace of work activities.

2. Furnish test personnel that are adequately trained and experienced to safely conduct and lead all tests and task activities under this Contract.

3. Ensure that all personnel have completed the safety training appropriate for the test and relevant work they will do.

4. Contractor and supplier personnel working on SEPTA's property shall undergo background checks for security purposes, and SEPTA's safety training prior to access to SEPTA facilities. They shall adhere to all SEPTA rules and regulations.

5. Become familiar with SEPTA's operating rules, processes and procedures concerning the operational testing in revenue and non-revenue service. The Contractor shall be present during all design qualification and routine tests.

6. Ensure adequate technical support, including software from the original designers, manufacturers, or both, of the key subsystems, such as propulsion, friction brake, side doors, communications, lighting, etc.

15.2.2.3 Operational Condition Assessment (OCA)

A. Prior to Conceptual Design Review (CDR), conduct an Operational Condition Assessment (OCA) to become familiar with all aspects of the Regional Rail System, including the current fleet and maintenance practices for all asset types.

1. As part of the OCA, perform the following tasks at a minimum:

a. Evaluate the existing car wash, as specified in Section 2, Design and Performance Criteria.

b. Evaluate the Regional Rail Systems physical characteristics, including dynamic clearances, station platforms, track geometry, and route profiles, as specified in Section 2.

c. Evaluate the catenary wire voltage characteristics and geometric characteristic, as specified in Section 2.

d. Evaluate the Regional Rail Systems, EMI characteristics, as specified in Section 2.

e. Evaluate inter-car swing and stretch conditions, as specified in Section 2.

f. Evaluate shop parameters in the context of BTE, as specified in Section 27, Special Tools and Test Equipment.

g. Gain a thorough understanding of shop performance and constraints by studying the maintenance practices, equipment, track condition, and other aspects of SEPTA's maintenance.

15.2.3 SEPTA Responsibilities

A. SEPTA will arrange access to the designated shops, test areas, yards, and mainline tracks as required. SEPTA will arrange for the necessary crew to conduct the required preparation for static and dynamic tests under the conditions specified in the Contract.

B. SEPTA will cooperate with the Contractor for the efficient implementation of testing, if it does not interfere with SEPTA revenue service operation. SEPTA has limited time

and track availability on its system, and therefore, both the time and location for testing are subject to change at any time, without penalty to SEPTA. However, SEPTA will notify the Contractor 24 hours in advance of the changes.

15.2.4 Third Party Test Facilities

A. In cases where the Contractor intends to use third party test facilities to perform static or dynamic tests, or both, that may require the equipment or car or married pairs to be moved to a specialized test center, those activities shall be declared in the Master Test Plan (see TS 15.3.3.1).

B. Third party test facilities shall be accredited to ISO/IEC 17025, or Approved equivalent.

15.3 Testing Program

15.3.1 General

A. The tests specified in this Section are considered a minimum by SEPTA.

1. Ensure that each design and performance requirement of the Specifications is assigned to a specific test effort, or other method of compliance demonstration acceptable to SEPTA, whether or not such testing is explicitly identified in the Specifications.

2. Additional testing, at SEPTA's discretion, may be required to diagnose and resolve outstanding technical issues.

a. The Contractor is required to participate in and supply technical assistance for such tests.

b. If these additional tests demonstrate that any equipment is noncompliant with the Contract, the Contractor is responsible for all costs (including SEPTA's costs) associated with conducting each test that demonstrated noncompliance.

c. The Contractor is responsible for corrections and retests until compliance is Approved.

15.3.2 Classification of Tests

A. The required tests shall be defined and categorized as follows:

1. Qualification Tests: Tests that are performed on one item or a subset of items, as defined in the applicable subsection, to demonstrate compliance with design requirements. Qualification Tests shall be subcategorized as follows:

a. Component Design Qualification Tests: Tests that shall demonstrate compliance with design requirements at the component level. These tests shall focus on component functionality within specific

environmental requirements. These tests are typically performed at a manufacturer's facility or in a designated lab.

b. Carbody Structure Design Qualification Tests: Test that shall demonstrate compliance of the carbody structure, and associated component-to-carbody connections, with design requirements. These tests are typically performed at the Contractor's facility.

c. Subsystem Design Qualification Tests: Tests that shall demonstrate compliance with design requirements at the subsystem level. These tests are typically performed at a manufacturer's facility or in a designated lab.

d. Car and Married Pair Design Qualification Tests: Tests that shall demonstrate compliance with design requirements at the car and married pair level. These tests shall be performed at the Contractor's facility.

e. On-Site Qualification Tests: Tests that shall demonstrate compliance with design requirements at the car and married pair level within the SEPTA operating environment. These tests shall be performed on SEPTA property.

2. Routine Tests: Tests that are performed on every item to demonstrate compliance with pre-established production requirements. Routine Tests shall be subcategorized as follows:

a. Factory Routine Tests: Tests that shall demonstrate compliance with production requirements at the component and subsystem level, as defined in the applicable subsection. These tests are performed at a manufacturer's facility or in a designated lab.

b. Pre-Shipment Routine Tests: Tests that shall demonstrate compliance with production requirements at the car and married pair level. These tests shall be performed at the Contractor's facility prior to shipment to SEPTA.

c. Routine Tests at SEPTA: Tests that shall demonstrate compliance with production requirements at the married pair level within the SEPTA operating environment. These tests shall be performed on SEPTA property.

15.3.3 Test Documentation

15.3.3.1 Master Test Plan

A. Submit a Master Test Plan covering all tests required by the Specifications and 49 CFR 213, 229, 238, and 239. The Master Test Plan shall be submitted for review and Approval no later than 180 calendar days after the Notice to Proceed. **(CDRL 15-01,**

Master Test Plan), Note that this plan is different from the inspection and test plan specified in Section 22, Quality Assurance.

1. Review the entire Specifications when preparing the Master Test Plan, using Section 15 as the key template. In case of discrepancies between the requirements in this Section and more specific details in other sections, the requirements in the other sections of the Specifications shall prevail.

2. CDRLs have been assigned by test type in this Section. Furnish a numbering scheme to differentiate between tests for which separate test procedures and test reports will be submitted. It is up to the Contractor to determine which tests of each type will be combined and which will be performed separately, subject to Approval, if the tests as performed confirm that the requirements of the Specifications are met.

3. Prepare a CDRL numbering scheme for sub-CDRLs and formats of the Master Test Plan, test procedures, and test reports for discussion at the kick-off meeting.

4. The frequency and proposed schedule for each test shall also be included. The master test plan shall be submitted to the FRA to comply with 49 CFR 238.111.

5. The master test plan shall cover all supplier and subcontractor tests to be completed at their plants, all Contractor tests to be completed at their plant prior to issuance by SEPTA of a release for shipment document, and all testing to be conducted on SEPTA's property prior to the issuance of a certificate of acceptance.

6. This document shall be updated monthly and presented as an attachment to the program meeting minutes showing the status of each test procedure, test, and associated report summarized in a spreadsheet format.

15.3.3.2 Test Procedures

A. Prepare a detailed procedure for each test.

1. Submit each test procedure no less than 60 days prior to the beginning of the test.

2. Each test procedure shall include the following, at a minimum. Note that the test procedure structure is not required to follow the order shown below:

a. Table of Contents

b. Criteria, objectives, assumptions, and constraints

c. Test setup, including calibration of test equipment

d. Initialization requirements

e. Input data

f. Test instrumentation.

g. Expected intermediate test results, where applicable

h. Requirements for recording output data

i. Expected output data

j. Minimum/maximum requirements for valid data to consider the test successful

k. Pass/fail criteria for evaluating results

l. Safety considerations and hazardous conditions

m. Forms used to record data accumulated during the test

n. Revision history and revision notes

o. Engineer's signature

p. Reference table to identify documents used for guidance (for example, ASTM standards or reference drawings)

q. Table of acronyms and definitions

r. Any necessary drawing attachments relevant to the testing.

3. Forms shall also contain a step-by-step format for data reduction, formulae used in deriving the data criteria for acceptability, and justification for the criteria set forth.

4. Clearly state the test objectives, testing criteria, and pass/fail criteria in the test procedure and state in relation to design or operations specifications. The test procedure shall explain all steps with sufficient detail as to not create confusion during the test execution. Test procedures shall be submitted for review and approval.

5. Include traceability from the Specifications or requirements to the test procedure. Where practical, identify the individual procedural step that satisfies the requirement.

6. Except as otherwise specified, all specified tests shall be performed by the Contractor and its subcontractors.

15.3.3.3 Test Reports

A. Submit each report, including copies of all test data, within 30 days of completion of testing.

1. Keep test hardcopies of reports for component routine tests conducted at the supplier's facility and present the reports to SEPTA upon request.

2. Each test report shall follow the structure of the applicable procedure and include the following additional information, at a minimum:

    a. Test date/time, location, testing staff, and witnesses.

    b. All instrumentation calibration records.

    c. All raw data collected in the test shall be furnished in an open electronic format, but may be furnished in an appendix.

    d. All data reduction forms.

    e. Color photographs, videos, or any additional data necessary to support the test results, in SEPTA approved formats.

    f. A summary of the results in a manner that can be directly compared to the corresponding procedure(s) without further calculations. Indicate the values corresponding to the pass/fail criteria in tabular form in the test reports. Note conclusions drawn and required next steps.

    g. Test report summaries shall include any software or hardware updates or changes to the equipment under testing necessary to meet the pass/fail criteria and note any alternative methods approved from SEPTA.

3. Pertinent test data shall be maintained in a quantitative form to permit the evaluation of performance under the various specified test conditions.

4. All test report data shall be in US Customary Units.

5. Subcontractor-produced test reports shall be approved by the Contractor before submittal to SEPTA.

15.3.4 Test Failure, Anomaly, and Discrepancy Analysis

A. Document anomalies, discrepancies, and failures occurring during test activities and disposition as specified below as a minimum:

1. In the event of a test failure, submit a draft Failure Analysis Report (FAR) as soon as possible after the failure occurrence for SEPTA to evaluate the severity of the failure.

    a. If SEPTA instructs the Contractor to do so, suspend the corresponding test until SEPTA Approves the corrective action in the FAR.

    b. The FAR shall identify the unit being tested, equipment and cause(s) of failure, indicate what corrective action is necessary, and the extent of

such action. Where the Contractor recommends that no change be made, submit justification for the recommendation.

c. Submit the formal FAR within 10 days after the draft FAR.

2. In the event of a test anomaly or discrepancy, submit documentation to SEPTA regarding the causes of the anomaly/discrepancy and any required mitigation methods or corrective actions.

a. An anomaly or discrepancy is defined as any test behavior that is not in accordance with documentation, may cause damage to the component under test or other components over the lifetime of the car, or poses a safety risk to SEPTA employees or customers.

b. The Contractor shall propose a format for this documentation for Approval.

c. Documentation shall be made available to SEPTA electronically within one business day of the occurrence of the anomaly or discrepancy.

3. All failure, anomaly, and discrepancy documentation shall be generated by the Contractor but shall include necessary background information and findings developed by applicable subcontractors.

15.3.5 Test Instrument Calibration

A. Except as noted, the Contractor is responsible for the maintenance and calibration of all inspection and test equipment necessary to ensure that testing conforms to the corresponding test requirements.

1. Calibration information for all test equipment used shall be traceable from each test report. It is understood that some equipment does not require calibration; this equipment must be clearly identified in the test procedure.

2. For each piece of test equipment used to obtain test data, a copy of the calibration procedure used, particularly if the test equipment was calibrated in-house or according to the manufacturer's recommended calibration procedure, shall be available for review upon request by SEPTA.

3. If the Contractor uses its in-house lab to calibrate test equipment, it shall have on file a list of all calibration standards, including copies of calibration certificates and traceability to the National Institute of Standards and Technology (NIST) standard and they shall be available for review upon request by SEPTA.

4. If an outside lab performed any of the calibration on the test equipment used, furnish a copy of the lab's NIST certification to SEPTA.

5. For each piece of test equipment used to obtain test data, a copy of the calibration certificates and traceability to the NIST standard shall be on file at the outside lab and available for review upon request by SEPTA.

6. All test equipment shall have calibration stickers and calibration seals, where required, that are intact and in place.

15.3.6 Modification Testing

A. If a modification is performed after initial testing is completed, perform regression testing as necessary to demonstrate continued compliance with the Specifications.

1. For each modification, provide a regression test procedure with justification regarding why the regression tests in the procedure were chosen.

2. If the Contractor determines that the modification does not require regression testing, due to the nature of the modification, provide written justification.

3. Regression test procedures, and justification regarding whether regression is needed or not, shall be subject to Approval.

4. Software regression testing shall be carried out in accordance with the Testing and Testability requirements of Section 19, Software Engineering.

15.4 Component Design Qualification Tests

15.4.1 General

A. Components subjected to tests that could potentially shorten component life expectancy or damage the component (including but not limited to vibration tests, shock tests, failed high pot tests, and extreme temperature tests) shall not be used on any production cars, unless otherwise Approved.

B. Submit test procedures and test reports. **(CDRL 15-02, Component Design Qualification Tests)**

15.4.1.2 Scope

A. Perform the tests in this section on all equipment in the car as applicable, whether or not the equipment is specifically included under Component Design Qualification Tests.

15.4.1.3 Materials Design Qualification Tests

A. All materials used in cars shall have been tested to demonstrate compliance with the requirements in Section 16, Materials and Workmanship.

15.4.1.3.1 Elastomer Tests

A. Furnish test data no older than five years for all elastomers used on the car to confirm performance to the elastomer standards of Section 16, Materials and Workmanship.

1. Testing Standards:

a. Conduct all tests according to the specified ASTM test procedures, unless otherwise specified.

b. Test resilient, natural rubber mounts and elastomeric truck suspension components for flammability, smoke emission, and toxicity in accordance with the procedures outlined for elastomers in NFPA 130, as specified in Section 23, System Safety and Security; submit the results of the testing during design review.

2. Testing:

a. The test specimens shall be cut out from the extruded material.

b. Perform at least one tensile strength and elongation test and one accelerated aging test on the material used for each order.

c. If the compound or cure, or both, are changed during the production of material for one order, perform at least one test of each type for each different batch.

d. When testing the 6-inch by 0.5-inch (152 mm by 13 mm) ASTM "dumb bell" type test specimen (or smaller size if the size of the part necessitates) by the methods specified in ASTM D3182, D3183, D3190, and D412, the tensile strength shall not be less than 1,500 psi (10.34 MPa) and elongation shall be a minimum 250%.

e. The tensile strength of the elastomer shall not be reduced more than 25% when subjected to accelerated aging by the methods specified in ASTM D573, for a period of 96 hours in an air oven at 158°F (70°C).

f. Test the ozone resistance of the elastomer in accordance with ASTM D1149 using an ozone concentration of 1 ppm, an exposure time of 100 hours at 100°F (38°C), and a specimen elongation of 20%. The elastomer shall not exhibit any cracks during the test period.

g. Test elastomers used in the truck primary or secondary suspension per EN 13913. Recommend specific test parameters based upon the new car application for review and Approval by SEPTA.

h. The air spring diaphragm shall be per EN 13597. Recommend specific test parameters based upon the new car application for review and Approval by SEPTA.

15.4.1.4 Flammability, Smoke Emission, and Toxicity

A. All combustible materials used in construction of the car shall be tested for flammability and smoke emission to demonstrate compliance with the requirements of 49 CFR 238 and NFPA 130.

B. All materials used in construction of the car shall be tested for toxicity in accordance with BSS 7239 or SMP 800-C. The tests shall be conducted in the flaming mode after 240 seconds using the NBS Smoke Density Chamber for sample combustion.

C. The flammability, smoke emission, and toxicity tests shall demonstrate compliance with the requirements of Section 23.2, System Safety and Security, and Section 16, Materials and Workmanship. Flammability and Smoke Emission.

D. The procedures and performance criteria for flammability and smoke emission testing are given in NFPA 130.

E. Furnish the following information for all materials tested:

1. Date of test.

2. Test description.

3. Material description, including both the name, brand name, and part number of the material tested.

4. Test facility, including proof of accreditation.

5. Test results, including a statement explicitly indicating if the material has passed or failed the test.

15.4.1.5 Equipment Noise Tests

A. Perform noise design qualification tests on all noise generating car equipment early in the production phase, prior to installation on cars, to demonstrate compliance with ISO 1996-2, "Description, measurement and assessment of environmental noise" and Section 2, Design and Performance Criteria.

B. Conformance with the Specifications shall be based on measurements taken in essentially a free-field environment, away from any reflecting surfaces other than the surface on which the equipment is resting.

C. Take measurements at locations where reflected sound, such as from nearby walls, floor, or other equipment, will not influence the directly radiated sound from the equipment measured by more than 2 dB.

D. Take measurements with an ambient sound level in the vicinity of the test measurement locations of 10 dB or more below the noise produced by the equipment being measured, when evaluated using the same weighting or octave band.

E. Where auxiliary methods of driving or loading equipment such as motors or dynamometers are required, these devices shall be temporarily enclosed or baffled to eliminate their effect on the equipment noise being measured.

15.4.1.6 Equipment Shock and Vibration Tests

A. Equipment and subassemblies shall be tested in accordance with the requirements of IEC-61373 Railway Applications Rolling Stock Equipment Shock and Vibration Tests.

B. The equipment and subassemblies when installed on the cars shall comply with the requirements of Section 2, Design and Performance Criteria.

15.4.1.7 Electrical and Electronic Components

A. Perform qualification tests on all electrical equipment installed on the car in accordance with IEC 60077, IEEE Std 16, or EN 50124 (if Approved). All optional tests (including any tests noted in standards as being subject to contract agreement) shall be performed.

B. Perform qualification tests on all electronic equipment installed on the car in accordance with EN50155, IEC 60571 and IEC 61287 for power converters. All optional tests (including any tests noted in standards as being subject to contract agreement) shall be performed.

15.4.1.8 EMI/EMC Tests

A. Comply with the following:

1. Subject all vehicle and components, regardless of power level, to lab EMI/EMC tests. This testing shall ensure compliance with EN50121-3-1 and EN 50121-3-2, and shall include as a minimum the following tests:

    a. Radiated Emissions

    b. Conducted Emissions

    c. Radiated Susceptibility

    d. Fast Transient Bursts

    e. Electrostatic Discharge

    f. Surge immunity

    g. Fluctuations, dips, and short interruptions of voltage supply

    h. Reverse polarity protection for battery supply input

2. Develop a test procedure for each of these tests, and any other tests necessary to demonstrate compliance with the EMI/EMC requirements in Section 2, Design and Performance Criteria, and in any other Section of the Specifications.

15.4.2 Coupler Draft Gear and Link Bar

15.4.2.1 Coupler Strength Tests

A. Conduct the following tests to verify compliance with the coupler strength requirements specified in Section 4, Coupler and Drawbar.

1. Perform structural strength in Buff loading to automatic coupler, drawbars, anchorage and any other load bearing assembly to withstand the Buff loading requirements. The coupler equipment shall be documented before and after load testing to verify that no permanent deformation is detected through use of coordinate measurements systems, tram balls or alternative methods.

2. Perform structural strength in Draft loading to automatic coupler, drawbars, anchorage and any other load bearing assembly to withstand the Draft loading requirements. The coupler equipment shall be documented before and after load testing to verify that no permanent deformation is detected through use of coordinate measurements systems, tram balls or alternative methods.

15.4.2.2 Coupler Coupling Tests

A. Conduct tests to demonstrate mechanical coupling and uncoupling operation during both normal and worst case curving conditions. Coupler must be able to be coupled under all curving conditions defined by the Section 2, Design and Performance Criteria. Coupler must be able to uncouple, assuming not in draft or buff loading conditions, under all curving conditions defined by the Section 2, Design and Performance Criteria.

15.4.2.3 Coupler Electrical Heads Test

A. Conduct tests to demonstrate automatic coupling and uncoupling of electrical heads, including validation of trainline signals and network connection.

B. Conduct tests to demonstrate electric coupler head heaters can maintain the contact tips free of frost or ice in environmental conditions defined in Section 2, Design and Performance Criteria.

C. Conduct tests to demonstrate that advance / retract mechanisms, if provided, allow for operation after 1/8” ice buildup.

15.4.2.4 Coupler Centering Ability Test

A. Conduct tests to confirm the ability of the coupler, drawbar, and draft gear to remain properly centered and or return to center during operation at maximum speed and curving conditions defined in Section 2, Design and Performance Criteria. Curving simulation maybe performed by rolling coupler to equivalent angle to represent curving acceleration forces and returning coupler to level.

15.4.2.5 Coupler Gathering Range Test

A. Conduct tests to confirm the gathering range under all gathering range conditions defined in Section 4 Coupler and Draft Gear.

15.4.2.6 Coupler Pneumatic Heads Test

A. Conduct tests to demonstrate coupling and uncoupling of pneumatic heads when couplers are joined. Verification shall include loss of pressure during uncoupling leading to emergency brake application, triggering of air brake emergency vent valve.

15.4.2.7 Shear Pin Device Release Strength

A. Conduct tests to confirm that the pins shear under the load determined during the coupler and vehicle design.

15.4.2.8 Coupler Compatibility

A. The coupler compatibility tests shall confirm that the mechanical coupler heads are fully compatible, and there is no interference between the electric coupler heads when coupled to Silverliner IV and Silverliner V mechanically. No equipment damage is allowed to existing fleet or new fleet components.

B. When coupled mechanically and conduct test to verify pneumatic coupling between a Silverliner V car and a Silverliner VI cars and that when uncoupled cars enter emergency brake.

C. Testing shall also be performed between Silverliner VI and to each type of non-automatic coupler rail equipment (including locomotives, work cars, and coaches), utilizing SEPTA's existing N-2 to AAR Knuckle adapters WABTEC PN: 0574985.

15.4.2.9 Electric Coupler Watertightness

A. Conduct tests to ensure that the coupler system is not affected by water spray associated with service and car wash systems to IP55 minimum, in accordance with IEC 60529.

15.4.2.10 Thermal Performance

A. The coupler system shall be environmentally tested to verify that coupler performance is maintained. The test shall verify that the electric coupler contacts are free from frost and that the mechanical coupler spear prevents ice buildup under worst case environmental conditions defined in Section 2, Design and Performance Criteria.

15.4.2.11 Coupler Cycling Test

A. The equipment supplier shall perform a life cycle test of 10,000 cycles to verify that coupling performance is maintained. Plating of electric coupler contact tips and coupler nose shall not degrade to a level to inhibit operation or allow for rust/corrosion to develop. Rail service proven plating methodologies may be

presented for approval. Each cycle shall include advancing, coupling, uncoupling, and retracting of electrical heads.

1. During the test, all pins shall be energized to simulate, to the extent possible, electrical loads and operation of the electrical heads in service.

    a. Appropriate inductive loads or capacitive loads shall apply.

    b. At the end of each forward and reverse movement, verify that the mechanism is in the correct condition.

    c. Examine selected contacts representing the worst cases periodically during the test and at the conclusion of the test to confirm the contact resistance remains within specification.

    d. Test network pins for the specified bandwidth and bit error rate, at the beginning and the conclusion of the test.

2. Disassemble the retracting mechanism after the test to verify and record equipment condition and wear. There shall be no deformations, cracks, crack indications, signs of material fatigue, or evidence of overstress.

B. All coupler cabling shall undergo a 100,000 cycle flexing test that simulates trainset operation with the cars negotiating the "worst case" conditions listed in Section 2, Design and Performance Criteria, and for vertical and horizontal curves and minimum radius turnouts.

1. The electric coupler and connecting cables shall be mocked up as installed on the car.

2. Each cable wire shall be energized throughout the test, and there shall be no loss of continuity of any signal during testing.

3. At the conclusion of the test, the cables shall exhibit no evidence of short circuits, open circuits, intermittent circuits, high resistance circuits, insulation wear or failure, or broken wire strands, as verified by disassembly and inspection and dielectric tests.

15.4.3 Auxiliary Motor Design Qualification Tests

A. Comply with the following:

1. First production ac auxiliary motor of each type and one selected at random by SEPTA, shall be given an IEC 60349-2 type test, IEEE Std 11 type test, or equivalent by the respective motor manufacturer.

2. Perform a complete post-test teardown and inspection on each AC auxiliary motor selected for qualification testing. If any anomalies are found, perform an additional qualification test, inspection, and teardown on the next available production motor within that group of 50 motors.

3. Load test the first production low-voltage DC motor, one selected at random, and one of every 50 motors as selected by SEPTA, at maximum application load and maximum ambient temperature conditions.

15.4.4 Auxiliary Power Supply (APS) Tests

A. Perform design qualification tests on the first production unit and then one other, as selected by SEPTA. Test in accordance with IEC 61287-1, including the optional type test in Section 4.5.3.16, Sudden variations of load. All tests, including optional tests, are to be performed in accordance with the standards listed in TS 15.4.2.6. Actual car equipment loads shall be used for the APS design qualification testing.

1. Standby Power Receptacles Tests

a. The vehicle 230VAC 3-phase wayside shop power receptacles shall be tested for full functionality with and without the shop power plug connected including changeover control, LEDs, and capacity.

2. Auxiliary Power Supply Tests

a. The vehicle auxiliary power supply shall be tested for:

(1) APS startup and Voltage/Frequency ramp up test

(2) APS output voltage and frequency test at maximum Catenary voltage and reduced catenary voltage.

(3) APS output Phase imbalance test

(4) The APS voltage droop shall be tested to be less than 20% under worst case motor startup.

(5) APS test for Harmonic Distortion and test for APS Efficiency to be greater than 90% as the load varies from 10% to 100%

(6) APS temperatures rise test under full loads and high ambient conditions.

(7) APS EMC test and audible noise test under full load conditions

(8) The APS Isolation, Protection, and lockout/reset conditions shall be tested and verified.

(9) APS test for maximum 40 milliseconds catenary power line interruption under full load

(10) APS stop and start test for motor stagger start.

15.4.5 Low-Voltage Power Supply

A. Perform design qualification tests on the first production unit and then one other, as selected by SEPTA. Test the low-voltage power supply (LVPS) in accordance with IEC 61287-1, including the optional type test in Section 4.5.3.16, Sudden variations of load.

1. The vehicle Low-Voltage Power Supply shall be tested for:

a. The LVPS shall tested to maintain its output battery charging voltage within the battery manufacturer recommended values including temperature sensor failure condition.

b. LVPS output voltage regulation test for input voltage between minimum and maximum of specified catenary voltage.

c. LVPS droop voltage test to be limited to 1 Volts as the load is varied from 20% to 100%

d. LVPS efficiency test to be greater than 80% as the loads varies from 20% to 100%

(1) The LVPS shall be tested to limit transients to ±10% of nominal voltage as a result of any step load change with the battery connected. The maximum overvoltage shall not exceed 42 Volts.

(2) With the batteries disconnected, The LVPS shall be tested to limit the voltage peak to peak ripple to 3% or less of nominal voltage.

(3) LVPS dead battery start test at available catenary specified Voltage range.

(4) A failure of the APS shall be simulated to ensure it does not affect the operation of the LVPS if the proposed design have the APS and LVPS packaged in the same enclosure.

15.4.6 Traction Motors

15.4.6.1 Traction Motor Design Qualification Tests

A. Perform an ac traction motor test as follows:

1. An IEC 60349-2 type test shall be performed by the manufacturer on the first production motor, one additional motor selected at random, and then one for every 50 motors, selected by SEPTA.

2. The type testing, as specified in IEC 60349-2, shall be made on converter supply, per IEC 60349-2, Section 7.1.2.2, Type tests on converter supply, and also with sinusoidal power, per IEC 60349-2, Section 7.1.2.3, Type tests on sinusoidal supply.

3. Perform locked rotor testing of IEC 60349-2, Section 9.3.1, Asynchronous motors, on the first 10 production motors, at which point if acceptable results

have been demonstrated, Section 9.3.1 testing may be discontinued for the balance of production.

4. The traction motor testing shall demonstrate compliance with the related requirements of Section 2, Design and Performance Criteria, and Section 10, Propulsion and High Voltage System.

5. Perform a complete post-test teardown and inspection on each traction motor selected for qualification testing. If any anomalies are found, perform an additional qualification test, inspection, and teardown on the next available production motor within that group of 50 motors.

15.4.6.2 Vibration Test

A. Perform a vibration test on the first three production motors, one additional motor selected at random, and then one for every 100 motors, selected by SEPTA.

1. Measure vibration of each traction motor and verify as complying with the requirements of Section 2, Design and Performance Criteria.

2. The peak-to-peak displacement anywhere on the motor shall not exceed 0.0015-inch (0.0381 mm) when the motor is detached and supported on resilient mounting providing at least 0.25-inch (6.35 mm) static deflection, while the motor is rotating at any and all speeds between 50% and 100% of maximum normal operating speed.

15.4.6.3 Insulation Verification Tests

A. Perform an insulation verification test as follows:

1. Two simulated sections of the stator and winding assemblies shall be manufactured to verify the VPI process. These simulated stator assemblies shall undergo the VPI process simultaneously with production stators.

2. Section these assemblies to establish freedom from voids and to verify that there is good bonding.

3. Conduct the VPI verification test with the first two stators and one additional stator selected at random by SEPTA. If voids are found, as determined by SEPTA, then the process shall be modified until corrected, and the sample size shall increase as directed by SEPTA.

15.4.7 Gear Unit

A. Perform a gear unit test as follows:

1. The traction gear unit proof-of-design test shall be a 100-hour test on two production gear units, the first production unit and one selected at random, by SEPTA, and shall be mounted with torque load simulation.

2. The test shall subject the unit to conditions that are in general 20% more severe than would occur under the most extreme operating conditions, i.e., torque increased by 20%.

3. Start the test with the unit at room temperature 60°F to 90°F (16°C to 32°C).

    a. In-service airflow conditions may be simulated.

    b. The temperature rise measured in the oil sump shall not exceed the gear oil supplier's recommendations for maximum temperature consistent with the life between oil changes, as stated in the Contractor's maintenance manuals.

4. Reverse the direction of rotation every 8 hours until the 100-hour test is completed.

5. During the test, the gear units shall display no signs of excessive heat, noise, or vibration.

6. After completion of the test, disassemble the gear units and examine all parts.

    a. Check gear tooth mesh and record before and after the test.

    b. Investigate any sign of deterioration of any part, including leaks, jointly with SEPTA.

    c. The test report shall include test records of running time, oil temperatures, vibration and sound level readings taken at such intervals as required to verify compliance with the Specifications.

    d. Conduct oil viscosity and metal content tests comparing new oil samples at the start and completion of the gear unit test.

    e. Use of the gear unit in car production will be determined by SEPTA after test report review.

15.4.8 Truck Structural Test

15.4.8.1 General

A. Perform structural design qualification tests on a finished truck frame, bolster and other major structural components as listed by the Truck Structural Validation Plan, to demonstrate conformance to Specification requirements.

B. Perform test on one of the first three truck frames and bolsters produced, selected at random by SEPTA.

15.4.8.2 Pretest Material and Non-Destructive Testing

A. Perform material and non-destructive testing on the test units to ensure there are no defects that might impair the performance of the truck during the test.

1. Perform non-destructive testing in accordance with Section 16, Materials and Workmanship.

    a. For castings, magnetic particle and radiographic testing.

    b. For forgings, magnetic particle and radiographic testing.

    c. For weldments, magnetic particle and radiographic testing.

2. Verify material chemistry and mechanical properties for the heat and/or lot of materials used for the test units.

3. Perform a baseline pretest magnetic particle inspection at the structural test laboratory; final inspection results at the production facility may not be substituted.

4. Record the defects found, and if required, repair using an Approved procedure.

5. Document the type, size, location, and repair of each defect by photographs and drawings.

15.4.8.3 Static, Overload, and Fatigue Tests

15.4.8.3.1 General

A. Apply no fewer than 100 temperature compensated bonded resistance (SR-4) or Approved equal rosette strain gauges to the truck for static load, overload, and fatigue tests at maximum stress points as Approved.

1. Determine the location of maximum stress points by finite element analysis and engineering judgement.

2. Single direction strain gauges may be substituted for rosettes in specific locations if Approved in the test procedure.

3. Include drawings showing the location of each strain gauge in the test procedure.

4. No less than five additional rosettes shall be available for additional locations if determined necessary jointly with SEPTA at the time of the test.

5. Load cells shall be located at all load application and load reaction points.

6. In these truck tests, the term “empty car weight” means AW0, less trucks.

15.4.8.3.2 Static Load Test

A. Perform truck static load tests.

1. The purpose of the static load test is to verify that the maximum allowable stresses specified in Section 11, Trucks, are not exceeded.

2. Conduct the test with the maximum static load specified in Section 11, Trucks, and again with the fatigue load stress range.

    a. Apply the maximum static loads simultaneously.

    b. Apply the fatigue loads simultaneously in the worst-case combination to be used in the fatigue test.

3. Apply loads twice for each case, with a complete release between applications.

4. Strain gauges shall be re-zeroed after each load application and the offset from zero recorded and reported.

5. The methods and points of test load application and reaction shall simulate as closely as possible the actual loading conditions to which the truck will be subjected in service, and produce the worst-case combined stress in each quadrant of the truck.

6. Compare the recorded test stresses for the two applications of each case with the FEA predicted stresses.

15.4.8.3.3 Static Maximum Load Test Criteria

A. Comply with the following:

1. Test stresses under the worst-case combination of all loads shall not exceed the allowable stress as established by the Truck Stress Analysis Plan and specified in Section 11, Trucks.

2. The loads shall not cause any fractures, cracks, or separations in the truck.

3. Following removal of all loads and review of all load cell and strain gauge readings, residual strains shall not exceed 50 microstrain.

15.4.8.3.4 Static Fatigue Load Test Criteria

A. Comply with the following:

1. For the fatigue range load case, the stresses in all areas of the truck shall not exceed the allowable fatigue stresses as established by the Truck Stress Analysis Plan and specified in Section 11, Trucks.

15.4.8.3.5 Overload Test

A. Perform a truck overload test.

1. The test shall demonstrate that the truck has adequate strength to sustain a maximum load in the presence of a combination of minor manufacturing defects.

2. Overload the truck statically once with the loads specified in Section 11, Trucks.

3. Document unit stresses at critical locations and dimensional measurements before and after the test between representative points on the truck as Approved.

15.4.8.3.6 Overload Test Criteria

A. Comply with the following:

1. Test stresses under the worst-case combination of all loads shall not exceed the allowable stress as established by the Truck Stress Analysis Plan and specified in Section 11, Trucks.

2. The loads shall not cause any fractures, cracks, or separations in the truck.

3. There shall be no permanent deformation as determined from displacement measurements and strain gauge readings.

a. If such deformation appears, correct the design to bring the stress under the test condition within the elastic limit of the material involved.

b. The Contractor shall retest the truck at its expense. All trucks installed on the cars shall be in accordance with the corrected design.

15.4.8.3.7 Base Fatigue Test

A. Perform a truck fatigue test to demonstrate that the fatigue strength of the truck meets the requirements of Section 11, Trucks.

1. Prior to the test, inspect the truck in the presence of SEPTA using magnetic particle inspection, and clearly identify all defects.

a. Furnish a drawing showing defects that existed in the truck elements as produced, and the repairs made to the parts containing those defects.

2. Conduct the fatigue test as follows:

a. Subject the truck to not less than 6 million cycles.

(1) Test the truck assembly as a unit, including its internal elastomeric cushioning and springs, if any, or an Approved substitute, but not including hydraulic damping devices.

b. Loading shall be according to Section 11, Trucks, and as follows:

(1) Loads applied to the truck bolster shall include those resulting from the vertical transfer of the applied lateral force from the height of loaded carbody center of gravity to the lateral bumper height.

(2) If the truck bolster is used as a part of the air suspension volume, the bolster pressure during the fatigue test shall be the maximum service pressure required for a load equivalent to the truck's share of the AW3 loaded car on the suspension.

c. The phasing of loads shall be selected by the Contractor and Approved, and shall be such as to produce the worst-case stresses at critical locations in each quadrant of the truck.

3. During the fatigue tests, record all loads and stresses periodically to check whether the load has changed, and virtually inspect the truck periodically to detect possible crack initiation and progression.

a. The frequency of the periodic recordings and inspections shall be Approved.

b. If evidence of progressive cracking or failure is found, SEPTA and the Contractor shall assess the cause, an appropriate correction shall be established and Approved, and the Contractor shall repeat the test at its expense.

15.4.8.3.8 Base Fatigue Test Criteria

A. Comply with the following:

1. Maximum combined stresses at the critical locations do not exceed those established by the Truck Stress Analysis Plan and required by Section 11, Trucks.

2. At the conclusion of the test, perform a magnetic particle inspection for cracks in the presence of SEPTA. If any crack is found, or pre-existing cracks have propagated, correct the design, retest the truck, and modify all trucks installed under the cars in accordance with the corrected design.

15.4.8.3.9 Extended Fatigue Test

A. Perform an extended truck fatigue test to demonstrate the additional fatigue margin in the truck design.

1. Upon completion of the 6 million cycle fatigue testing, continue the test for an additional 2 million cycles, or until failure, at an applied dynamic load factor of 1.5.

a. The purpose of this test is to verify design margin and to identify potential crack initiation points.

b. At the conclusion of the extended fatigue test, a magnetic particle inspection shall be made for new cracks and propagation of pre-existing cracks.

c. Data gathered during the extended fatigue test shall be used as part of the Fatigue Assessment Validation Report.

d. Potential crack initiation points shall be incorporated in periodic maintenance inspections and shall be reflected in the Heavy Repair Manuals.

e. SEPTA reserves the right to require lessons learned during the extended fatigue test to be incorporated in the design or quality control of production units, such as weld workmanship, surface finish, inspection criteria, etc.

15.4.8.4 Primary Suspension Test

A. Perform the following tests:

1. A load deflection test shall be performed to demonstrate that the spring rates of the primary suspension system in all axes are within the design limits. This test shall demonstrate that the primary suspension system behaves as predicted and will not result in excessive deflection or a decrease in truck clearance above top of rail to less than the minimums prescribed.

2. For elastomeric primary suspension elements, the following tests are also required following the guidance in EN 13913: low temperature (stiffness), high temperature (heat aging), fatigue resistance, static creep, stiffness under sinusoidal motion and damping.

3. Hydraulic shock absorber (damper) accelerated life cycle endurance tests shall be performed following the guidance in EN 13802, selection of additional operational environment, physical characteristic and functional requirement tests to be proposed by the Contractor and Approved.

15.4.8.5 Secondary Suspension Test

A. Perform the following tests:

1. A load deflection test shall be performed to demonstrate that the spring rates of the secondary suspension system in all axes are within the design limits. This test shall demonstrate that the secondary suspension system behaves as predicted and will not result in excessive deflection.

2. Hydraulic shock absorber (damper) accelerated life cycle endurance tests shall be performed following the guidance in EN 13802, selection of additional operational environment, physical characteristic and functional requirement tests to be proposed by the Contractor and Approved.

15.4.9 Floor Assembly Fire Resistance Test

A. Comply with the following:

1. Test the floor assembly in accordance with ASTM E119 and NFPA 130 Section 8.5, Fire Performance, to demonstrate a minimum 30-minute endurance rating.

    a. Upon meeting the 30-minute endurance requirement, the test shall continue to run until failure as determined by the testing laboratory.

    b. Obtain Approval of the test procedure, test facility, and test results prior to the procurement of flooring material necessary for car production.

2. The following test criteria shall be met:

    a. The test specimen shall be a full car-width section including, for the flooring test, side sills or that portion of the wall that extends below the floor.

    b. The specimen shall have a minimum exposed area of 172 square feet (15.98 m^2). If Approved, the exposed area may be reduced to meet a length limitation imposed by the size of the test furnace, but the length shall not be less than 11 feet (3.35 m).

    c. Include all penetration types, spaced at a distance from each other no greater than that which will exist in actual construction, in the test specimen. The specimen shall include typical configuration elements such as floor splices.

    d. Apply concentrated loads to simulate underfloor mounted equipment. Load the floor test specimen to AW3 loading conditions.

    e. The test specimen shall include at least three typical transverse supports.

    f. The test specimen shall represent the actual construction used in production. For example, for the floor this includes the floor covering, floor boards, floor structure, thermal and acoustical insulation, and floor pans.

    g. The detailed drawing of the test specimen shall be submitted with the test procedure for Approval.

    h. Conditions of acceptance for this test shall be those required for unrestrained assembly.

    i. Video recording of the test, per Section 15.3.3.3 Test Reports, shall be provide to SEPTA.

15.4.10 Cab Control Components

15.4.10.1 Master Controller

A. Cycle test the Master Controller to a minimum of 500,000 cycles through all positions. The Master Controller shall have full functionality after the cycle test and shall not exhibit any damage or wear.

B. Test the Master Controller to meet the intrusion requirements of IP54, in accordance with IEC 60529, in the installed and uninstalled condition.

15.4.10.2 Brake Controller

A. Cycle test the Brake Controller to a minimum of 500,000 cycles through all positions. The Brake Controller shall have full functionality after the cycle test and shall not exhibit any damage or wear.

B. Test the Brake Controller to meet the intrusion requirements of IP54, in accordance with IEC 60529, in the installed condition.

15.4.10.3 Cab Control Key Switch

A. Cycle test the cab control key switch to a minimum of 50,000 cycles through all positions. The cab control key switch shall have full functionality after the cycle test and shall not exhibit any damage or wear.

B. Test the cab control key switch to meet the intrusion requirements of IP54, in accordance with IEC 60529, in the installed and uninstalled condition.

15.4.10.4 Reverser Switch

A. Cycle test the Reverser switch to a minimum of 50,000 cycles through all positions. The Reverser switch shall have full functionality after the cycle test and shall not exhibit any damage or wear.

B. Test the direction switch to meet the intrusion requirements of IP54, in accordance with IEC 60529, in the installed and uninstalled condition.

15.4.10.5 Deadman Switch

A. Cycle test the Deadman to a minimum of 50,000 cycles. The Deadman shall have full functionality after the cycle test and shall not exhibit any damage or wear.

15.4.11 Door Panel

A. One door panel of each type shall be tested to demonstrate proper strength and rigidity to sustain a concentrated load of 200 lbf (890 N) shall be applied over an area of 4 by 4 in. (0.1 by 0.1 m), acting on the door panel. The load shall be applied perpendicularly to the plane of the door surface, at the center of the leading edge of the panel. If the center of the leading edge is not the weakest area of the panel, then the load shall be applied to the weakest section.

B. The maximum deflection of the panel at the applied load shall be no more than 0.25 in. (6.35 mm), without permanent deformation. For side doors that are full length for low-level boarding, the maximum deflection at the applied load shall be no more than 0.5 in. (12.7 mm) without permanent deformation in accordance with APTA PR-CS-S-012-02.

15.4.12 Windows and Windshield

A. Test all window and windshield material according to the requirements in Section 14 Interior & Exterior Appointments, 49 CFR 238.221 and Appendix A to Part 223 Certification of Glazing Materials.

B. The drop sash window shall be cycle-tested using opening and closing forces which simulate a rough service environment to qualify the design. The opening and closing forces shall adhere to Human Engineering requirements as described in Section 2, Design and Performance Criteria. The cycle count utilized in the testing are subject to Approval. Each window test shall test the complete window system including all frames, moldings, rubber extrusions, etc. Each window system shall be tested in a fixture that represents and simulates the manner and method of the actual window installation on the car.

15.4.13 Passenger Seats

A. All seat types including the longitudinal flip up seats shall be tested to demonstrate the capability to withstand the loads defined in 49 CFR 238. Transverse seat frames shall be tested using the standardized pedestal location dimension.

1. Testing shall be performed using mocked up structural connection elements as found for each installation configuration found in the car. In the case where the car structure connection points differ, both connections shall be tested though the seat used would be the same.

2. Seat frame construction and attachments to the carbody and pedestal shall be sufficient to withstand without permanent deformation the loads listed in the referenced standard below.

3. One sample seat of each seat type (including flip up longitudinal) identical to a production version shall be tested in a simulated carbody structure by the manufacturer for all criteria specified in APTA Standard PR-CS-S-016-99 and submitted to SEPTA with a detailed test report and the detailed drawing of the seat and attachment to the carbody for Approval.

4. This test result must be Approved before additional seats can be ordered and assembled into the pilot cars for pre-delivery testing.

15.4.14 Operator Seats

A. Operator seat shall be tested in accordance with APTA PR-CS-S-011-99 and 49 CFR Part 238.233.

15.4.15 Luggage Storage Stacks and Overhead Luggage Racks

A. Luggage Racks and Storage Stacks shall be tested in accordance with 49 CFR 238.233 and APTA PR-CS-S-006-98.

15.4.16 Bicycle Racks

A. Bicycle Racks shall be tested in accordance 49 CFR 238.233 and APTA PR-CS-S-006-98.

15.4.17 Brake Resistor Assembly

A. Test first production resistor assembly, and one selected at random, per IEC 60322.

15.4.18 Car Battery

A. Test first production battery assembly, one selected at random, and two additional assemblies as selected by SEPTA.

1. Test in accordance with IEC 60623, Section 4.2.1, Discharge Performance at 68°F (20°C).

2. The test shall be at the 5-hour rate, at 68°F (20°C) ambient temperature.

3. Battery capacity and Emergency loads shall be tested for compliance with required emergency loads.

4. The Battery temperature, battery charging voltage, and battery overtemperature protection shall be tested and verified.

15.4.19 Crash Hardened Memory Modules (CHMM)

A. Demonstrate via test that the crash-hardened memory modules used for the event recorder meet the memory module requirements specified in Section 20, ATC/PTC, including testing to the following requirements:

1. Appendix D to 49 CFR 229 Criteria for Certification of Crashworthy Event Recorder Memory Module.

2. IEEE 1482.1 Standard for Rail Transit Vehicle Event Recorders

B. The crash hardened memory modules used in the Video Surveillance System VSS as specified in Section 13, Communications shall be considered an ERMM and meet the performance criteria of Appendix D to 49 CFR 229 Section C, Criteria for the ERMM.

15.4.20 High Performance Photoluminescent (HPPL) Markings for Emergency Signage and Low-Location Exit Path Markings

A. Test each high performance photoluminescent (HPPL) material, marking or assembly, to the minimum material illuminance defined in APTA PR-PS-S-006-23, “Emergency Egress/Access Signage and Low-Location Exit Path Markings for Passenger Rail Equipment”, Section 4.1.2.1 HPPL (passive) systems, Material luminance.

15.4.21 Main Transformer

A. All tests shall be performed in accordance with ANSI Specifications numbers C57.12.00 and C57.12.90. Testing in accordance with IEC 60310 may also be proposed, however test procedures and test levels shall be modified in accordance with values and details specified below and in Section 2, Design and Performance Criteria, and Section 10, Propulsion and High Voltage System.

B. Each transformer shall be given the standard Railroad tests.

1. A basic impulse insulation level (BIL) test shall be made on the first production transformer of all primary windings.

a. The primary winding configuration shall withstand an 110,000 volts basic impulse level test.

b. In the event this transformer fails to pass the impulse test, the next three production transformers shall also be given this impulse test. Should failure occur on any of these three transformers, then every transformer produced shall be given and must pass an impulse test.

2. The first production transformer shall be given both a heat run test to verify cooling system capability, and a cold start test to verify coolant pump capability with viscous coolant.

a. The heat run test shall be conducted in a heat chamber held at a constant temperature of 140 degrees F during the test.

(1) The transformer shall first be heat soaked for a period of 6 hours, and then energized at full rated power for a 2 hour period without showing evidence of any overheating or damage.

b. The cold start test shall be conducted in a cold chamber held at a constant temperature of minus 7 degrees F during the test.

(1) The transformer shall first be cold soaked for a period of 10 hours, and then energized with full auxiliary winter loads (full heating loads) for a 1 hour period.

(2) The coolant pump shall start and operate normally without any damage, and the transformer shall operate without showing evidence of any overheating or damage.

15.4.22 Floor Panel Test

A. Floor Panel Fire Resistance

1. Approved sample of materials representing structural flooring and floor panels shall be tested to verify the ability to withstand the requirements of ASTM E119, when exposed for 15 minutes at up to 1400°F on the material underside.

B. Floor Panel Strength Test

1. Perform floor panel strength test and submit results as described in Section 16, Materials and Workmanship, CDRL 16-19, Phenolic Composite Floor Panel Test Results.

15.5 Carbody Structure Design Qualification Tests

A. For each structurally unique carbody shell module, test the first module to prove compliance of the structure with the strength requirements of Section 3, Carbody.

B. Test procedures shall be submitted 60 days before testing begins**. (CDRL 15-03, Carbody Structure Design Qualification Tests)**

C. Test Reports shall be submitted within 45 days of the start of applicable testing **(CDRL 15-04, Carbody Structure Design Qualification Results)**

D. For each line item Section 15.5 that does not apply to Tier I Alternative or Tier III trainsets, the Test Plan required in Section 3.5.1.A.1 shall document justification for its exemption, including references to the relevant CFR provisions and results from any supporting alternative testing.

15.5.1 General

A. Carbodies shall be structurally complete and shall exclude such items as exterior and interior trim, windows, doors, seats, lights, insulation, and interior linings.

B. All equipment shall be simulated by equivalent weights applied at the equipment mounting points.

C. The Contractor may propose testing a single car if it can be demonstrated that the worst-case load condition for all structural configurations, including equipment mountings and supports, are validated.

D. For each test, apply the maximum load twice as follows:

1. For the first loading, the load shall be applied in increments of 25%, 50%, 75%, 87.5% and 100% of full load. After each load increment, reduce the load to the release load of 2% of maximum load, where the release load is defined as a minimum load that does not completely unload the test article. If the test article becomes completely unloaded (moves in the fixture), repeat the entire sequence with a higher release load.

2. Apply a second loading in three increments: release load, maximum load, release load.

E. Use the same carbody shell for all static nondestructive structural tests.

F. Conduct the tests after the carbody stress analysis and crashworthiness analysis have been Approved.

G. Make provisions to conduct data analysis at the time of the test to compare the collected data against all pass/fail criterial. Testing shall not proceed until agreed upon by SEPTA. Investigate areas failing to meet criteria to determine the course of action needed to bring the area in question into compliance with the Specifications.

H. If the specified pass/fail criteria of a test are not met, the Contractor shall correct the carbody design and perform the entire body of tests at its expense.

I. In addition to the requirements of TS 15.3.3.2 the test procedures shall include the following:

1. Step-by-step instructions of how the specimen is to be loaded and loading increments.

2. Step-by-step procedure including all initialization steps and instrumentation nulling, load application steps, data recording steps, and steps to obtain Approval prior to proceeding.

3. Sample forms for all inspections required and measurements to be taken during the test.

4. All equations for strain conversion, and factors such as strain gauge factors, temperature compensation, and any other calculations.

5. Details of loading equipment, supports, and fixtures.

6. Drawings showing the test fixture, the specimen installed in the fixture, and location of load application points.

7. Listing, type, numbering, and location of strain gauges and deflection gauges with channel numbers.

8. Drawings showing locating dimensions for all gauges.

9. Table of strain gauge value predictions based on analysis, and maximum allowable gauge reading based on pass/fail criteria, for all gauges for each load case.

10. Table of deflection gauge prediction based on analysis.

11. Complete description with accuracy of all instruments, later to be used to determine the uncertainty of the test.

12. Details of data acquisition and a log of preloaded conversion or gauge factors (by channel number) as applicable.

13. Typical logging sheets, print-outs, plotting forms, and examples of other data sheets that will be used during the test or in the final report

14. Table of predicted or required load cell readings at support points. For jacking load cases, furnish values for each load increment during jacking.

15. Tables showing allowable criteria for all test parameters.

16. Reference to the current certification for every instrument and gauge to be used during the test.

J. In addition to the requirements of TS 15.3.3.3, the test report content for this test shall be agreed between SEPTA and the Contractor before any test is begun. At a minimum, include the following:

1. All load cases and all test steps, clearly presented.

2. Correction factors.

3. Tables for each test showing stresses and deflections equal to or greater than 85% of the allowable.

4. Description and explanation of values that exceeded the test criteria and plan of action.

5. For each test, stress/strain at each load increment vs. load curves for the 10 greatest tension stresses and the 10 greatest compressive stresses. The first and second test shall be on the same plot.

6. Completed logging sheets in electronic format showing strain gauge number/ channel number, predicted stress/strain, measured stress strain for both loadings, pass/fail criteria stress/strain.

7. Completed logging sheets in electronic format showing deflection gages number/channel number, predicted deflection, measured deflection from both loadings, and pass/fail criteria if defined.

8. Completed logging sheets in electronic format showing analysis load applied, actual load applied, and specified load.

9. Correlation analysis of the test and predicted results.

10. Photographs of the following:

a. Carbody in the test fixture

b. Each gauge application

c. Repairs or modification

d. Deviations from drawings

e. Areas found noncompliant.

15.5.2 Instrumentation

A. Comply with the following:

1. Apply the following minimum quantities of bonded resistance (SR-4), or Approved equal, strain gauges:

    a. Vertical Load Test: 300 gauges

    b. End Sill Compression Test: 300 gauges

    c. Coupler Anchorage Test: 300 gauges

    d. Jacking Tests: 300 gauges

    e. Collision and Corner Post Tests: 100 gauges per test

2. Gauge types shall include uniaxial and rosette gauges. For locations using uniaxial gauges, show that the stress is in one direction only and identify that direction.

3. Place strain gauges locations where stresses may be critical and at locations to validate the carbody FEM (low stress gradient locations), with all points agreed upon in advance with SEPTA.

4. Apply deflection gauges as follows:

    a. Apply deflection gauges measuring vertical deflection along the side sills at minimum 11 locations per side, including the end sills, bolsters, and transverse centerline.

    b. Apply deflection gauges measuring the diagonal deflection of critical carbody openings, such as doors, windows, and HVAC roof openings.

    c. Apply deflection gauges measuring the horizontal deflections of the carbody at the belt rail and above the door openings at three locations.

    d. Apply deflection gauges measuring longitudinal deflections at both ends of the carbody at the end sills.

    e. Apply deflection gauges measuring horizontal deflections at a minimum 7 locations on each collision and/or corner post being tested.

5. Measure loads at all load application points and supports.

6. Load cells shall be calibrated to 1% accuracy over 1.5 times the full load range that the load cell will be subjected to during the test.

7. Record strain gauge, deflection gauge, and load cell data simultaneously using the same data logging equipment.

15.5.3 Vertical Load Test

A. Subject the carbody test shells to a vertical load test with test loads of the maximum operating loads for the Carbody Vertical Static Load defined in Section 3, Carbody and APTA-PR-CS-S-034-99.

1. During this test, zero the strain gauge readings with the empty carbody shell at no load.

2. Apply a test load equal to maximum operating load in Section 3, Carbody, to the empty carbody shell.

3. For the first application of vertical loading, five increments shall include increments starting at AW0, and include an increment at AW2 and AW3 each.

4. Test loads may be applied by means of weights or jacks and shall be distributed in proportion to the distribution of weight in the finished car.

5. During the first vertical load application, make a measurement of carbody camber, with the empty shell loaded to the ready-to-run AW0 weight, at AW2, and with the carbody at absolute maximum passenger load, AW3.

6. During the load test, the two diagonal deflections shall be measured on all unique door openings for all load steps.

    a. After the test, these deflection measurements shall be jointly reviewed by the Contractor and door system supplier to ensure and document that the door system offers full functionality and performance under these deflected conditions.

    b. As an alternative to the above, the Contractor may propose a physical test under which the performance of the door system under loaded conditions (vertical loads) can be verified.

7. After each load increment, measure and record changes in transverse width of the car at the belt rail and top of the door caused by door post bending, and changes in the dimensions of the door opening caused by carbody shear loads.

8. The car will be considered to have met the Specification requirements with respect to vertical load if all of the following are met:

    a. All stresses calculated from strain readings are in accordance with the requirements of Section 3, Carbody.

    b. Plotted vertical deflections did not deviate, at any load increment, from a straight line, drawn from the origin to the deflection at the absolute maximum passenger load, by more than 5% of the deflection at the absolute maximum passenger load.

    c. Strain readings plotted against load do not vary by more than +/- 5% from a straight line (linear) curve, with one end point at the origin (no

load) and the other near the point that represents the measured strain at maximum load.

d. Recorded residual vertical deflections between bolsters, transverse deflections, and door opening diagonal dimensions do not exceed 0.04-in (1.0 mm).

e. Indicated residual strain at strain gauges do not exceed the maximum error resulting from the accuracy of the instrumentation.

f. The carbody camber does not measure less than 0 inches when loaded to AW3.

g. There are no permanent deformations, fractures, cracks, or separations in the car structure. Broken welds shall be jointly inspected by the Contractor and SEPTA to determine if the failure is the result of weld quality or stress.

h. The flatness and straightness of structural members meet the requirements of Section 3, Carbody after unloading.

i. Side doors operated at the prescribed speeds without binding at all test load increments.

15.5.4 End Sill Compression Test

A. Subject the carbody test shells to an end sill compression test to demonstrate compliance with the End Sill Compression Load strength requirements in APTA-PR-CS-S-034-99.

1. During the compression test, support the carbody on trucks, or a simulation thereof, to allow longitudinal movement.

2. Load the carbody with sufficient dead weight to bring the total body weight up to AW0. Distribute the loading in proportion to the distribution of weight in the finished car.

3. Apply a load to the end sill at its center, over an area the height of the end sill by no more than 12 in (305 mm) wide, for end sill load case, as specified in APTA-PR-CS-S-034-99.

a. Apply the load using a controlled hydraulic ram that is supported, but remains free to move longitudinally with respect to the car end.

b. Provide cushioning means, such as lead sheets, to ensure uniform bearing on the end sill.

4. Take strain gauge, deflection gauge, and load cell readings at each load increment and at each relaxation of load.

5. If energy absorbing elements of the end sill would prevent testing in the way specified in this Section, provisions may be used to bypass these energy absorbing elements during the test. Submit the provisions for Approval.

6. The carbody structure is compliant with the Specifications if all the following criteria are met:

    a. Stresses are in accordance with the requirements of APTA-PR-CS-S-034-99.

    b. Vertical deflection readings plotted against load do not vary by more than +/- 5% from a straight line (linear) deflection curve, with one end point at the origin (no load) and the other near the point that represents the measured deflection for maximum vertical load.

    c. Strain readings plotted against load do not vary by more than +/- 5% from a straight line (linear) curve, with one end point at the origin (no load) and the other near the point that represents the measured strain at maximum load.

    d. Maximum stresses calculated from strain readings in any structural element do not exceed the allowable stresses Approved as part of the stress analysis prior to starting the test program.

    e. Recorded residual vertical deflection between bolsters, following removal of the maximum vertical test loading, does not exceed 0.04 in (1.0 mm).

    f. Recorded residual horizontal deflection between ends, following removal of the maximum test load, does not exceed 0.04 in (1.0 mm).

    g. Indicated residual strains at strain gauges on principal structural elements, following removal of the maximum vertical loading, do not exceed +/- 50 microstrain.

    h. There are no permanent deformations, fractures, cracks, or separations in the car structure. Broken welds shall be jointly inspected by the Contractor and SEPTA to determine if the failure is the result of weld quality or stress.

    i. The flatness and straightness of structural members meet the requirements of Section 3, Carbody, after unloading.

15.5.5 Coupler Anchorage Compression Test

A. Subject the carbody test shells to a coupler anchorage compression test to demonstrate compliance with the maximum Coupler Anchorage Compression Load strength requirements in APTA-PR-CS-S-034-99.

1. Support the carbody on trucks, or a simulation thereof, to allow longitudinal movement.

2. Load the carbody with sufficient dead weight to bring the total body weight up to AW0. Distribute the loading in proportion to the distribution of weight in the finished car.

3. Apply a load to the coupler anchorage for the coupler anchorage load case as specified in APTA-PR-CS-S-034-99.

4. Apply the load using a controlled hydraulic ram that is supported but remains free to move longitudinally with respect to the car end.

5. Take strain gauge, deflection gauge, and load cell readings at each load increment and at each relaxation of load.

6. The carbody structure is compliant with the Specifications if all the following criteria are met:

   a. Stresses are in accordance with the requirements of APTA-PR-CS-S-034-99.

   b. Vertical deflection readings plotted against load do not vary by more than +/- 5% from a straight line (linear) deflection curve, with one end point at the origin (no load) and the other near the point that represents the measured deflection for maximum vertical load.

   c. Strain readings plotted against load do not vary by more than +/- 5% from a straight line (linear) curve, with one end point at the origin (no load) and the other near the point that represents the measured strain at maximum load.

   d. Maximum stresses calculated from strain readings in any structural element do not exceed the allowable stresses Approved as part of the stress analysis prior to starting the test program.

   e. Recorded residual vertical deflection between bolsters, following removal of the maximum vertical test loading, does not exceed 0.04 in (1.0 mm).

   f. Recorded residual horizontal deflection between ends, following removal of the maximum test load, does not exceed 0.04 in (1.0 mm).

   g. Indicated residual strains at strain gauges on principal structural elements, following removal of the maximum vertical loading, do not exceed +/- 50 microstrain.

h. There are no permanent deformations, fractures, cracks, or separations in the car structure. Broken welds shall be jointly inspected by the Contractor and SEPTA to determine if the failure is the result of weld quality or stress.

i. The flatness and straightness of structural members meet the requirements of Section 3, Carbody, after unloading.

15.5.6 Symmetric and Diagonal Jacking Tests

A. Subject the carbody test shells to jacking tests to demonstrate compliance with the Symmetric Loading and Diagonal Loading jacking pad requirements in Section 3, Carbody and APTA-PR-CS-S-034-99. The test shall be conducted on the most outboard set of jacks.

1. Lift the carbody, loaded to equal AW0, with trucks attached, at four jacking points.

2. From the symmetric jacking position, lower one jack location until clear of all other support, to determine compliance with the diagonal jacking strength requirements.

3. The carbody structure is compliant with the Specifications if all the following criteria are met:

a. Stresses are in accordance with the requirements of APTA-PR-CS-S-034-99.

b. Vertical deflection readings plotted against load do not vary by more than +/- 5% from a straight line (linear) deflection curve, with one end point at the origin (no load) and the other near the point that represents the measured deflection for maximum vertical load.

c. Strain readings plotted against load do not vary by more than +/- 5% from a straight line (linear) curve, with one end point at the origin (no load) and the other near the point that represents the measured strain at maximum load.

d. Maximum stresses calculated from strain readings in any structural element do not exceed the allowable stresses Approved as part of the stress analysis prior to starting the test program.

e. Recorded residual vertical deflection between bolsters, following removal of the maximum vertical test loading, does not exceed 0.04 in (1.0 mm).

f. Recorded residual horizontal deflection between ends, following removal of the maximum test load, does not exceed 0.04 in (1.0 mm).

g. Indicated residual strains at strain gauges on principal structural elements, following removal of the maximum vertical loading do not exceed +/- 50 microstrain.

h. There are no permanent deformations, fractures, cracks, or separations in the car structure. Broken welds shall be jointly inspected by the Contractor and SEPTA to determine if the failure is the result of weld quality or stress.

i. The flatness and straightness of structural members meet the requirements of Section 3, Carbody, after unloading.

15.5.7 Collision Post Elastic Test

A. Subject the carbody test shells to collision post elastic tests to demonstrate compliance with the Collision Post Load (elastic) strength requirements in APTA-PR-CS-S-034-99. Test each unique type of collision post and connection.

1. Support the carbody on trucks, or a simulation thereof, to allow longitudinal movement.

2. Load the carbody with sufficient dead weight to bring the total body weight up to that of a ready-to-run car. Distribute the loading in proportion to the distribution of weight in the finished car.

3. Apply a load to one collision post at the height specified, for collision post elastic load case as specified in APTA-PR-CS-S-034-99.

4. The elastic portion of the design load shall be determined by the published ratio of the material's yield to ultimate strength.

5. Apply the load using a controlled hydraulic ram that is supported but remains free to move longitudinally with respect to the car end.

6. The load shall be uniform in bearing. Use cushioning methods, such as lead sheets. Distribute the load over the loaded surface over an area not to exceed the width of the collision post by a height of 6 in (152 mm).

7. Take strain gauge, deflection gauge, and load cell readings at each load increment and at each relaxation of load.

8. The carbody structure is compliant with the Specifications if all the following criteria are met:

a. Stresses are in accordance with the requirements of APTA-PR-CS-S-034-99.

b. Vertical deflection readings plotted against load do not vary by more than +/- 5% from a straight line (linear) deflection curve, with one end

point at the origin (no load) and the other near the point that represents the measured deflection for maximum vertical load.

c. Strain readings plotted against load do not vary by more than +/- 5% from a straight line (linear) curve, with one end point at the origin (no load) and the other near the point that represents the measured strain at maximum load.

d. Maximum stresses calculated from strain readings in any structural element do not exceed the allowable stresses Approved as part of the stress analysis prior to starting the test program.

e. Indicated residual strains at strain gauges on principal structural elements, following removal of the maximum vertical loading, do not exceed +/- 50 microstrain.

f. There are no permanent deformations, fractures, cracks, or separations in the car structure. Broken welds shall be jointly inspected by the Contractor and SEPTA to determine if the failure is the result of weld quality or stress.

g. The flatness and straightness of structural members meet the requirements of Section 3, Carbody after unloading.

15.5.8 Corner Post Longitudinal Test

A. Subject the carbody test shells to a corner post longitudinal load test(s) to demonstrate compliance with the Corner Post Load (elastic design load) in the longitudinal direction strength requirements in APTA-PR-CS-S-034-99. Test each unique type of corner post and connection.

1. Support the carbody on trucks, or a simulation thereof, to allow longitudinal movement.

2. Load the carbody with sufficient dead weight to bring the total body weight up to that of a ready-to-run car. Distribute the loading in proportion to the distribution of weight in the finished car.

3. Apply a load to one corner post at the height specified for corner post longitudinal elastic load case, as specified in APTA-PR-CS-S-034-99.

4. Apply the load using a controlled hydraulic ram that is supported but remains free to move longitudinally with respect to the car end.

5. The load shall be uniform in bearing. Use cushioning methods, such as lead sheets. Distribute the load over the loaded surface over an area not to exceed the width of the collision post by a height of 6 in (152 mm).

6. Take strain gauge, deflection gauge, and load cell readings at each load increment and at each relaxation of load.

7. The carbody structure is compliant with the Specifications if all the following criteria are met:

    a. Stresses are in accordance with the requirements of APTA-PR-CS-S-034-99.

    b. Vertical deflection readings plotted against load do not vary by more than +/- 5% from a straight line (linear) deflection curve, with one end point at the origin (no load) and the other near the point that represents the measured deflection for maximum vertical load.

    c. Strain readings plotted against load do not vary by more than +/- 5% from a straight line (linear) curve, with one end point at the origin (no load) and the other near the point that represents the measured strain at maximum load.

    d. Maximum stresses calculated from strain readings in any structural element do not exceed the allowable stresses Approved as part of the stress analysis prior to starting the test program.

    e. Indicated residual strains at strain gauges on principal structural elements, following removal of the maximum vertical loading, do not exceed +/- 50 microstrain.

    f. There are no permanent deformations, fractures, cracks, or separations in the car structure. Broken welds shall be jointly inspected by the Contractor and SEPTA to determine if the failure is the result of weld quality or stress.

    g. The flatness and straightness of structural members meet the requirements of Section 3, Carbody after unloading.

15.5.9 Corner Post Transverse Test

A. Subject the carbody test shells to a corner post transverse load test(s) to demonstrate compliance with the Corner Post Load (elastic design load) in the transverse direction strength requirements in APTA-PR-CS-S-034-99. Test each unique type of corner post and connection.

    1. The transverse load applied to the corner post shall be resisted at the truck-to-carbody interface, the symmetric location on the opposite side corner post, or an alternative location as Approved.

    2. Support the carbody on trucks, or a simulation thereof, to allow longitudinal movement.

    3. Load the carbody with sufficient dead weight to bring the total body weight up to that of a ready-to-run car. Distribute the loading in proportion to the distribution of weight in the finished car.

4. Apply a load to one corner post at the height specified for corner post transverse elastic load case, as specified in APTA-PR-CS-S-034-99.

5. Apply the load using a controlled hydraulic ram that is supported but remains free to move transversely with respect to the car side.

6. The load shall be uniform in bearing. Use cushioning methods, such as lead sheets. Distribute the load over the loaded surface over an area not to exceed the width of the collision post by a height of 6 in (152 mm).

7. Take strain gauge, deflection gauge, and load cell readings at each load increment and at each relaxation of load.

8. The carbody structure is compliant with the Specifications if all the following criteria are met:

    a. Stresses are in accordance with the requirements of APTA-PR-CS-S-034-99.

    b. Vertical deflection readings plotted against load do not vary by more than +/- 5% from a straight line (linear) deflection curve, with one end point at the origin (no load) and the other near the point that represents the measured deflection for maximum vertical load.

    c. Strain readings plotted against load do not vary by more than +/- 5% from a straight line (linear) curve, with one end point at the origin (no load) and the other near the point that represents the measured strain at maximum load.

    d. Maximum stresses calculated from strain readings in any structural element do not exceed the allowable stresses Approved as part of the stress analysis prior to starting the test program.

    e. Indicated residual strains at strain gauges on principal structural elements, following removal of the maximum vertical loading, do not exceed +/- 50 microstrain.

    f. There are no permanent deformations, fractures, cracks, or separations in the car structure. Broken welds shall be jointly inspected by the Contractor and SEPTA to determine if the failure is the result of weld quality or stress.

    g. The flatness and straightness of structural members meet the requirements of Section 3, Carbody, after unloading.

15.5.10 Collision Post Elastic-Plastic Test

A. Load the leading end collision post structure beyond the yielding limit to demonstrate the post's ability to absorb the minimum energy requirements of APTA-PR-CS-S-034-99. Test each unique type of collision post and connection which may be in lead.

1. The test specimen shall be a full scale structural model of the end of a car. The structural model shall contain all structural elements required to support the collision and corner posts, including the end underframe and roof extending from the forward end of the end frame to the bolster. Alternatively, a simple conventional collision post design can propose only the collision post and connection for SEPTA review and approval.

2. All connections shall be the same as on production cars.

3. Apply the same number of strain gauges and displacement gauges in the same locations as were used on the collision post elastic test.

4. Apply the test load for each test using a hydraulic ram, with the force measured by a means independent of that producing the force.

5. The hydraulic ram shall be supported at the car end and shall be free to move longitudinally with respect to the car.

6. The load shall be uniform in bearing. Use cushioning means, such as lead sheets. Distribute the load over the loaded surface over an area not to exceed the width of the collision post by a height of 6 in (152 mm).

7. Apply the longitudinal test load to the collision post at the height specified in APTA-PR-CS-S-034-99 for the collision post plastic energy absorbing load.

8. Apply the initial load in increments of the same magnitude as those used during the collision post elastic load test, as described in TS 15.5.7.

9. The carbody structure is compliant with the Specifications if all the following criteria are met:

    a. The strain gauge readings and deflections measured during this test are within +/- 10% and +/- 5% respectively of the gauge readings for the same load and location measured during the collision post elastic test, as in Section 15.5.7.

    b. Strain gauge correlation shall be based on gauges applied to low strain gradient locations as agreed between SEPTA and the Contractor.

    c. If allowed differences are exceeded between the two tests, the Contractor shall propose to correct the fixture, the model, or both, and rerun the test until the specified percentage agreement between the two tests is obtained.

10. After agreement between the two tests is demonstrated the load or displacement shall be increased in increments of 25%, 50%, 75%, and 87.5% of the remaining predicted load or displacement to reach the 135,000ft-lb (0.18MJ) plastic energy absorption. The load shall then be increased until 135,000ft-lb (0.18MJ) is reached.

11. At each Approved increment, record all load cell(s), strain gauges, and deflection gauges. The load need not be relaxed at each step.

12. The collision post is compliant with the Specifications if at the moment the corner post has absorbed the minimum energy:

    a. The post shall not permanently deflect more than 10 in. (254 mm) into the operator's cab or passenger seating area.

    b. There shall be no complete separation of the post, its connection to the underframe, structural shelf, sidewall structure, or its connection to either the roof structure or A-T plate (if used).

15.5.11 Corner Post Elastic-Plastic Test

A. Load the leading end corner post structure beyond the yielding limit to demonstrate the post's ability to absorb the minimum energy requirements of APTA-PR-CS-S-034-99. Test each unique type of corner post and connection.

1. The test specimen shall be a full scale structural model of a cab end of a car. The structural model shall contain all structural elements required to support the collision and corner posts, including the end underframe and roof extending from the forward end of the end frame to the bolster. Alternatively, a simple conventional corner post design can propose only the corner post and connection for SEPTA review and approval.

2. All connections shall be the same as on production cars.

3. Apply the same number of strain gauges and displacement gauges as were used on the corner post longitudinal test.

4. Apply the test load for each test using a hydraulic ram, with the force measured by a means independent of that producing the force.

5. The hydraulic ram shall be supported at the car end and shall be free to move in the normal direction with respect to the car.

6. The load shall be uniform in bearing. Use cushioning means, such as lead sheets. Distribute the load over the loaded surface over an area not to exceed the width of the corner post by a height of 6 in (152 mm).

7. Apply the test load to the corner post at the height specified in APTA-PR-CS-S-034-99 for the corner post plastic energy absorbing load.

8. The starting load shall be 300,000lb (1334kN) or a proposed load resulting in stresses just under yielding. The load or displacement shall then be increased in increments of 25%, 50%, 75%, and 87.5% of the remaining predicted load or displacement to reach the 120,000ft-lb (0.16MJ) plastic energy absorption. The load shall then be increased until 120,000ft-lb (0.16MJ) is reached.

9. At each Approved increment, record all load cell(s), strain gauges, and deflection gauges. The load need not be relaxed at each step.

10. The corner post is compliant with the Specifications if at the moment the corner post has absorbed the minimum energy:

    a. The post shall not permanently deflect more than 10 in. (254 mm) into the operator's cab or passenger seating area.

    b. There shall be no complete separation of the post, its connection to the underframe, structural shelf, sidewall structure, or its connection to either the roof structure or A-T plate (if used).

15.5.12 Alternative Dynamic Performance for Front End Structures of Cab Cars Test (CFR 238 Appendix F)

A. If CFR 238 Appendix F is used in lieu of meeting the requirements of CFR238.211 or 238.213, comply with the following:

1. Test procedures shall be submitted 60 days before testing begins. **(CDRL 15-05, Appendix F Design Qualification Test)**

2. Test Reports shall be submitted within 45 days of the start of applicable testing **(CDRL 15-06, Appendix F Design Qualification Results)**

3. Perform full-scale crash testing of a cab end to validate the Alternative design for both the collision post and corner post. The same test specimen can be used for both tests if analysis is provided showing deformation is limited to one side of the specimen and is Approved.

4. Measure the deformation and striking speed via two methods.

5. Time-displacement curves for each test shall be provided for information only.

6. Test specimens shall be:

    a. Of appropriate length to represent all marginally stressed structural components and shall be Approved.

    b. Manufactured in the same manner as the parts to be used on the car.

    c. Include sufficient grid patterns appropriate to the predicted deformation zone size and geometry.

    d. If the striking surface is dynamic, it shall also include sufficient grid patterns appropriate to the striking surface size.

7. Record the test concurrently with the force and deflection data on two color video cameras situated to best show the crushing of the specimen. Set up one of the cameras to show the time-deflection plot and the specimen in the same frame.

8. Prior to testing, submit a test procedure and obtain Approval.

9. The procedure shall follow the general guidelines in TS 15.3.3.2, and shall include the following:

    a. Location of video cameras.

    b. Complete descriptions of all instruments, gauges, and data acquisition.

    c. Drawing(s) showing the specimen with grid pattern, the fixtures, the attachment of the specimen to the fixture, and test apparatus.

    d. Step-by-step instructions describing how the dynamic loads are applied, and how they are recorded.

    e. Detailed steps, calculations, and tables for the correlation of analysis results with test results.

10. Submit a test report that follows the general guidelines in TS 15.3.3.3, and includes the following:

    a. Raw test data as well as reduced data

    b. Time-deflection curves

    c. Photographs of the specimens before, during, and after the tests

    d. Copy of all the videos on digital storage media with the original report

    e. Correlation of test and analysis data.

11. Approval of the final Appendix F analysis per Section 3, Carbody, will depend on Approval of the CEM element test report.

15.5.13 Crash Energy Management Tests

A. IF CEM is provided, prior to production, conduct full-scale dynamic tests to verify the crashworthiness analysis per the crashworthiness requirements of Section 3, Carbody.

15.5.13.1 Elemental Crash Energy Management Tests

A. IF CEM is provided, comply with the following:

1. Validate the energy absorption properties of structural elements by performing a series of crush tests using full size elements, to be witnessed by SEPTA.

2. Measure the force required to compress or crush a structural element, and the defined distance to develop force-displacement curves for each member contributing to the total energy absorption of the car.

3. Also test members designed to not contribute to the total energy absorption to validate that these members do not interfere with the energy absorption elements.

4. Test specimens shall be:

    a. Manufactured in the same manner as the parts to be used on the car.

    b. Marked over the specimen's entire surface with grid patterns appropriate to the specimen size.

    c. Connected to a fixture in the same manner it is connected in the car assembly.

    d. Mounted in a calibrated test machine with the test fixture.

5. Specimens shall be dynamically compressed (crushed).

6. Continuously record (plot) the force and deflection during the test.

7. Record the test concurrently with the force and deflection data on two color video cameras situated to best show the crushing of the specimen. Set up one of the cameras to show the force-deflection plot and the specimen in the same frame.

8. Prior to testing, submit a test procedure and obtain Approval.

9. The procedure shall follow the general guidelines in TS 15.3.3.2, and shall include the following:

    a. Location of video cameras.

    b. Complete descriptions of all instruments, gauges, and data acquisition.

    c. Drawing(s) showing the specimen with grid pattern, the fixtures, the attachment of the specimen to the fixture, and test apparatus.

    d. Step-by-step instructions describing how the loads are applied, and how they are recorded.

    e. Detailed steps, calculations, and tables for the correlation of analysis results with test results.

10. Submit a test report that follows the general guidelines in TS 15.3.3.3, and includes the following:

    a. Raw test data as well as reduced data

    b. Force-deflection curves

    c. Photographs of the specimens before, during, and after the tests

d. Copy of all the videos on digital storage media with the original report

e. Correlation of test and analysis data.

11. Approval of the final crashworthiness analysis per Section 3, Carbody, will depend on Approval of the CEM element test report.

15.5.13.2 Carbody Crash Energy Management Test

A. IF CEM is provided, comply with the following:

1. Perform full-scale crash testing of a car F-end to validate the CEM strategy and the results of the CEM analysis per the crashworthiness requirements in Section 3, Carbody.

2. The CEM test shall be dynamic to simulate the maximum calculated crash energy absorption of the car end as determined from the train-to-train crash simulations.

3. The test specimen shall be:

a. Manufactured in the same manner as the end assembly used on the production car and shall incorporate all elements contributing to CEM performance.

b. Marked over the specimen's entire surface with grid patterns appropriate to the specimen size.

4. Record the CEM test using a minimum of four high-speed color video cameras with a minimum frame rate of 1,000 frames per second, and two standard frame rate color cameras. The location of the cameras shall be situated to best show the performance of the structure.

5. Record key test parameters such as impact velocity, rebound velocity, and maximum dynamic deflection by at least two means.

6. Prior to testing, submit a test procedure and obtain Approval.

7. The procedure shall follow the general guidelines in TS 15.3.3.2, and shall include the following:

a. Location of all video cameras.

b. Drawing(s) showing the specimen with grid pattern, test fixtures, test apparatus, and location of instrumentation.

c. Step-by-step instructions describing how the dynamic load is applied, and how it is recorded.

d. Typical logging sheets, print-outs, plotting forms, and examples of other data sheets that will be used during the test or in the final report.

e. Tables showing the maximum allowable gauge readings for each gauge and loading condition.

f. Tables showing allowable criteria for all tests.

g. Detailed steps, calculations, and tables for the correlation of analysis results with test results.

8. Prepare and submit a final test report after successful completion of the carbody CEM test.

9. Approval of the final crashworthiness analysis per Section 3, Carbody, will depend on Approval of the carbody CEM test report.

10. The test report shall follow the general guidelines in TS 15.3.3.3, and shall include the following:

a. Description and explanation of each value that did not meet the test criteria.

b. Comparison between the test data and the (test) simulation of the test showing:

(1) Force versus displacement curves for all (non-recoverable) crash energy absorption structure and components.

(2) Energy absorption versus time for all crash energy absorbing structure.

(3) Deformation plots after the test stops.

(4) Animations or static displays of animation frames showing progressive crushing.

(5) Velocity versus time curves.

(6) Acceleration versus time curves.

(7) Displacement versus time curves.

(8) Appendices containing all data. These data shall be identified with the date that they were recorded.

(9) Color photographic images mounted on pages the same size as the report pages.

(10) Video recording of the testing on digital storage media including audio narration with the original report.

(11) Calibration certification for the equipment used to perform the test.

15.6 Subsystem Design Qualification Tests

15.6.1 General

A. Submit test procedures and test reports. **(CDRL 15-07, Subsystem Design Qualification Tests)**

B. Ensure all testing in TS 15.4.2, has been completed prior to commencement of applicable subsystem design qualification tests.

C. Associated software tests shall be part of the Subsystem Design Qualification Tests, as applicable (see Section 19, Software Engineering).

D. Diagnostics Capability Test (Faults, Event, and Signals): The subsystem suppliers shall perform laboratory testing to ensure that diagnostics functions as designed. Note that it will not be necessary to exercise all faults and events, but to rather test all faults, events, and signals as practical.

15.6.2 Door Subsystem

A. A door qualification test shall include an accelerated life test of 1.5 million cycles for one complete door set (1 high level and 1 low level boarding doorway). All parameters of the life test shall be Approved. A physical door obstruction shall activate the obstruction-sensing device for a test of 200,000 door recycles.

1. The test rig shall automatically stop from further cycling if either door panel fails to reach the fully open position after an open request or if either door panel fails to reach the closed and locked position after a close request.

2. These tests shall be completed before the first car is ready for final assembly. Failures recorded during testing must correlate within specified reliability values. Door speed and noise tests shall be performed at the beginning, mid-point, and end of the life test for comparative evaluation.

3. A qualification test of at least 100,000 cycles shall be conducted on the trapdoor assembly located on the opposite side of the Cab. As a minimum, the trapdoor springs, bushings, and other trap door components shall survive the duration of the test without failing and wearing. All parameters of the life test shall be Approved.

15.6.3 HVAC Subsystem

A. Perform HVAC subsystem testing on the HVAC subsystem, including components in the passenger area and the cab, under simulated load conditions, in a certified laboratory. Perform this test one year prior to the climate room tests or earlier.

1. Test Purpose: Design tests to demonstrate subsystem performance compliance with all aspects of Section 7, Heating, Ventilation and Air Conditioning, under the full range of conditions.

2. Prerequisites: All component testing shall be completed prior to performing these tests.

3. Test Setup:

    a. Perform testing according to ASHRAE Standard 37 and AHRI Standard 210/240 following the recommendations, test conditions, procedures, and acceptance criteria of ASHRAE Guideline 23 Section 9, Equipment Level Testing, except where specified otherwise.

    b. The HVAC unit used for this test shall be of a production configuration. The FAI shall not be scheduled until final approval of test reports are given, and all open items are resolved.

    c. All equipment shall be present that is normally mounted to or around the unit and that could impact the unit performance, including the return air grille, unit supply air duct connections, drain piping and connections, and all electrical connections, at a minimum.

    d. Use production-quality sections of car shell and other in-car equipment as practical to develop a test specimen that closely models the in-car application.

    e. Run tests with the controller performing automatic control where possible, including but not limited to all high ambient testing.

    f. Tests shall follow standard industry practices as described in ASHRAE Standard 23 and all procedures shall require approval prior to scheduling tests. Refer to Climate Room Test in TS 15.7.5 for additional details on each test.

    g. Instrumentation and data collection shall be in accordance with TS 15.7.5. as applicable to unit testing.

4. Testing:

    a. At a minimum, perform the following tests.

        (1) Airflow Rate

        (2) Refrigerant Charge Determination

        (3) Cooling Capacity

        (4) Cooling Capacity with a Loaded Filter

        (5) Control Functionality Including Reheat Regulation

        (6) Control Stability, including extreme high and low voltage variation

        (7) Maximum Operating Conditions

(8) Extreme High Ambient Cooling

(9) High-Pressure Cut-Off Switch Reset

(10) Low-Temperature Operation

(11) Low-Pressure Cut-OFF Switch and Reset

(12) Condensate Carry-over

(13) Refrigerant and Oil Sample

(14) Heating Capacity

(15) Air Flow Switch Verification Testing

(16) Heating Protective Device Operation Under Restricted Air Condition including extreme high and low voltage variation

(17) Heating Protective Device Operation Under No-Airflow Condition including extreme high and low voltage variation

(18) Back-up protection including extreme high and low voltage variation.

b. Additional Qualification Tests may be performed outside of the climate chamber:

(1) Evaporative Blower and Condenser Fan Balancing

(2) Ventilation and Duct Sealing

(3) Ventilation Prototype

(4) Floor Heat Design Qualification Test to confirm that the performance conforms to the floor heat requirements of Section 7, Heating, Ventilation, and Air Conditioning (HVAC). Testing shall include verification that the system produces the heat specified in the Contractor's load calculations, the surface temperatures do not exceed 125°F, the system responds to commands from the HVAC system and that a fault is reported to the HVAC unit and driver's monitoring system.

(5) Visual Inspection of the Interior and Exterior of the Equipment

(6) Top Walkway Surface Load Bearing Structural Test

(7) Cab Heater Qualification tests

(8) Windshield heater Qualification test.

15.6.4 Propulsion

15.6.4.1 General

A. Test the propulsion subsystem in a propulsion lab with a brake rack using a complete married pair's worth of traction equipment, defined as the exact quantity of propulsion inverters and traction motors required for a complete married pair plus all controls necessary to interface with the brake rack.

B. Include auxiliary power equipment subsystem as necessary to demonstrate correct interactions between the propulsion system and the auxiliary power system.

15.6.4.2 Combined Subsystem and Operation Subsystem Capacity Test

A. Conduct a laboratory test on a set of propulsion equipment using a dynamometer simulating car inertia, train resistance, and grades.

1. Provide all actual production propulsion and related equipment for the test, including traction motors, power converters and all associated components and control electronics, traction transformer, dynamic brake equipment, any other control logic (including but not limited to vehicle and brake system interface equipment, auxiliary power converters and vehicle level equipment) required to make the power converters operate as they would on the vehicle, propulsion cooling, and other propulsion equipment intended for use on the car. If any system is to rely on vehicle movement for cooling, then any force cooling that is used to simulate air movement over the car shall be controlled such that the air speed of the forced cooling mimics the simulated vehicle speed as the simulated vehicle speed varies throughout the test.

2. The test shall also include friction brake subsystem control electronics to simulate appropriate and realistic friction braking subsystem interaction with propulsion subsystem operation and logic.

3. All equipment shall be production-grade and positioned and wired to simulate on-car configuration. Modifications are permitted only as required to simulate external inputs, and details for modifications shall be proposed for Approval.

4. Maximum ambient temperature shall be presented to all equipment via heated air sources or other Approved means.

5. The test shall demonstrate the following:

    a. That all relevant requirements of Section 2, Design and Performance Criteria, and Section 10, Propulsion and High Voltage System, are met.

    b. That all relevant requirements of Section 9, Auxiliary Power, are met, with the exception of those requirements that are demonstrated by laboratory testing of the APS, LVPS, and battery subsystem as described in TS 15.6.7.

c. That all equipment operates continuously (as appropriate) below Approved ratings.

d. That stable operation is achieved under all conditions.

6. Record equipment temperatures, currents, voltages, speed, response times, and other pertinent information, as Approved, and include in the test report.

7. Confirm conformance to performance requirements by programming a simulator to mimic all operating lines of the SEPTA Regional Rail System (with indicated profiles), or by applying the duty cycle simulation results specified in Section 10, Propulsion and High Voltage System.

8. Determine consumed and regenerated energy during the combined subsystem test, using simulation of the operating lines of the SEPTA Regional Rail System profile, or by applying duty cycle simulation results, with actual speed limits, and AW0 car weight.

a. Measure the consumed and regenerated energy for minimum of 10 runs in each direction with both 100%- and 0%-line receptivity.

b. Calculate the energy consumed and regenerated per mile.

15.6.5 Friction Brake Subsystem

A. Test the complete functionality of the friction brake subsystem to the requirements in Section 12, Friction Brake, and Section 2, Design and Performance Criteria, in a lab using complete sets of equipment to represent each car type and be capable of simulating end changes between 2 different cabs, defined as the exact quantities required for a complete married pair plus all controls necessary to interface with the propulsion subsystem.

B. Testing shall include characterization of the force-pressure curve and hysteresis of the brake calipers and tread brake units, if provided.

15.6.5.1 Subsystem Pressure Test

A. All components within the pneumatic system shall be rated for a minimum of 1.5 times the main reservoir safety valve setting. Pressure test reports shall be provided.

15.6.5.2 Friction Brake Rate Characteristics Test

A. Perform dynamometer tests to evaluate the characteristics of the friction brake materials proposed for use on the cars.

1. Demonstrate that the friction materials are capable of developing the friction brake rate characteristics under all operating conditions.

2. Coefficient of Friction shall be evaluated and reported for each test case.

3. Tests shall include, but not be limited to, combinations of new and bedded-in friction material, hot and cold disc tests, and tests under wet and dry conditions. Wet, cold and hot tests shall be according to UIC 541-3.

4. Performance tests shall also include stops from 110mph for all of the load cases, except where speed limits are otherwise explicitly defined, such as in the route profile simulations.

5. Evaluate the materials, discs, and pads based on attaining consistent results under all tested conditions and demonstrating that the materials selected will provide or exceed the service life required under these conditions. Extrapolated wear rates and predictive life estimates shall be included in the reporting for discs pads and shoes. If scrubbers are provided in place of tread brakes, scrubber shoe must be included in the testing.

6. The car builder shall provide a wheel for usage during dynamometer testing.

7. Dynamometer testing shall include installation of strain gauges to the wheel rim to determine the heat level at which stress reversal occurs.

8. Each simulated test run shall be performed on the worst SEPTA route configuration for that specific test. Routes to be tested shall be Approved.

9. Dynamometer test shall include simulated service run with new friction materials to evaluate the number of stops before pad and shoe performance stabilizes.

10. Dynamometer test shall include a simulated service run with an emergency brake application added at the maximum speed achieved after the highest temperature of the route.

11. Dynamometer test runs shall be made for simulated car weight AW0, AW2, and AW3 from each of the entry speeds of max speed, 88, 70, 60, 45, 30, 20, and 15 mph. For each entry speed, input signals calling for 25 percent, 50 percent, 75 percent, and 100 percent of full service braking effort and for emergency braking effort shall be applied. Results shall be plotted to show the relationship between input signal and output braking effort over the speed and weight range.

12. A snow brake test shall be performed to ensure that snow brake functionality shall not result in thermal damage, metal pickup, glazing, or other undesirable conditions.

13. A glazing test shall be performed to ensure that friction material is not susceptible to glazing. No evidence of glazing shall be permitted.

14. Evaluate smoke, smell, squeal, and other similar criteria and include in the test reports.

15. Dynamometer tests shall also confirm that the maximum allowable disc temperature will not be exceeded during simulated operation under the following conditions:

    a. Passenger loadings as specified for friction brake duty cycle in Section 2, Design and Performance Criteria.

    b. When conducting the test, use "friction only" full service brake rates for all braking.

15.6.5.3 Brake Unit Fatigue Test

A. Perform a brake unit fatigue test:

1. Arrange a test set-up such that a disc brake unit (one disc and caliper assembly) and a tread brake unit is exposed as nearly as possible to the same conditions it would encounter in service, particularly with regard to pad force and force developed by braking torque in each direction.

2. Subject it to 1 million cycles of the predicted working loads. The load level shall represent AW2 conditions.

15.6.5.4 Brake Subsystem Endurance Test

A. Perform an endurance test on the friction brake subsystem in accordance with Duty Cycle requirements in Section 2, Design and Performance Criteria:

1. The test shall consist of 500,000 cycles of normal applications and releases to demonstrate that the control apparatus has the endurance required for service.

2. Control of cycling shall be via the electronic control unit, held at a temperature of 130°F (54°C) and 90% humidity.

15.6.5.5 Parking Brake Test

A. Test the adequacy of the parking brake design of the disc and caliper assembly and maybe included within the dynamometer test:

1. Perform the test using first new, and then bedded-in brake pads.

2. Perform the test by measuring with a load cell the force needed to move the car with the parking brake applied, per the parking brake requirements of Section 12, Friction Brake.

15.6.6 Automatic Train Control/Positive Train Control

A. All electronic apparatus shall be designed and tested in accordance with IEEE 16, EN 50155, EN 50121 and all the referenced standards contained therein.

1. This includes, but is not limited to, operating/storage temperature environment, EMC and shock and vibration.

2. Any variation from these requirements shall be submitted to the SEPTA Project Manager for review and approval.

B. Perform type testing on the initial production ATC/PTC subsystem to confirm that the design complies with the applicable requirements of the Specifications. All standards imposed including associated constraints, limits, and details of testing are subject to Approval.

C. Type testing shall include, at a minimum, the following:

1. Cab Signal Interference (CSI) Susceptibility Test: Laboratory testing to determine the Cab Signal Interference Susceptibility threshold for the following:

a. ATC subsystem reliability: Testing shall subject each cab signal (generated at its lowest level) to a range of in-band frequencies and a range of signal levels in order to determine the thresholds for which the cab signal is not recognizable by the ATC subsystem.

b. ATC subsystem safety:

(1) Testing shall subject each possible cab signal (generated at 15% above its lowest level) to a range of in-band frequencies and a range of signal levels in order to determine thresholds for which a more permissive code rate is perceived by the ATC subsystem.

(2) In consideration of the effects of CSI on a constant cab signal carrier, testing shall subject a constant cab signal carrier (generated at various levels over the range of one-fourth to three-fourths of the calibration level including one-half calibration level) to a range of in-band frequencies and a range of signal levels in order to determine the threshold for which each cab signal is emulated and perceived by the ATC subsystem as a valid code rate.

2. Subsystem and software functional test to validate that the ATC/PTC subsystem complies with the ATC/PTC requirements in Section 20, Automatic Train Control – Positive Train Control.

D. The ATC/PTC supplier shall perform testing to confirm performance of the cab signal decoding function. The testing shall include validation of the pick and drop characteristics and refresh functions using a function generator and code box and loops well as overall performance using the recorded cab signal data.

E. The ATC/PTC subsystem supplier shall perform the following:

1. Verification and validation testing of all revenue service releases including functional test, code reviews, event testing, and any other testing necessary to ensure safety and reliability.

2. Furnish a safety certification to SEPTA upon completion of each revenue service release.

15.6.7 APS, LVPS, and Battery

A. Laboratory test the APS, LVPS, and battery subsystem using a married pair's worth of equipment. The tests shall provide all results that are not provided during the propulsion combined tests. The tests shall demonstrate compliance with the requirements of Section 9, Auxiliary Power. Test the following, at a minimum:

1. Battery voltage and capacity

2. APS output characteristics over the full range of loads (including overload) and supply voltages, including (but not limited to):

    a. Voltage

    b. Frequency

    c. Harmonic distortion

    d. Current limits

    e. Power limits

    f. Thermal limits

3. LVPS output characteristics over the full range of loads (including overload) and supply voltages, including (but not limited to):

    a. Voltage

    b. Voltage Ripple

    c. Current limits

    d. Power limits

    e. Thermal limits

4. Starting and restarting tests

5. Behavior during power interruptions from Catenary power

6. Behavior during Catenary power maximum voltage, and minimum voltage conditions, and at all voltages between maximum and minimum.

7. Staggered starting of auxiliary loads.

8. APS and LVPS maximum load application

9. APS and LVPS maximum load shedding

10. APS and LVPS overload testing

11. APS and LVPS short circuit response

12. APS and LVPS Rated load (thermal) testing and temperature rise testing

13. Behavior at low battery voltage, including load-shedding.

14. The APS Isolation, Protection, and lockout/reset conditions shall be tested and verified.

15. APS test for Load shedding and power sharing between two auxiliary power supply for a married pair train configuration

16. A failure of one LVPS for a married pair train configuration shall be simulated to ensure that all loads transfer to the operational LVPS. The single LVPS shall carry all loads within the married pair under the worst-case supply voltage. No damage or overheating shall occur.

15.6.8 Communications Subsystems

A. Laboratory test the communications subsystem using a complete married pair's worth of equipment. Ensure the functionality of the following at a minimum:

1. Public Address (PA), including the assistive listening subsystems, intercom, and Passenger Emergency Intercom (PEI).

    a. Verify transmission of speech through all relevant combinations of microphones and speakers.

2. Verify complete functionality of the PEIs, as specified in Section 13, Communications.

3. Automatic Vehicle Location (AVL)

4. Passenger Information Subsystem (APIS)

    a. Verify that the PIS can display location-specific data provided by the AVL subsystem.

    b. Verify that the PIS displays a text version of prerecorded announcements when these are played.

5. Voice Radio: Verify both transmission and reception of voice traffic.

6. Video Surveillance System (VSS)

7. Automatic Passenger Counting (APC)

8. Onboard Dynamic Advertising System

9. Communication Controls

10. Communication diagnostic and reporting requirements.

B. For the following components, in addition to the above tests, simulate throughout the entire Regional Rail System, including SEPTA and Amtrak territory, on all operating tracks in all directions and ensure that the components accurately reflect the expected passenger audio/visual information through the supply of a test report including journey log:

1. Exterior speakers

2. Interior speakers

3. AVL subsystem

4. PIS screens including dynamic route map displays, exterior display signs, and advertising capabilities.

5. Bluetooth LE Broadcast

C. Demonstrate compliance with the interchangeability requirements of Section 13, Communications, by substituting a screen from a different manufacturer, of the same resolution, and confirming that system functionality is unaffected. Perform this substitution for the route map signs and information signs.

D. Demonstrate compliance with the self-test requirements of Section 13, Communications.

15.6.9 Event Recorder Subsystem

A. Laboratory test the event recorder subsystem using a married pair's worth of equipment, such as sensors, transducers, etc.

B. Network interfaces, as required by Section 17, Network and Trainline Control, shall be tested.

1. Report its health status to the Vehicle Monitoring and Diagnostic Subsystem (VMDS).

2. Receive vehicle parameters from the measuring subsystems.

3. Report to the VMDS the vehicle parameter which are measured independently of other systems.

C. The Event Recorder shall be subjected to testing that demonstrates:

1. Compliance with the requirements of IEEE Std. 1482.1-1999, Standard for Rail Transit Vehicle Event Recorders.

2. Event Recorder's functional capability to record all required data correctly.

3. Capability to retrieve data with a laptop Portable Test Unit through the Universal Service Port.

15.6.10 Network Subsystem

A. Laboratory test the network subsystem using a complete married pair's worth of network connected equipment. Perform the following lab tests on the network subsystem:

1. Test of each network interface card (NIC). The tests shall ensure compliance with the requirements established in the NIC Specification CDRL, as required by Section 17, Network and Trainline Control, prior to their implementation into SEPTA's network subsystem.

2. Progressive laboratory Network Integration Test of all the train subsystems, following completion of the NIC Specification validation.

a. Train subsystems include the electrical coupler, network switches, all network connected subsystem end devices, and remote I/O stations.

b. The testing shall resolve conflicts, establish the susceptibility limits of the network-to-noise, and prequalify the proposed architecture of networks before its implementation into the Pilot Cars.

c. The testing shall include a capacity test, PTU operational verification test, and integration test of the completed vehicle and train networks.

d. Network timing tests shall be performed, indicating the relationship between the processing of discrete inputs through each controller, and the speed at which they report and interpret network signals.

e. The test shall verify that all protocols, datasets, and messages used on all networks correspond to the Network Interface Control Documents submitted to SEPTA, and that the specific signal, message, and dataset documentation provided for each network completely describes all network communication used.

f. At the time of these integration tests, the Contractor shall demonstrate the fault tolerance of the network by simulating all possible faults.

3. Penetration testing on the integrated network and all network subsystems as specified in Section 24, Cybersecurity. Perform penetration testing in the time periods specified in Section 24.

15.6.11 Electromagnetic Compatibility Lab Tests

15.6.11.1 General

A. Perform the following lab EMI/EMC tests to demonstrate compliance with the EMI/EMC requirements of Section 2, Design and Performance Criteria, for applicable equipment, including propulsion and auxiliary converters and relevant sub-components, at the integrated subsystem level in compliance with EN 50121-3-2:

1. Conducted emissions

2. Inductive emissions (per UMTA-MA-06-0153-85-8)

3. Radiated emissions tests on equipment smaller than 50 kVA. Radiated emissions from larger power converters shall be measured at vehicle level.

4. The test report shall identify the source of all narrow band emissions from 14 kHz to 6000 MHz.

B. Testing may be performed as part of other combined subsystem lab testing as specified in TS 15.6.14.

15.6.11.2 Electromagnetic Emission Tests and Limits

A. The tests shall demonstrate compliance with the emission limit requirements of Section 2, Design and Performance Criteria.

15.6.11.3 Lab Conducted EMI Test

A. Perform lab conducted EMI tests as specified above.

B. In addition to separate component tests required by TS 15.4.2.7, perform a combined conducted EMI test of the propulsion subsystem and the auxiliary inverter(s) to ensure electromagnetic compatibility (EMC).

15.6.11.4 Lab Inductive EMI Tests

A. Perform lab inductive EMI tests as specified above.

B. In addition to separate component tests required by TS 15.4.2.7, perform a combined inductive EMI test of the propulsion subsystem and the auxiliary inverter(s) per UMTA-MA-06-0153-85-8 to ensure EMC.

15.6.11.5 Lab Line Current Harmonics Test

A. Under normal operation of the vehicle, the harmonic content of current drawn from or regenerated to the line from a married pair shall not exceed the individual

harmonic requirements of IEEE Std 519-2022, Table 10-3, with Isc/IL < 20, with a resulting THD of 9.7% and Telephone Influence Factor of 257 as calculated according to the methods and weighting factors of Section 6.9 of IEEE Std 519-2022. Compliance of the harmonic content shall be verified when measured in laboratory under the following conditions:

1. All converters switching and interlacing used for harmonic reduction are available and tested simultaneously,

2. The THD or individual harmonic level calculation is based on the fundamental current at peak rated power for the number of converters under test,

3. The line voltage under no load condition is a pure sine wave,

4. The laboratory substation impedance is purely inductive over the frequency range specified,

5. The laboratory line impedance is purely inductive over the frequency range specified,

6. No resonances exist at any power frequency harmonic when the line is loaded with a vehicle equivalent passive load.

15.6.12 Lighting Subsystem

A. Perform lab testing of the following controllers to verify proper functionality before car level testing:

1. Normal Lighting Control, Layover Mode, Cleaning Mode, and Diagnostics reporting functionality.

2. Emergency Lighting Control, Independent Power Sources, Self-test, and Diagnostics reporting functionality.

3. Exterior Lighting Control including headlight (dim and bright), auxiliary light (on and flashing), and any other exterior lights that have switching devices.

4. Test and/or provide certifications for exterior light compliance to 49 CFR 229.125 and 49 CFR 231.

5. Water tightness levels. Interior light fixtures within 3 feet of a doorway shall be tested to IP55 or higher, in accordance with IEC 60529. Exterior light fixtures including stepwell lights shall be tested to IP56 or higher.

6. All components shall be EMC tested to EN 50121-3-2

7. All components shall be environmentally tested to EN 50155 including all referenced supplemental standards.

8. Measure the power consumption of the lighting system in normal and emergency lighting modes. Data shall be used for battery capacity tests.

15.6.13 VMDS Test

A. Perform a test of the VMDS, including TODs and related equipment, to verify the proper function and integration of the VMDS software and hardware. Tests shall include:

1. Reading from and writing to VMDS memory.

2. Full use of the TODs and their interfaces.

3. Full use of the PTU and its software programs.

B. A combined factory level system test shall be conducted on one complete set of VMDS equipment and subsystem control units networked over the Train Communication and Diagnostic Network (TCDN) described in Section 17, Networks and Trainline Control, to simulate a full train consist prior to the VMS first article inspection. This testing may be combined with the network integration test described Section 17.

1. The test shall include:

a. A Fault Management Qualification test, Capacity test, PTU operational verification test, VMS performance test and an integration test of the completed VMS.

b. Subsystem reporting to VMU, Fault Display, PTU operation and snapshot configuration and retrieval, etc. The tests shall verify reporting within a single Married Pair as well as fault reporting, display and controls over the TCDN train bus.

c. Verification that the VMD status, help and maintenance screens perform as specified in this section.

d. Verify proper display of consist composition and display.

C. Test results shall be submitted to SEPTA for review and approval.

15.6.14 Combined Subsystems Test

A. Perform lab testing of combined subsystems under controlled conditions to validate the proper function and integration of all the primary subsystems on the car. These tests are in addition to thorough tests on the individual subsystems.

1. Propose a set of combined tests that are appropriate for Contractor-provided equipment. Include the following subsystem combinations, at a minimum:

a. Propulsion/Brake: Perform in the propulsion lab with a brake rack.

b. Propulsion/Brake/ATC: Perform in the propulsion lab with a brake rack.

c. EMI, as specified in Section 15.6.11, Electromagnetic Compatibility Lab Tests, above. Inductive emissions shall also be measured.

d. Networks: Include all network devices and end units on a married pair, plus simulated equipment for a complete train.

e. VMDS: Include all equipment communicating to the VMDS from a married pair, plus simulated equipment for a complete train. Test, at a minimum, the following VMDS functionality:

(1) Detection of subsystem faults. Introduce or simulate all faults from each subsystem controller at separate times during this test.

(2) Detection of remote input/output (I/O). Simulate each remote I/O to verify expected VMDS software functionality.

(3) Notification to the Operator of these faults via the TOD.

(4) Test each method of Operator fault resetting.

(5) Transmission of data to/from a wayside server via the Train-to-Wayside Data Transfer (TWDT). A hard-wired connection may be used to simulate the TWDT if the lab cannot support a wireless connection.

2. As part of the test procedure, propose a suitable sequence of partial tests to ensure timely testing and validation, as well as complete coverage of all related subsystem parameters and interfaces before a final test of the combined subsystems.

3. The test facilities shall be capable of the following:

a. Providing power and input signals covering the extremes of ranges to simulate the full operational ranges that would be encountered in service, including abnormal situations (e.g., emergency braking, loss of signal, slip-slide, and spin, etc.).

b. Measuring and recording all data necessary to demonstrate that Contract requirements have been met.

15.7 Car and Married Pair Design Qualification Tests

15.7.1 General

A. Perform the car design qualification tests on the pilot cars at the Contractor’s or third-party's facility.

B. Submit test procedures and test reports. **(CDRL 15-08, Car and Married Pair Design Qualification Tests)**

15.7.2 Watertightness Test

A. Comply with the following:

1. Perform a water tightness test on a married pair:

a. Water shall be sprayed from nozzles which are spaced no more than 3 feet from, and aimed directly at, the roof and sides of the car, with the side wall nozzles continuing in a vertical plane to 1 foot above top of rail.

b. Not less than 0.625 gallon per minute shall be delivered to each square foot of surface being tested, and the nozzle velocity of the water shall not be less than 150 feet per second.

c. All spray applications shall run for 10 minutes before the inspection for leaks and shall run continuously during the inspection.

d. The test will include the fresh air and electric equipment ventilation intake ducts with all auxiliary blowers and fans running at full speed, to determine the effectiveness of the water-excluding features of the ductwork.

e. Exterior equipment enclosures, interior equipment enclosures that have access to the outside, and the HVAC units shall be watertight.

f. Water test enclosures at the point of manufacture in accordance with Section 7, Heating, Ventilation, and Air Conditioning, and Section 14 Interior and Exterior Appointments.

g. During test of the enclosures, direct the required spray at the exposed sides and ends of the enclosures and water spray from the wheels, and wind driven rain.

15.7.3 Side Door Operation Tests

A. Before delivery, all of the passenger doors and controls of one of the Pilot Cars shall be operated for 25,000 continuous trouble-free cycles each.

B. Monitoring apparatus shall verify the true fully open and fully closed and locked position of each door leaf during the test.

C. No adjustments or maintenance shall be allowed during the test.

D. Any door or door control failure occurring prior to completion of the test shall nullify the test, and the test will be resumed at the beginning for all car doors.

15.7.4 Climate Room Testing Requirements

15.7.4.1 General

A. Perform climate room tests on one of the first three married pairs agreed upon between SEPTA and the Contractor. If the Contractor does not find a climate room capable of performing the tests on a complete married pair, it shall provide a recommendation for Approval.

1. The climate room test shall demonstrate the HVAC subsystem's ability to comply with the temperature control and operational requirements of Section 7, HVAC.

2. The climate room tests shall be in accordance with the recommendations, test conditions, procedures, and acceptance criteria of ASHRAE Guideline 23 Section 10, Rail Vehicle Heating, Ventilating, and Air-Conditioning Climate Room Test Procedure except where specified otherwise.

3. Test procedures shall include clear step-by-step instructions for conducting the tests and shall pass/failure criteria shall be defined.

4. The cab heater shall be instrumented and tested concurrently with the HVAC units serving the passenger area for all applicable tests.

5. All protective heat shall be verified in these tests. Protective heat shall include door thresholds, door pockets (if applicable), tank drain valves, coupler heaters, coupler contact heaters and any other protective heaters as required based on the vehicle design.

6. Conduct a visual inspection of the interior and exterior of the HVAC equipment prior to the start of testing and again after the completion of testing to document any defects, damage, clearance conflicts, maintenance accessibility issues, safety concerns, manufacturing defects or premature wear.

15.7.4.2 Climate Room Test Prerequisites

A. Comply with the following:

1. Prior to being shipped to the climate room test facility, the test married pair shall successfully pass all production conformance testing including the HVAC Subsystem Testing specified in TS 15.10.10.

2. Perform an air balance and air distribution adjustment and test to demonstrate compliance with the nominal design fresh air and return air volumes and the uniformity of supply air and car pressurization requirements specified in Section 7, Heating, Ventilation, and Air Conditioning. Any variable fresh air loads agreed during design shall be validated.

a. Record the volumes of the variable cab air supply.

b. The combined return and fresh air volumes of each HVAC unit shall be within +10% to -5% of the design supply air volume.

3. Demonstrate the delivered air distribution and diffuser outlet velocities required by Section 7, Heating, Ventilation, and Air Conditioning.

4. On the climate room test married pair, the diffusers shall be adjustable and adjusted from inside the passenger compartment without the need to open panels or dismantle the diffusers. The approach to setting all subsequent cars to the climate room settings shall be established.

5. Conduct a refrigerant charge verification test to verify that HVAC units are properly charged with refrigerant as determined by the HVAC supplier at the design qualification testing.

6. Demonstrate that the refrigerant compressor capacity reduction method and associated subsystem and control design permits the HVAC unit to operate continuously at any inside or outside temperature within the specified control range and without damage or detriment to the HVAC unit or its components. Demonstrate the lock-out ambient temperature of the compressor.

7. The design passenger load shall be as specified in Section 7, Heating, Ventilation, and Air Conditioning.

8. The design solar load shall be calculated according to the ASHRAE Load Calculation Applications Manual or ASHRAE Guideline 23.

9. The fresh air loads shall be as agreed during design reviews.

10. Conduct a load bearing test to demonstrate that the top walkway meets the design requirements of Section 7, Heating, Ventilation, and Air Conditioning.

15.7.4.3 Climate Room Requirements

A. The climate room shall meet the following requirements:

1. The climate room shall be certified for providing and maintaining suitable test temperatures that meet the requirements of all tests in the Specifications.

2. Temperatures in the facility shall be uniform throughout. Fans may be used to circulate the air in the facility. There shall be no more than 5°F (2.8°C) variation from 24 in (610 mm) above the running rail to 24 in (610 mm) above the car roof and from end to end of the car.

3. Passenger load shall be simulated by means of heaters and humidity generating equipment.

a. Solar and equipment loads shall be simulated by means of electric heaters inside the cars.

b. Humidity introduced into the car to simulate the latent heat loads shall be carefully metered to ensure the accurate proportioning of sensible and latent design loads.

4. Load simulating equipment shall be evenly distributed throughout the car as closely as possible to represent the actual operating conditions.

15.7.4.4 Instrumentation

A. The test car and the climate room instruments shall comply with the following:

1. Measure the relative humidity of the fresh air and the car interior at each return air grille and fresh air inlet using an Approved sampling device in accordance with ASHRAE Standard 41.1.

2. Provide a minimum of 100 car and cab interior temperature measurement locations, determined during the air balance and distribution testing, in locations in the passenger and cab areas as agreed to between the Contractor and SEPTA. The intent is to place the devices to arrive at an average car and cab interior temperature.

3. If a low ceiling section is used near the ends of the car, provide an additional three temperature sensors located on the high ceiling panels, with one sensor located at the transverse center on the car longitudinal centerline and the other two between 16 and 30 in (406 and 760 mm) from each low ceiling transition.

4. Continuously record all data (temperatures, pressures, voltages, currents, motor speeds, and events) using an Approved data acquisition system using appropriate and Approved transducers. The data acquisition system shall be capable of providing graphical representation of selected channels while testing is in progress. The data sampling rate shall be adjustable to one sample per second.

5. Record data every 10 seconds unless specified otherwise for a specific test in this section or in ASHRAE Guideline 23.

6. Record data every minute for 30 consecutive minutes at each stabilization point, to demonstrate the temperature variations as the HVAC equipment cycles.

7. Measure refrigerant pressure with Bourdon tube gauge or electronic pressure transducers.

8. Accurately measure refrigerant pressure to within +/- 2.0% of value being measured. In no case shall the smallest scale division of pressure measuring instrument exceed 2.5 times the specified accuracy.

9. Measure air pressure with manometers, or Approved equal, having an accuracy of +/- 0.01 inch of water (2.49 Pa).

10. Measure the electrical input to heaters accurately to +/- 1.0% of the quantity measured. Instruments used for measuring the electrical input to fan motors, compressor motors, or other equipment accessories shall be accurate to +/- 2.0% of the quantity measured.

11. Measure rotational speed with either a revolution counter, tachometer, or stroboscope having an accuracy of +/- 1.0%.

12. Monitor operation of relays and contactors with a suitable recorder.

15.7.4.5 Data Collection

A. The following data shall be available during testing. Record only the data pertinent to the test being performed.

1. Temperatures:

a. Return air (nine-point grid)

b. Fresh air (nine-point grid)

c. Mixed Air (nine-point grid)

d. Air exiting evaporator (nine-point grid)

e. Supply air to the evaporator/heater

f. Supply air (nine-point grid)

g. Condenser inlet (nine-point grid)

h. Condenser outlet (nine-point grid)

i. Floor heater grille: At two of the hottest spots determined in initial testing

j. Climate Room: 12 places

k. Car interior: Minimum 28 thermocouples

l. Evaporator blower motor

m. Condenser fan motor.

2. Refrigerant Subsystem Temperatures:

a. Refrigerant compressor discharge line 12 in (305 mm) from the refrigerant compressor

b. Refrigerant compressor suction line 12 in (305 mm) from the refrigerant compressor

c. Liquid line leaving the condenser coil

d. Liquid line at the thermal expansion valve(s) or capillary header, as applicable

e. Suction line at the evaporator header(s)

f. Refrigerant compressor crankcase.

3. Refrigerant Pressures (psig):

a. Discharge at the refrigerant compressor

b. Suction at the refrigerant compressor

c. Liquid leaving condenser

d. Liquid at thermal expansion valve(s) (if applicable)

e. Suction at evaporator(s).

4. Air Pressures (w.g.):

a. Evaporator blower (fan) total or static pressure

b. Evaporator coil pressure drop

c. Condenser coil pressure drop

d. Air supply plenum

e. Car pressurization

f. Cab pressurization

5. Electrical Data:

a. Evaporator blower motor voltage: Each phase

b. Evaporator blower motor current: Each phase

c. Evaporator blower motor watts: Each phase

d. Evaporator blower motor power factor

e. Evaporator blower motor speed

f. Condenser fan motor voltage: Each phase

g. Condenser fan motor current: Each phase

h. Condenser fan motor watts: Each phase

i. Condenser fan motor power factor

j. Condenser fan motor speed

k. Refrigerant compressor motor voltage: Each phase

l. Refrigerant compressor motor current: Each phase

m. Refrigerant compressor motor watts: Each phase

n. Refrigerant compressor motor power factor

o. Refrigerant compressor speed

p. Overhead heater watts

q. Floor heater watts, (each stage if applicable).

6. During all tests, monitor and record the temperature of the HVAC unit inverters, if used, and incorporate into the test report. Monitor the following at a minimum:

   a. Input power

   b. Output voltage each phase

   c. Output current each phase

   d. Temperature of the most sensitive temperature-critical component(s) of the inverter.

7. Event Data:

   a. Compressor operation

   b. Contactor operation (if applicable)

   c. Liquid line solenoid valve(s)

   d. Overhead heat over-temperature thermostats

   e. High-limit switch

   f. High- and low-pressure cutout switches

   g. Back-up protection activating devices

   h. Door openings and closings if applicable.

15.7.5 Car Climate Room Design Parameter Verification Tests

A. Perform the following tests to demonstrate that the HVAC equipment meets the criteria specified in Section 7, Heating, Ventilation, and Air Conditioning, before conducting cooling and heating tests specified in TS 15.7.6 and 15.7.7. Continuously record relevant data during all testing.

15.7.5.1 HVAC Control Verification Test

A. Conduct an HVAC control verification test to demonstrate that HVAC equipment controls function as designed across the full range of design ambient conditions.

B. The climate room temperature and internal vehicle loading shall be varied throughout the design condition range shown in Section 7, Heating, Ventilation, and Air Conditioning, to drive the system through all operating modes. Transitions between modes shall be seamless and the specified vehicle interior temperature design conditions shall be maintained during the test. Operational mode changes resulting from changing ambient temperature as well as changing interior conditions shall be included.

15.7.5.2 Heat Transfer: UA Factor Determination

A. Conduct a carbody heat transfer (UA-Factor) test to verify that the carbody insulation is in conformance with the thermal insulation requirements of Section 14, Interior and Exterior Appointments.

1. Perform the test at an ambient temperature between -20°F and 25°F (-29°C and -4°C) with the evaporator blowers shut down and all external grilles blocked. Internal heating shall be supplied by the car heated floor (if applicable) and sidewall heaters. No additional space heaters shall be applied.

2. For UA-Factor calculations, consider the heat generated by circulating fans used to minimize temperature stratification, part of the internal heat load.

15.7.6 Car Climate Room Heating Tests

A. Perform the following tests to demonstrate that the heating equipment meets the criteria specified in Section 7, Heating, Ventilation, and Air Conditioning. Continuously record relevant data during all testing.

15.7.6.1 Layover Heat Test

A. Conduct a layover heat test to demonstrate that the interior temperature can be maintained in conformance with the design requirements at the minimum ambient condition.

1. Perform the test at the climate room ambient temperature of -15°F (-26°C) with no internal loads, at the nominal supply voltage.

2. The interior temperature shall remain in the range shown for layover heating interior car temperatures in Section 7, Heating, Ventilation, and Air Conditioning.

15.7.6.2 Pull Up from Stable Layover Condition

A. Conduct a pull up test from a stable layover condition to demonstrate the capability of the heating subsystem to raise the interior temperature from a stabilized layover condition to the required interior temperature in the required amount of time.

1. Perform the test at the climate room ambient temperature of -7°F (-21.7°C) with no internal loads, at the nominal supply voltage.

2. Following the layover heat test, place the HVAC subsystem in Environmental Control mode and record the time required for the internal temperature to reach 68°F (20°C). The pull up time (defined as the time to reach the required temperature from the layover temperature) shall not be greater than that specified. Determine the mass capacitance of the car during this test.

3. Temperature variations within the Operator's cab and passenger area shall follow ASHRAE Guideline 23.

4. If the requirements of Section 7, Heating, Ventilation, and Air Conditioning, are not met, correct the air balance and diffuser settings. At the discretion of SEPTA, and based on the severity of the readjustments, repeat the test sequence.

15.7.6.3 Steady State Heating: Minimum Ambient, No Passenger Load

A. Conduct a steady state heating test at the minimum ambient temperature to demonstrate the capability of the heating subsystem to control the temperature according to the stability and uniformity requirements.

1. Perform the test at the climate room ambient temperature of -7°F (-21.7°C) at the minimum and nominal supply voltage with no internal loads, no passenger load, and no solar load.

2. Measure and record the surface temperatures of the heat guards throughout the test.

15.7.6.4 Steady State Heating: Minimum Ambient, Passenger Load

A. Conduct a steady state heating test at the minimum ambient temperature to demonstrate the capability of the heating subsystem to control the temperature according to the stability and uniformity requirements.

1. Perform the test at the climate room ambient temperature of -7°F (-21.7°C) at the nominal supply voltage with passenger load, no internal loads, and no solar load.

2. Measure and record the surface temperatures of the heat guards throughout the test.

15.7.6.5 Heating Control Stability for Cooling/Heating Transition Ambient

A. Conduct a control stability test at an ambient condition that will require the system to operate continuously near the cooling/heating mode transition to demonstrate the capability of the heating subsystem to control the temperature according to the stability and uniformity requirements.

B. Perform the test at the climate room ambient temperature of 40°F (5°C) at the nominal supply voltage with passenger load, internal loads, and solar load.

15.7.6.6 Heating Performance with Passenger Door Cycling

A. Conduct a passenger door cycling test to demonstrate the capability of the heating equipment to meet the requirements of Section 7 for interior car temperatures.

1. Perform the test at the climate room ambient temperature of -7°F (-21.7°C) at the nominal supply voltage with no internal, passenger, or solar load.

2. Perform the test with the interior temperature stabilized.

3. Cycle doors open for 20 seconds and closed for 2 minutes for a test duration of no less than 1 hour.

4. Record data every 5 seconds during the test.

15.7.6.7 Forced-Air Heater Over-Temperature Protection, Restricted Airflow

A. Conduct a restricted air backup protection test to demonstrate that primary heating equipment protection operates properly, and the primary setpoint is appropriate and functions as designed in coordination with the secondary overheat protection.

B. Record the temperature rise of the evaporator blower motor during the test. The highest recorded temperature should not exceed manufacturer recommendations.

15.7.6.8 Forced-Air Heater Over-Temperature Protection, No Airflow

A. Conduct a no-airflow backup protection test to demonstrate that primary heating equipment protection operates properly, and the primary setpoint is appropriate and functions as designed in coordination with the secondary overheat protection.

15.7.6.9 Forced-Air Heater Over-Temperature Protection, No Airflow, Backup Overheat Protection

A. Conduct a no-airflow backup protection test to demonstrate that the backup heating equipment protection operates properly without nuisance tripping and the setpoint for the backup heat protection is appropriate.

15.7.6.10 Cab Heater Subsystem Test

A. Conduct cab heater testing to demonstrate that operation and performance of the cab heater and the associated protective devices are in conformance with the design requirements.

1. Perform the test at the climate room ambient temperature of -7°F (-21.7°C) at the nominal supply voltage with no internal, passenger, or solar loads.

2. Perform the test with the cab heaters on high heat at the minimum, nominal, and maximum supply voltage.

3. After documenting results of the first test, perform the test with no airflow through the unit to test the operation of the high-limit thermostat and back-up protection device.

4. Measure and record the time necessary for the cab interior temperature to reach the specified design temperature in accordance with Section 7, Heating, Ventilation, and Air Conditioning, at the minimum, nominal, and maximum supply voltage.

5. Measure the cab heater supply and return air temperatures as the average of a nine-point thermocouple UL-type grid for each.

6. Record the following measurements:

    a. Blower motor voltage, current, and power

    b. Blower motor speed

    c. Heater element voltage, current, and power

    d. Airflow with and without heater element energized

    e. Inlet and outlet air temperature

    f. Surface temperature of exposed side of heater housing

    g. Temperature at high-limit switch

    h. Temperature at fusible link or the associated secondary protection thermostat

    i. Temperature at blower motor

    j. Climate laboratory ambient temperature.

15.7.6.11 Cab Windshield Defrost Test

A. Conduct a cab windshield heater test using SAE J902 as a guide to demonstrate compliance with the requirements of Section 7, Heating, Ventilation, and Air Conditioning.

1. Perform the test on a cold-soaked car at the climate room ambient temperature of -20°F (-28.9°C) at the nominal supply voltage with passenger load, no internal loads, and no solar load.

2. Apply an even test coating of ice on the outer surface of the windshield by spraying water at 0.01 oz/in² (439 g/m²) on the entire surface of the windshield.

3. No less than 80% of the windshield surface shall be clear and dry after 15 minutes.

4. The windshield wipers shall be turned off and shall not be used during the test.

15.7.6.12 Cab Windshield Demist Test

A. Conduct a cab windshield heater test to demonstrate compliance with the requirements of Section 7, Heating, Ventilation, and Air Conditioning:

1. Perform the test with the climate room ambient temperature of 45°F (7°C) and car interior initially soaked at 45°F (7°C).

2. No less than 80% of the windshield surface shall be clear and dry after 15 minutes.

3. The cab end door and cab door shall be closed for the duration of the humidification period and the demisting period.

15.7.6.13 Door Icing Conditions

A. Conduct a door icing test to demonstrate that the door threshold heaters perform according to the design requirements.

1. Perform the test with the climate room ambient temperature of -20°F (-28.9°C) and the car in environmental control.

2. Perform the test for icing, simulated snow, freezing rain and ice accumulation following ASHRAE Guideline 23 recommendations.

15.7.6.14 Water Freeze Protection

A. Conduct a water freeze protection test to demonstrate that water on the floor from car cleaning or from residual rain or snow does not cause a slipping hazard to operators, staff, or passengers.

1. Perform the test with the climate room ambient temperature of -20°F (-28.9°C) and the car in a layover heating condition for at least 8 hours.

2. The portion of the water freeze protection test in ASHRAE Guideline 23 associated with onboard water systems is not required.

3. Ensure that the systems drain by the automatic drain valve only after loss of power. Check the system for any cracks or damage from residual water.

15.7.7 Car Climate Room Cooling Tests

15.7.7.1 General

A. Perform the following tests to demonstrate that the cooling equipment meets the criteria specified in Section 7, Heating, Ventilation, and Air Conditioning.

1. Continuously record relevant data during all testing.

2. Conduct the cooling tests specified below in sequence and without prolonged interruptions or temperature changes between tests, except for car interior temperature changes due to the application of heat loads.

3. During each test, no condensate shall drip, run, or be entrained in the airflow beyond the HVAC cooling coil. All condensate from the evaporator coil shall flow into and drain freely from the drain pan without spillage or overflow. Condensation on the heaters shall be considered a failure.

15.7.7.2 Layover Cooling Test

A. Conduct a layover cooling test to demonstrate that the interior temperature can be maintained in conformance with the design requirements at the maximum ambient condition.

1. Perform the test at the climate room ambient temperature of 100°F DB / 81°F WB (37.8 °C DB / 27.2°C WB) with no internal loads, at the nominal supply voltage.

2. The interior temperature shall remain in the range shown for layover cooling interior car temperatures in Section 7, Heating, Ventilation, and Air Conditioning.

15.7.7.3 Pull Down from stable layover cooling, Design Conditions

A. Conduct a pull down test from steady state layover cooling condition at the design cooling ambient temperature to demonstrate the capability of the cooling subsystem to lower the interior temperature from a stable layover cooling condition to the required interior temperature in the required amount of time.

1. Perform the test at the climate room ambient temperature of 100°F DB / 81°F WB (37.8 °C DB / 27.2°C WB) at the nominal supply voltage with internal loads, solar load, and no passenger load.

2. Place the HVAC subsystem in Environmental Control mode and record the time required for the internal temperature to reach 72°F (22°C). The pull down time (defined as the time to reach the required temperature) shall not be greater than specified in Section 7, Heating, Ventilation, and Air Conditioning.

3. Temperature variations within the Operator's cab and passenger area shall follow ASHRAE Guideline 23.

4. If the requirements of Section 7 are not met, correct the air balance and diffuser settings. At the discretion of SEPTA, and based on the severity of the readjustments, repeat the test sequence.

5. After the initial pull down period, permit the car interior to stabilize under automatic control and record the time required to reach stabilization.

15.7.7.4 Steady State Operation at Design Conditions

A. Conduct a steady state cooling test at the design cooling ambient condition to demonstrate the capability of the cooling subsystem to control the temperature and humidity according to the stability and uniformity requirements.

1. Perform the test at the climate room ambient temperature of 100°F DB / 81°F WB (37.8 °C DB / 27.2°C WB at the nominal supply voltage with internal loads, passenger load, and solar load.

2. Simulate power interruptions following ASHRAE Guideline 23, Section 7.10, Temperature and Humidity Control.

15.7.7.5 Loaded Recirculating Air Filter Cooling Capacity Test

A. Conduct a cooling capacity test with loaded recirculating air filters at the design cooling ambient condition to demonstrate the capability of the cooling subsystem to control the temperature and humidity according to the stability and uniformity requirements.

1. Perform the test at the climate room ambient temperature of 100°F DB / 81°F WB (37.8 °C DB / 27.2°C WB at the nominal supply voltage with internal loads, passenger load, and solar load.

2. Perform test in the same manner as the Steady State Operation at Design Conditions test except for using a loaded recirculating air filter.

3. The filter shall be considered loaded when it has twice the initial pressure drop of a new filter measured by the air differential pressure switch.

4. Perform airflow switch testing to ensure heaters and compressors are disabled when airflow is not present. Ensure that the device indicates a need to change filters without disabling HVAC operation.

15.7.7.6 Cooling Performance with Passenger Door Cycling

A. Conduct a passenger door cycling test at the design cooling ambient condition to demonstrate the capability of the cooling subsystem to meet the requirements of Section 7, Heating, Ventilation, and Air Conditioning, for interior car temperatures.

1. Perform the test at the climate room ambient temperature of 100°F DB / 81°F WB (37.8 °C DB / 27.2°C WB at the nominal supply voltage with internal loads, passenger load, and solar load.

2. Perform the test with the interior temperature stabilized.

3. Cycle doors open for 20 seconds and closed for 2 minutes for a test duration of no less than 1 hour.

4. Alternate between high level and low level doors.

5. Record data every 5 seconds during the test.

15.7.7.7 Maximum Operating Condition

A. Conduct a maximum operating condition test to demonstrate the capability of the cooling equipment to operate at the maximum operating conditions according to the design requirements.

1. Maintaining the final conditions achieved in the Elevated Design Conditions test, raise the climate room temperature to 125°F (51.7°C) DB/82.7°F (28°C) WB with the interior temperature stabilized.

2. Items 2 through 4 of the Elevated Design Conditions test shall apply, except that the average interior temperature shall be less than or equal to 15°F (8°C) below ambient.

3. After one (1) hour of operation, the power input to the system shall be removed for two (2) seconds and then reapplied. The system shall recover from the power interruption and restart. After restart, the system shall function properly with all components free from malfunction. The removal of power simulates a power gap or phase break. The exact method of power removal and duration may be modified as agreed to and approved by the SEPTA.

15.7.7.8 Extreme High Ambient Temperature Operation

A. Conduct an extreme high ambient temperature test to demonstrate the capability of the cooling equipment to operate at the extreme high ambient temperature conditions in accordance with Section 7, Heating, Ventilation, and Air Conditioning.

1. As the climate room temperature rises above 125 degrees F (51.6 degrees C), the HVAC unit shall not shut down due to high operating pressure. Record the maximum temperature attainable prior to trip.

2. The subsystem shall maintain stable operation and shall not exceed any limits recommended by the HVAC supplier.

3. Record the temperature rise of the condenser motor during the test and verify it to be within the motor manufacturer's motor winding insulation and overheat protection design ratings.

15.7.7.9 High-Pressure Control Reset Test

A. Slowly raise the climate room temperature and record the maximum temperature attainable prior to trip allow the system to trip and restart in accordance with the requirements of Section 7, Heating, Ventilation, and Air Conditioning.

B. Time delay between trips shall be demonstrated.

C. Reset of the trip counter shall be demonstrated.

15.7.7.10 Low-Temperature Operation

A. Conduct a low-temperature cooling test to demonstrate the cooling equipment operates in accordance with the design requirements at low ambient temperatures.

1. Slowly lower the climate room temperature to just above the cooling lockout temperature at a rate not to exceed 2°F (1.1°C) per minute and maintain at stabilization.

2. During the climate room temperature transition, the refrigeration subsystem shall not be permitted to be locked-out and the internal heat loads shall be energized as needed to maintain continuous refrigerant compressor operation at minimum capacity.

3. The interior temperatures shall remain in the ranges shown in Section 7, Heating, Ventilation, and Air Conditioning.

4. During the test period, the HVAC equipment shall operate without damage to itself and without the formation of ice or frost on the evaporator coil or refrigerant piping. Verify oil-return volumes are acceptable for compressor operation. Oil sight glasses shall be fitted to the compressors if not utilized on all compressors.

5. The subsystem shall maintain stable operation and shall not exceed any limits recommended by the HVAC supplier.

15.7.7.11 Partial Cooling/Reheat Test

A. Conduct a partial cooling test to demonstrate that the HVAC subsystem and controls can maintain the car interior temperature and relative humidity in accordance with the design requirements at a reduced ambient and partial load conditions.

B. In each of the following tests, demonstrate that the system remains in reheat until the humidistat indicates that Relative humidity is under 60%. The compressor shall not shut down and the supply air temperature shall be maintained at the setpoint.

1. Perform the test with the climate room temperature of 65°F (18°C) DB/60°F (16°C) WB and with the AW2 passenger load and solar load.

2. Perform the test with the climate room temperature of 65°F (18°C) DB/60°F (16°C) WB without the passenger load and solar load.

3. Apply AW2 passenger load and slowly lower the climate room temperature down to 45°F (18°C). The system shall drop out of reheat mode at the temperature determined in design review.

4. Perform the test with the climate room temperature of 80°F (27°C) DB/75°F (24°C) WB without the passenger load and solar load.

5. Perform the test for 30 minutes after stabilization is attained for each ambient and load condition combination.

15.7.7.12 Condensate Carry-Over

A. Conduct a condensate carry-over test to demonstrate that no water (condensate) is carried from the evaporator coil into the supply-airstream or past the drain pan.

B. Perform this test for a period of 4 hours with the climate laboratory ambient air temperature at 80°F (27°C) dry bulb (DB)/75°F (24°C) wet bulb (WB). The system shall not enter ventilation moved during the test period.

C. At the end of the test, all heater coils, evaporator blower compartments (in draw through units), supply air discharge plenums, air ducts, and diffusers shall be examined for the presence of condensed water The test shall be considered successful if examined items remain dry.

15.7.7.13 HVAC Energy Verification Testing

A. At conclusion of the climate room cooling and heating testing, energy consumption simulations from TS 2, Design and Performance Criteria, shall be validated in accordance with EN 50591. The test shall be performed to validate In-Service with commercial operation mode, In-service without commercial operation mode and parking mode.

B. The operational points for this testing shall align with ASHRAE 23 and the climatic conditions specified in Section 7, Heating, Ventilation, and Air Conditioning. Parking mode shall include operational modes and service hours for layover conditions specified in Section 7.

15.7.8 Lighting Test

15.7.8.1 Lighting Controls

A. Confirm the proper operation and functions of all interior and exterior lighting assemblies and respective control circuits.

B. Test Normal Lighting Mode, Layover Mode, and Cleaning Mode.

15.7.8.2 Light Intensity Readings

A. All light intensities shall be met using the LED L70 end-of-life light output.

B. Take light intensity readings (without light from other sources) to verify conformance with the requirements in Section 8, Lighting, Lighting Intensity for Normal Lighting Mode.

1. Interior light intensity shall meet the requirements defined in APTA PR-RP-012-99, Normal Lighting System Design for Passenger Cars.

2. The light intensity shall be a minimum of 5 foot-candles of illumination on both high level and low level station platform surfaces when the side door is opened, for a distance of 3 feet from each step landing at low level doors, and at door threshold at high level doors. This level is greater than the minimum requirements for the Outside Platform defined in APTA PR-E-RP-012-99, Normal Lighting System Design for Passenger Cars Section 5.1 and Table 1.

3. Outside the A-end door, in the diaphragm area, the lighting levels at floor level shall reach 5 foot-candles

4. Interior equipment locker lights shall be a minimum of 20 foot-candles measured at the floor and at all signage within the locker.

C. Take light intensity readings (without light from other sources) to verify conformance with the requirements in Section 8, Lighting, Lighting Intensity for Emergency Mode and LLEPM and HPPL Emergency Signage Charging.

1. Interior emergency light intensity shall meet the requirements defined in APTA PR-E-S-013-99, Emergency Lighting System Design for Passenger Cars.

2. The emergency lighting system shall provide a minimum of 2foot-candles of illumination at floor level for all potential evacuation routes, greater than the minimum requirements of APTA PR-E-S-013-99, Emergency Lighting System Design for Passenger Cars.

3. LLEPM and HPPL Emergency Signage Charging shall meet the requirements defined in APTA PR-PS-S-006-23 Emergency Egress/Access Signage and Low-Location Exit Path Markings for Passenger Rail Equipment.

D. Take light intensity readings (without light from other sources) to verify conformance with the requirements in Section 8, Lighting, Lighting Intensity for the Operator's Cab area.

1. The cab area white reading light, when in use by the Operator, shall produce a minimum of 25 foot-candles at an elevation of 2 feet, 9 inches above the floor in the Operator's work area, or on the cab console desk.

2. The cab area red nighttime light, when in use by the Operator, shall produce a minimum of 2 foot-candles at an elevation of 2 feet, 9 inches above the floor in the Operator's work area, or on the cab console desk.

3. All backlighting for cab switches and controls shall provide sufficient lighting to illuminate controls without the use of the ceiling lights.

E. Take light intensity readings (without light from other sources) to verify conformance with the requirements in Section 8, Lighting, Lighting Intensity for Layover Mode.

1. Layover minimum average light intensity shall be 5 foot-candles measured at the floor for all emergency exit path locations.

2. Layover maximum average light intensity shall be 10 foot-candles measured at the floor for all emergency exit path locations.

15.7.8.3 Emergency Lighting

A. Confirm the proper operation and self-test functions of the emergency lighting system and independent power sources.

B. Test each emergency light independent power source and the fixtures that they power in accordance with Section 8 Emergency Lighting, 49 CFR 238.115 and APTA PR-E-S-013-99.

C. Test each independent power source capacity to power all emergency light fixtures for minimum duration of 180 minutes.

15.7.8.4 Exterior Lighting

A. Comply with the following:

B. Test exterior lighting to verify light installation and aiming to 49 CFR 229.125 and 49 CFR 221.

C. Test headlight and auxiliary light functionality when operating the horn.

D. Test exterior signal light functionality for brake applied, brake released, parking brake applied, and door open.

E. Test exterior signal lights are visible to a minimum of twelve (12) car train length.

15.7.8.5 Blue Flag Signal Protection Light

A. Test blue flag signal protection light to verify conformance to 49 CFR 218 Subpart B – Blue Signal Protection of Workers.

B. Test blue flag signal protection light is visible to a minimum of 500 feet ahead of the windshield.

15.7.9 Truck Tests

A. Use the first car or pair of cars and perform tests for truck wheel load equalization, static lean (rollover resistance), truck rotational resistance, and clearance.

15.7.9.1 Wheel Load Equalization Tests

A. Perform truck wheel load equalization tests:

1. Verify the wheel load equalization requirements in Section 11, Trucks, by test.

2. Truck wheel load equalization tests shall be performed on level tangent track with air springs inflated and leveling valves disconnected.

3. Tests shall be performed for both lifting and lowering each wheel on one truck and shall be conducted with an empty car (AW0) and loaded car at AW3.

4. APTA PR-M-S-014-06 shall be followed for test method, data reduction and calculation.

5. Test results shall meet the requirements of Section 11, Trucks.

6. If the results of these tests indicate that the required equalization is not attained, correct the truck design and retest until compliant results are attained, and modify all trucks in accordance with the corrected design.

15.7.9.2 Static Lean (Rollover Resistance) Test

A. Perform a test to verify the rollover resistance provided by the truck design.

1. Perform the test on the first car, with an empty car (AW0) and with simulated AW3 load. Conduct test with air springs inflated and the leveling subsystem disabled.

2. Raise the wheels on one side of the car to simulate the maximum superelevation as specified in Section 2, Design and Performance Criteria. Repeat the test in the opposite direction.

3. Measure wheel loads, lateral displacement and roll angle of the carbody.

4. Static lean allowance shall be tested at both AW0 and AW3 load to verify compliance under all specified suspension conditions.

5. If the test indicates that wheel loads and roll angle of the carbody required by Section 11, Trucks, is not attained, the Contractor shall alter the truck design, retest at its expense, and modify all trucks in accordance with the corrected design.

6. Tests shall be performed on a superelevation of both 5 in. and 6 in. to measure body roll and wheel unloading to verify compliance with 49 CFR Part 213.329 (d). The Contractor shall provide a test report providing all data required by 49CFR Part 213.329 and shall fully support SEPTA's submission to the FRA with additional information as requested by the FRA.

15.7.9.3 Truck Rotational Resistance Test

A. If required as part of the Vehicle Dynamic Model Validation Plan, conduct tests to measure the rotational resistance (yaw stiffness) of the truck assembly relative to the carbody, per Rail Safety and Standards Board, GM/RC2641 Section 2.5.

1. Conduct tests at AW0 and AW3 loads and perform at a minimum of two rotation speeds with 0.5 degrees/second and 1.8 degrees/second suggested. Other rotation speeds will be considered by SEPTA if proposed by the Contractor and justified by the SEPTA operating environment.

2. If test results do not agree with the dynamic model’s predicted values, update the car dynamic model using the test results to confirm that Specification-compliant dynamic performance is achieved in all required conditions. Modify the truck design as needed and retest for compliance.

15.7.9.4 Truck Weight

A. Separately weigh a minimum of three completely assembled trucks for each configuration using an Approved weighing scale.

B. These weights shall be:

1. Compared to the maximum allowable weight established by the Contractor.

2. Used to establish a nominal weight and acceptable tolerance for routine weighing of all production trucks.

15.7.10 Coupled Car Clearance Test

A. Couple the first completed cars to create three married pairs, and verify proper carbody, truck, drawbar, coupler, cable, and hose clearance under the worst-case geometric requirements for these elements, including curve and crossover negotiation.

1. Perform this test with F-ends coupled together between married pairs. Check the car ends for proper intercar clearance. Include allowances for suspension and draft gear movement.

2. Check the couplers and drawbar for proper vertical and horizontal swing and for clearance from the truck, undercar components, end sill and ground (top of rail).

3. Verify the operating height of the pantograph.

4. Check all truck, trainline, and coupler cables and hoses for clearance and the absence of stretching and chafing.

5. Check the trucks for proper vertical and horizontal swing and for clearance from undercar components.

6. Check the intercar barriers for proper function at entry to, and exit from, curves and in reverse curves. Verify barriers do not have any gap between them in curves as there are some station stops on curved platforms. Intercar barriers should adhere to 49 CFR 38.63 (a) to ensure individuals are unable to step off the platform between cars.

7. The married pairs, with springs loaded statically to AW0 and AW3 conditions, shall be demonstrated by either approved testing method or analysis to confirm that the car conforms to the Contractor's designs and that all the specified clearances and static car envelope requirements have been met, both to wayside and rail.

8. Test results must verify compliance with the Contractor's clearance calculations and diagrams for a trainset under all operating conditions.

15.7.11 Pipe Pressure Test

A. After the installation, connection and cleaning of all piping, the piping shall be pressure tested in accordance with the latest edition of the Code for Pressure Piping, ANSI B31.1. All leaks which appear during pressure testing shall be repaired, after which the system shall be retested until leak-free.

15.7.12 Brake Pad and Shoe Force Test

A. Tests shall be conducted on the first car to verify the actual force produced at the brake pad and shoe by the brake assembly at both a parking brake and a non-parking brake location agreed with calculated values.

B. Tests shall be conducted with brake cylinder pneumatic pressures in 5 pounds/square inch increments, from 0 pounds per square inch to the maximum used, and from application of the parking brake.

C. Load cell brake disk caliper force and shoe force measurements shall be taken on each car type to determine brake efficiency.

D. Measurements shall include values for release, minimum, suppression, full service and emergency brake, operating from nominal 110 psig brake pipe setting and 130-150 psig main reservoir value.

E. Force test sequence shall also be measured with the parking brake applied.

15.7.13 Parking Brake Test

A. Perform a parking brake subsystem test on the first completed married pair to demonstrate that brake design complies with Section 12, Friction Brake, by measuring the force required to move a married pair with the parking brake applied.

1. Perform the test with bedded pads with a minimum of 85% contact area and with new pads.

2. Perform a test to demonstrate the brake response times, and pad force vs. pressure concurrent with the parking brake testing.

3. Apply the force to move the vehicle for a minimum of 10 minutes.

15.7.14 Height Control Test

A. Check and record height-control valve adjustments, measurement of carbody floor height, coupler heights, and air-spring heights.

1. Tests shall verify that load leveling requirements from Section 11, Trucks, are satisfied.

2. Schedule a specific test for the first married pair upon delivery to SEPTA to demonstrate that the cars can be leveled per requirements in Section 11, Trucks, and can maintain level condition in service.

3. The test shall demonstrate minimum wheel unloading and percent wheel load differences within a truck due to air spring imbalance, leveling valve and linkage operation, time to level, and compensating valve performance.

15.7.15 Noise and Vibration Tests

A. Perform noise and vibration tests on the first married pair to confirm compliance with the static condition requirements of Section 2, Design and Performance Criteria, and 40 CFR 201 Noise Emission Standards for Transportation Equipment; Interstate Rail Carriers.

1. Base compliance with the Specifications on measurements taken in a field environment such as outdoors, away from any reflecting surfaces other than the ground, ties, and ballast, on-track with newly ground, welded rail.

2. Reflected sound shall be such as to not influence the directly radiated sound from the equipment measured by more than 2 dB.

3. Take all measurements with an ambient sound level in the vicinity of the test measurement locations of not less than 10 dB below the noise produced by the equipment being measured, when evaluated using the same scale or octave band.

4. For these tests, record the following:

   a. Description of noise or vibration source being measured, including pertinent performance data.

   b. Description of the environment where the noise or vibration source is measured, including a sketch showing source and measurement positions.

   c. Operating conditions of noise or vibration source during measurements.

   d. Pertinent meteorological data.

   e. Locations and orientations of microphones with respect to noise source.

   f. Equipment used for making measurements.

   g. Description and measurements of ambient noises.

   h. Data obtained, including range of variation.

   i. Instrument settings, corrections, and calibration records.

5. Evaluate the results, and any corrective action required shall be Approved. After corrective action is taken, rerun the applicable tests. If the corrective action is successful, apply to all cars. If not successful, repeat these steps until compliance is successfully attained.

15.7.16 Horn Test

A. Test each horn, as mounted on each end of the first married pair, as required by 49 CFR Part 229.129 and calibrate to the lower end of the FRA required sound level.

15.7.17 Car Networks and VMDS Test

A. Test the network subsystems and VMDS on the first married pair. A simulator may be used to generate trainline signals. Testing shall include wayside data transmission. See the TWDT requirements of Section 18, Monitoring and Diagnostics.

B. The test shall include, but not be limited to, the following:

   1. Test the ability to communicate with all network nodes.

   2. Measure data rates and error rates, where criteria for error rates is defined in the Contractor's Signal Quality Plan required by Section 17, Network and Trainline Control.

3. Verify proper transmission and reception of all signals by nodes and their connected subsystems.

4. Exercise all network commands.

5. Verify proper response to faults.

6. Verify fault resetting.

7. Verify proper functioning of PTUs connected to Network

8. Perform penetration testing as specified in Section 24, Cybersecurity.

9. Verify functionality of the TOD and other displays associated with the VMDS.

15.7.18 Communication Subsystems Test

A. Comply with the following:

1. Test the equipment specified in Section 13, Communications, on the first married pair. Verify proper functionality based on all requirements in Section 13. Ensure the functionality of the following at a minimum:

a. PA, including assistive listening subsystem, intercom, and PEI.

(1) Ensure that speech intelligibility, through all relevant combinations of microphones and speakers, complies with the IEC 60268-16 requirements of Section 13, Communications.

(2) Verify the function of the automatic volume control. Conduct the test with internal and external noise levels at 100 dB, 70 dB, and 40 dB.

(3) Verify that there is no audio feedback between all relevant combinations of microphones and speakers.

b. The assistive listening induction loop system shall be tested in accordance with IEC TR 63079. Testing shall demonstrate:

(1) Background magnetic noise is minimized.

(2) Magnetic Field is strong enough to provide full car coverage while minimizing interference with RF on the train (Wi-Fi, Mobile Voice and Data, etc.)

(3) Frequency response is appropriate for T-Switch capable equipment.

c. AVL: Verify that the AVL system can correctly receive, process, and transmit vehicle location data.

d. Passenger Information System:

(1) Verify that the PIS can display/play location-specific content, messages, and announcements based on location data.

(2) Conduct an update of PIS announcements and verify that the new announcements are correctly displayed.

e. Voice Radio: Verify both transmission and reception of voice traffic.

f. VSS

g. APC

2. For the following components, in addition to the above tests, simulate a complete round trip on the Regional Rail System and ensure that the components accurately reflect the expected passenger audio/visual information:

a. Exterior speakers

b. Interior speakers

c. Bluetooth LE Broadcast

d. PIS Subsystem screens including dynamic route map displays, exterior display signs, and advertising capabilities.

15.7.19 Automatic Train Control/Positive Train Control Test

A. Comply with the following:

1. Develop and demonstrate proof-of-design test procedures that validate all systemic, operational and programming designs, functions and requirements for the ATC/PTC system per Section 20, Automatic Train Control – Positive Train Control. These procedures shall be developed in accordance with system requirements as established by the system manufacturer, the FRA, and railroads. Portions of this testing may be performed at the sub-supplier and on-site. At a minimum include:

a. Vital control voltage and ATC/PTC subsystem isolation

b. Wheel wear calibration

c. Decelerometer calibration

d. Braking system interfaces

e. Speed sensor interface

f. Event recorder interfaces

g. Network interfaces

h. PTU interface

i. Departure Test

j. Operator control and cab makeup interfaces

k. Cutout switch function.

15.7.20 Windshield and Window Tests

A. Comply with the following:

1. Test one first production windshield, and one selected at random by SEPTA to confirm compliance with the strength requirements specified in Section 14, Interior and Exterior Appointments.

2. Tests shall be conducted to measure the force required to remove each type of emergency window from the carbody per 49 CFR 238.113. This shall be done both from inside and outside the car. The test shall include a check that car interior furnishings do not interfere with window removal.

15.7.21 Weight Balance Test

A. Test the first completed three "A" and first completed three "B" cars and three first married pairs of completed cars to verify compliance with the weight and balance criteria of Section 2, Design and Performance Criteria.

B. These cars shall be completely assembled.

C. Repeat this test for up to ten additional cars, to be selected by SEPTA.

15.7.22 Battery Capacity

A. Test all battery packs on one married pair for compliance with the battery capacity requirements of Section 9, Auxiliary Power, to verify that essential loads and duty cycles can be maintained for the required time.

B. The married pair batteries shall be discharged so that the remaining capacity corresponds to the worst-case design conditions.

15.7.23 Thermal Mapping

A. Perform a Thermal Mapping test to validate the temperature simulation model(s) and condition assumptions used in design of car equipment.

B. Instrument one operating married pair to measure the actual thermal profile of all temperature sensitive components during the most severe operating conditions permissible within the requirements and design parameters of the Specifications.

15.7.24 Maintainability Demonstration Test

A. Perform Maintainability testing to validate the requirements in Section 21, Reliability Availability and Maintainability.

1. This test shall be performed to ensure that all components are easily accessible and maintainable.

2. The Contractor shall perform a maintainability demonstration on the vehicles of the Pilot Train and demonstrate the repair time of maintained items for each system meets the Mean Time to Repair (MTTR) as described in Section 21.5.

3. SEPTA reserve the right to request a redesign if maintenance of any item requires removal of more than one adjacent component, requires the shifting of pipes or wires, or fails to meet the MTTR requirements.

15.8 On-Site Design Qualification Tests

15.8.1 General

A. Comply with the following:

1. Perform the married pair and three married pair train on-site design qualification tests on SEPTA's property to demonstrate that the married pair design complies with the requirements of the Specifications and is suitable for revenue service operation.

2. Prior to on-site design qualification testing, the Pilot Cars shall have successfully completed all component, carbody structure, subsystem, car, and married pair design qualification tests.

3. For the Pilot Cars, perform the following inspections and testing prior to on site design qualification testing:

a. Unpacking inspection

b. Incoming inspection

c. Miscellaneous body tests and adjustments (see TS 15.11.2)

d. Pneumatic subsystem leakage test (see TS 15.11.3)

e. Functional tests (see TS 15.11.4)

4. Submit test procedures and test reports. **(CDRL 15-09, On-Site Design Qualification Tests)**

15.8.2 Train Networks

A. Perform train network test to validate the operation of the complete subsystem on the maximum train length as specified in Section 2, Design and Performance Criteria.

1. Tests shall include verification of all coupling configurations before the Simulated Revenue Service Test specified in TS 15.8.14.

2. Tests shall verify network inauguration after coupling and uncoupling operations as well as network behavior during switch and wire failures.

3. Tests shall contain all elements tested in lower-level network design qualification tests that demonstrate compliance with Section 17, Network and Trainline Control.

15.8.3 Trainlines

A. Perform trainline test to validate operation of the trainlines on a 12-car train.

1. Trainline validation tests shall include all trainline and network signals that are routed through the coupler electrical heads and intercar cables as necessary.

2. Verify all operating conditions and including faults.

3. Verify that all trainlined subsystems – including communications, doors, braking, and propulsion, respond appropriately to all inputs and faults across the full-length train.

15.8.4 VMDS

A. Verify functionality of the VMDS, in particular its train-to-wayside communication functions using the TWDT.

1. This shall include, at a minimum:

a. Remote upload of software from the wayside to the train, and installation of this software upon maintainer confirmation.

b. Retrieval of fault log information from the train, via both wired and wireless connections.

c. Real-time logging and transmission of fault information, as per Section 18, Monitoring and Diagnostics.

d. Verification of the functionality of the TOD, including Operator and Maintenance screens.

2. To test the wireless connection functionality of the TWDT, this test shall be performed on each route of the Regional Rail System.

15.8.5 Clearance Test

A. Comply with the following:

1. Operate one married pair and one three-married-pair train at low speeds on all SEPTA operated tracks, yards, and maintenance facilities to verify clearances both on the car and on the wayside.

    a. The test shall include all track configurations such as crossovers.

    b. Check the exterior of the car for proper carbody, truck, intercar, and undercar equipment clearance.

    c. Verify the operating height of the pantograph.

    d. Confirm that clearances meet the dynamic clearance envelope. Check the trucks for proper vertical and horizontal swing and for clearance from undercar components.

    e. Check all truck, trainline, and coupler cables and hoses for clearance and the absence of stretching and chafing.

    f. Check couplers for proper vertical and horizontal swing and for clearance from the truck, undercar components, endsill and top of rail.

    g. Check the vertical and horizontal gaps at each doorway on the train against a nominal platform.

    h. Check all inter-car barriers for operation and clearances.

    i. Check diaphragms for proper operation.

    j. Slowly traverse and carefully monitor the following areas:

        (1) Tightest crossovers and turnouts.

        (2) Tightest horizontal and vertical curves.

        (3) Greatest unbalanced superelevation.

        (4) Worst-case combinations of all of the above.

2. Also test these rescue scenarios:

    a. One married pair to Silverliner IV

    b. One married pair to Silverliner V

    c. One married pair to ACS-64

    d. One married pair to a work locomotive (class to be determined prior to test).

15.8.6 Vehicle Stress and Load Test – On-Track, Dynamic

15.8.6.1 Purpose

A. The vehicle dynamic stress and load test shall consist of operating an instrumented truck and carbody at maximum allowable revenue speeds over a representative portion of the Regional Rail System, on track selected by SEPTA. The purpose of this test is to:

1. Validate the truck and carbody design loads used for stress analysis and structural testing of the truck frame, bolster, and carbody.

2. Validate the truck-mounted equipment mass inertia loads specified in Section 11, Trucks.

3. Validate the fatigue life of the truck frame, bolster, carbody, and truck-to-carbody connection elements in service against the design conditions assumed.

4. Validate the axle design loads used for masses in motion.

15.8.6.2 Instrumentation

A. During ride quality testing or as a standalone test, the truck assembly shall be instrumented as listed below.

B. Instrument a carbody and one of its truck assemblies on a married pair at AW0, and again loaded with AW3 passenger weight, with strain gauges, displacement transducers and accelerometers.

15.8.6.2.1 Accelerometers

A. Furnish a working procedure for the attachment of accelerometers for truck testing.

B. Place tri-axial accelerometers at the following locations, subject to Approval:

1. Two journal bearing boxes, diagonally opposite from each other.

2. One gear unit.

3. One traction motor.

4. One of each brake unit type, TBU and DBU.

5. The truck frame transoms, both center and end transoms as applicable.

6. One carbody bolster

7. Two as an option for SEPTA to decide where to place.

15.8.6.2.2 Displacement Transducers

A. Place displacement transducers at the following locations and orientations, subject to Approval:

1. Primary suspension, vertical, both ends of lead axle

2. Primary suspension, lateral, both ends of lead axle

3. Secondary suspension, vertical, both sides of truck

4. Secondary suspension, lateral, near truck centerline.

5. Any remaining truck-to-carbody connections, subject to Approval

15.8.6.2.3 Strain Gauges

A. Place strain gauges on at least 20 locations to validate the structural design of the truck frame, bolster and other major structural components as listed by the Truck Structural Validation Plan, subject to Approval.

B. Place tri-axial strain gauges on at least 20 locations to validate the structural design of the carbody, focus should be given to highly fatigued areas, coupler connections, and truck-to-carbody connections.

15.8.6.3 Data Comparison

A. The strain gauge, displacement transducer and accelerometer data recorded during the vehicle dynamic stress and load test shall be used to validate each item listed in the purpose of this test.

1. Compare data using rain flow counting of the measured data (per ASTM E1049), frequency-domain analysis of the data, or other Approved method with the results of the carbody and truck FEA reports.

2. Filtering used during data analysis shall not attenuate frequencies between 1 Hz and 200 Hz.

3. Stresses calculated from the strain gauge data shall be below the allowable fatigue stresses for the design and from the truck and carbody stress analysis for each location instrumented for strain.

4. The data shall be used to calculate a resultant accumulative damage in the material and projected out to 40 years. The total damage shall be compared to the materials tested fatigue life.

15.8.7 Vehicle Dynamic Performance Test

15.8.7.1 Ride Quality Test

A. Perform road tests on the first married pair on the SEPTA Regional Rail System line to verify conformance to the ride quality requirements of Sections 2, Design and Performance Criteria.

1. The ride quality test data shall be evaluated in accordance with ISO 2631-1.

2. The married pair shall not exceed the RMS acceleration absolute limits listed in Section 2, Design and Performance Criteria for any time interval at any location in any test condition. For the purpose of this section, each time interval shall be the lesser of 240 seconds, or the time between adjacent station stops.

3. Test shall be performed with inflated and deflated air bags and each car loaded to AW0 and AW2.

4. Evaluate acceleration data over the frequency range of 0.5 to 80 Hz. Where appropriate use frequency weighting Wb (ISO 2631-4) instead of Wk.

5. Ride quality tests shall consist of operating cars in simulated revenue service, at normal scheduled operating speeds, under two load conditions:

    a. Empty (AW0)

    b. With simulated load (AW2)

6. Furnish instrumentation capable of measuring and charting the magnitude and frequency of the expected vertical, longitudinal, and lateral vibrations and shocks, up to 1.0 G and 80 Hz.

    a. Locate and apply sensing units directly to the car floor (with floor coverings removed) above the intersection of the car's longitudinal centerline and the transverse centerline of both trucks, and also at the center of the car.

    b. Record the following:

        (1) Vertical, lateral, and longitudinal shocks (vibrations) concurrently

        (2) Speed

        (3) Distance in 100-ft (30.5 m) increments

    c. The entry of event markers on recorded data for these tests shall be possible.

7. Furnish the weights used for the tests.

15.8.7.2 Vehicle/Track System Qualification Test

A. Develop a test plan in accordance with the requirements of 49 CFR 213.345 (e) “Qualification Testing Plan”. Contractor shall provide all necessary documentation, submittal and revision support to obtain FRA approval of the test plan.

B. Perform qualification testing in accordance with the requirements of 49 CFR 213.345 (f). Testing shall be conducted in two stages, stage-one per CFR 213.345 (f)(1) and stage-two per 49 CFR 213.345 (f)(2).

C. Testing shall be conducted on the first married pair on the SEPTA Regional Rail System and Northeast Corridor (NEC) to verify conformance to 49 CFR 213.333 vehicle/track interaction safety limits up to the maximum speed and cant deficiency specified by Section 2, Design and Performance Criteria, and Section 11, Trucks.

1. General:

   a. Testing shall be conducted on representative portions of the Regional Rail System, and representative portions of the NEC.

   b. Testing shall be conducted with an empty car (AW0).

2. Test instrumentation:

   a. Test instrumentation shall be provided by the Contractor to record wheel-rail forces, carbody and truck acceleration data necessary to demonstrate compliance with the acceleration limits identified in 49 CFR 213.333.

   b. Each truck on each instrumented car shall be equipped with two lateral accelerometers, mounted on the truck frame at diagonally opposite locations along the vertical line passing through the center of the journal bearing. One truck on each instrumented car shall be equipped with two instrumented wheelsets.

   c. All instrumented cars shall be equipped with three carbody lateral and vertical accelerometers. They shall be located on the interior floor, on the car longitudinal centerline, above each carbody bolster and at the middle of the car.

   d. All instrumented cars shall also be equipped with additional accelerometers and displacement transducers, as proposed by the Contractor and Approved by SEPTA, to enable performance of vehicle dynamic model validations after testing.

   e. A GPS location system shall be used during testing to accurately report the location of the car. An accurate speed signal shall be provided in the data.

3. Data collection and reporting:

   a. The Contractor shall provide carborne test equipment capable of recording all data required, analyzing these data for compliance with CFR criteria and reporting results to test train personnel in graphical form.

   b. The reporting software shall be capable of generating the following for each data package:

      (1) A graphical depiction of the wheel-rail forces, truck acceleration and carbody acceleration signals. It shall be possible to directly

correlate these signals with the location, speed and time/date data. The location of the worst case data in each data set shall be indicated.

(2) A summary report of the worst case values recorded for the wheel-rail forces, truck acceleration and carbody acceleration data. Any values which are in excess of those allowed by CFR shall be flagged as exceptions.

4. Failure to Satisfy Requirements

a. Should the car fail to satisfy the vehicle/track interaction requirements, a program for correcting the deficiencies shall be submitted to SEPTA for approval. The Contractor shall submit to SEPTA, within 60 calendar days, a program containing mathematical analysis of the problem and a course of action for its correction. If SEPTA Approves the analysis and corrective measures, those corrective measures shall be made effective on the Pilot Cars within 90 calendar days at the expense of the Contractor, the car shall be retested, and if the measures are successful, they shall be applied to all the cars. If not, the analysis and correction steps shall be repeated, resubmitted, and retested until success is attained.

5. Test reports

a. The Contractor shall prepare the required final test reports. SEPTA reserves the right to require additional vehicle modeling, instrumentation and/or testing if test results show failure to comply with the CFR requirements, or if additional dynamic behavior which may present a safety issue is observed.

15.8.8 Performance Tests

15.8.8.1 General

A. Perform the specified tests to demonstrate the proper functioning of propulsion and braking subsystems according to this Section, and to verify compliance with Section 2, Design and Performance Criteria.

1. Unless otherwise specified, at a minimum, perform two round trips at SEPTA-designated test location for each test. For the Power and Energy Consumption test, perform a minimum of three round trips.

2. The test shall contain steps to determine the optimum settings of the propulsion and braking equipment.

3. The tests shall contain steps to determine the relationships of motor torque vs. car loading and the brake cylinder pressure vs. car loading, for a continuous range of loads from AW0 to AW3 as measured by air spring pressure. Those relationships shall be used as a reference to validate the performance of all

other married pairs, which may then be tested without load during dynamic Pre-Shipment Routine Tests and Routine Tests at SEPTA.

15.8.8.2 Instrumentation

A. Instrument each test married pair with a multiple-channel digital data acquisition system and produce a permanent test record.

1. The data acquisition system shall be capable of real time viewing and processing of raw data signals. Process collected data immediately following a test, or concurrently during the test, and present for preliminary review in an Approved format.

2. Label each test run with the date, time, trip number, elapsed time from departure, and identity of the test engineer.

3. Provide a high accuracy independent speed sensor for speed and distance measurements. Verify the furnished hardware against the devices that are already Approved or used by SEPTA.

4. Provide all equipment needed to power and operate this instrumentation.

5. Instrumentation shall use the car battery low-voltage power subsystem supply. The equipment shall function over the battery low-voltage range and otherwise not be damaged by the conditions specified in Section 2, Design and Performance Criteria.

6. Internal combustion engines driving a generator or use of the car auxiliary inverter to power the instrumentation is prohibited.

7. Provide isolation amplifiers as part of the instrumentation package to isolate the inside car instrumentation wiring and equipment from high voltages.

8. Exposed terminals with potential differences greater than 50 volts are prohibited.

9. The test wiring termination panels shall include test jacks and switching for each channel to permit calibration signals to be injected into each recorder channel, without requiring wiring or connectors to be disconnected, and shall be arranged so that calibration signals cannot be fed back into the monitored equipment.

10. The accuracy and response of the instrumentation shall be sufficient to determine the degree of compliance with the Specifications and design data.

11. For each performance test, permanently record the following channel assignments simultaneously, in addition to other channels deemed necessary by the Contractor:

    a. Acceleration (positive and negative)

b. Traction motor torque (each axle)

c. Spin slide control subsystem active (each truck - magnitude of spin or slide as required for validation)

d. Brake cylinder pressure (each truck)

e. Air spring pressures

f. Braked wheel temperature on one axle

g. Catenary voltage

h. Catenary current

i. Brake signal current for all trucks

j. Speed (married pair and individual axles)

k. Cab signal code rate signals

l. Auxiliary current

m. Auxiliary Voltage

n. Propulsion trainline control signals

o. Braking trainline control signals

p. An independent time base with 1 second time intervals

q. Distance intervals using digital odometer to record 10-, 100-, and 1,000-foot (3.05-, 30.5-, and 305-meter) increments.

r. Such channels as the Contractor feels necessary to record voltage transients.

s. A voice narration or comment channel.

t. Two spare event channels for additional tests that may be requested by SEPTA.

u. Two spare analog channels for additional tests that may be requested by SEPTA.

15.8.8.3 Propulsion Performance Tests

A. Perform, on a two married pair train, a set of propulsion performance tests at simulated AW0, AW2, and AW3, and at normal operating temperature.

1. The tests shall demonstrate compliance with the performance requirements in Section 2, Design and Performance Criteria.

2. Monitor dynamic and friction braking effort during the tests.

3. Verify proper functionality of the following at a minimum:

    a. Acceleration and dynamic braking at the required rates

    b. Time to achieve speeds as specified in Section 2, Design and Performance Criteria

    c. Jerk limiting.

    d. Mode change dead time.

    e. Performance operating from SEPTA catenary power supply system

    f. Performance operating from Amtrak catenary power supply system.

4. Brake blending, including conformance to the braking rate tolerance limits specified in Section 2, Design and Performance Criteria.

15.8.8.4 Braking Performance Tests

A. Perform All Friction Brake Rate and Stopping Distance Tests on a two married pair train.

1. The tests shall demonstrate compliance with the performance requirements for friction and emergency braking of Section 2, Design and Performance Criteria.

2. Perform these tests at AW0, AW2, and AW3 loads.

3. Before initiation of each test, cool brake elements to a maximum of 125°F (52°C) as measured by thermocouples. Alternative methods of measuring brake component temperatures may be proposed for Approval.

4. Brake pads and shoes used in stop tests shall be bedded in to a minimum 85% contact area.

5. Test the emergency brake subsystem to verify compliance with the emergency brake response time requirements of Section 2, Design and Performance Criteria.

15.8.8.5 Duty Cycle Confirmation Test

A. Perform a Duty-Cycle Confirmation Test:

1. Test Purpose: To verify compliance with the duty cycle requirements specified in Section 2, Design and Performance Criteria.

2. Test Setup:

    a. Load a train that has had its performance successfully qualified according to this Section with weight equivalent to an AW2 passenger load.

    b. Instrument the cars and equip with bedded-in brake pads and shoes.

        (1) Measure the brake pad thicknesses before the test and document with pictures.

        (2) Measure the brake shoe thickness before the test and document with pictures.

3. Testing:

    a. Operate the train according to the duty cycle specified in Section 2, Design and Performance Criteria.

    b. As specified for duty cycle rating in Section 10, Propulsion, confirm by loaded car tests the validity of the rms and peak currents or temperatures extracted from the duty-cycle simulations and used in the Design Qualification Tests of the critical propulsion components.

4. Documentation During Test:

    a. Make subjective observations of brake pad and shoe smoke, smell, and noise during each station stop, which usually serve as good indicators of friction material temperatures during a brake application and the likely effect on performance.

    b. Provide preliminary test data to prove compliance with these requirements before the equipment is removed from the cars and immediately furnish copies of the test data to SEPTA.

5. Test Results:

    a. Measure and record brake pad and shoe thicknesses following the test to establish a wear rate that may be used to verify the service-life requirement for friction disc and pads as specified in Section 12, Friction Brake. Document condition of the brake pad and shoe friction material with pictures following the test to establish possible damage or unexpected wear characteristics.

    b. Submit a final report that includes all data, observations, pictures, data reduction, and analyses of results.

    c. The report shall include a single graph, preferably using Microsoft Excel, that communicates the following, at a minimum, in a well-organized and appropriately scaled manner. Varying colors, line styles, background

shading, and notations shall be used so that the eye may easily find and follow specific information.

(1) Disc Face Temperature vs. Time

(2) Wheel Tread Temperature vs. Time

(3) Train Speed vs. Time

(4) Ambient Temperature vs. Time

(5) Brake Cylinder Pressure vs. Time

d. Include a comparison of the results with the data generated by the brake capacity test to establish confidence in the capability of the laboratory and computer analytical software to accurately simulate and predict real world performance. In this way, performance during the warmest environmental temperature conditions specified by Section 2, Design and Performance Criteria, may be predicted and accepted with confidence as fulfilling the relevant requirements of the Specifications.

15.8.8.6 Wheel Slide Test

A. Perform a test to demonstrate that the wheel slide subsystem complies with Section 2, Design and Performance Criteria and Section 12, Friction Brake.

1. Test Purpose: These tests shall be sufficient to demonstrate that the slip-slide system effectiveness is attained.

2. Test Setup:

a. Perform the test using a two married pair train at AW0.

b. The test shall use a wetting agent, as follows:

(1) When sprayed on the rails during tests, it shall result in a reasonably accurate simulation of conditions that would be produced by damp rail. The adhesion rate produced by the spray shall allow for the slide scenario in Item 4, Testing on Wet Track (TS 15.8.8.6).

(2) Apply the controlled spray on the rail immediately in front of the lead wheels on each truck in the direction of travel.

(3) Regulate the spray in a manner that permits flow rate to be controlled and turned on or off to individual trucks from within the car.

(4) Initial adhesion shall be calculated per UIC 541-5.

c. Include a means to verify the time-out feature performance in accordance with the wheel slide requirements of Section 2, Design and Performance Criteria.

3. Testing on Dry Track:

   a. Perform tests initially on a designated dry section of track that is reasonably straight and within +/- 1% of level.

   b. The married pair shall make four stops each from 30 mph, 50 mph, and max operating speed, (two with blended brake and two with friction only braking) at full service brake rate requests (twelve stops total) with dry rail conditions.

   c. Make a single emergency brake stop from max operating speed using the Brake Controller Handle Emergency brake command.

   d. Measure time, speed, stop distance, and instantaneous deceleration rate for each stop. From this information, calculate average deceleration rates and typical jerk rates and verify distances. Average the data from the stops at each rate. These averages will define the baseline stop performance at each of the two speeds.

4. Testing on Wet Track:

   a. Repeat the tests at the specified low-adhesion conditions.

   b. The sprayers shall use a mixture of water, concentrated windshield washer solution, and dish wash soap (if necessary). Vary the mixture until the test pair experiences virtually continuous and significant wheel slippage at any given time on at least 75% of the axles throughout max operating speed stops at full service brake request. Initial adhesion shall be calculated per UIC 541-5.

   c. This mixture shall become the test mixture that may be adjusted periodically to accommodate the effects of changing environmental conditions such as ambient temperature and humidity on the mixture. SEPTA will determine the acceptability of wheel slippage throughout each test run.

   d. Use the test mixture for slippery rail stops from 30 mph and max operating speed) using a full service brake rate. Make four runs (i.e., two blended and two friction only) at each speed.

   e. All slippery rail stops shall comply with the wheel-slide efficiency requirements specified in Section 2, Design and Performance Criteria and Section 12, Friction Brake.

f. Following successful testing, make a single slippery rail stop from max operating speed using the Brake Controller Handle Emergency brake command and with WSP enabled.

g. After completion of the tests, spray rail with only water to clear any windshield washer or soapy solution from the rail.

5. Test Results:

a. The wheel slide equipment shall comply with performance requirements specified in Section 12, Friction Brake and effectively protect against wheel flats during the above test without creating jerking exceeding the values defined in Section 2.0 for the cars throughout the stop.

b. Test the effectiveness both for dynamic (where applicable) and for friction brake. Calculate available adhesion according to UIC 541-5.

15.8.8.7 Auxiliary AC Power Supply

A. Perform tests to demonstrate performance of auxiliary ac power supply and verify compliance with requirements of Section 9, Auxiliary Power.

1. Instrument the auxiliary AC power supply throughout performance tests to sample and record the auxiliary ac power supply operating characteristics.

2. Include the test records of auxiliary AC power supply conformance test and married pair performance test in auxiliary ac power supply test report.

15.8.8.8 Power and Energy Consumption

A. Comply with the following:

1. Perform motoring energy consumption efficiency tests as specified in Section 10, Propulsion and High Voltage System.

a. Use one two married pair train for both tests, in the AW0 load condition.

b. Use the same test area for both tests.

c. Conduct test runs in both directions to account for wind and grade effects.

d. Test report shall include relevant data for each run, averaged and normalized for car weight energy use values.

2. Perform a power and energy consumption test to validate the energy consumption estimates used in the design calculation, and as specified in Section 2, Design and Performance Criteria.

a. Perform the test while operating under simulated AW2 load over the entire Regional Rail System line per a normal operating schedule as directed by SEPTA.

b. Propulsion Subsystem: Present the collected data in the test report, showing motoring, regenerative braking, and net power and energy consumption.

c. Auxiliary AC Power Supply: Present the collected data in the report, showing combined power and energy consumption.

d. Climate Control Subsystem (HVAC and floor heaters, simulating summer and winter conditions): Present the collected data in the report, showing combined power and energy consumption.

e. Include the following in the test report:

(1) A histogram of overall power consumption level over the duration of test.

(2) Data of stationary energy consumption of auxiliary systems during yard layover conditions, in two different scenarios: keeping the cab control key switch in the Run position, and when the cab control key switch is moved to the Storage position and operating in layover mode.

15.8.8.9 Transient Power

A. Test three married pairs separately and together to demonstrate that transient power consumption levels associated with main transformer magnetizing current, and capacitive filter charging operation are compatible with SEPTA's power distribution system and meet the requirements of Sections 2, Design and Performance Criteria, and Section 10, Propulsion.

B. Instrument the married pairs and the substation in the area to measure vehicle main transformer primary currents under all Yard operating scenarios.

15.8.8.10 Power Collection Performance Tests

A. Comply with the following:

1. Perform a test to demonstrate system performance while negotiating overhead wire phase and system gaps. Perform a series of tests at selected gap locations to measure the performance of the system under a variety of load and speed conditions.

a. Load conditions shall include train in regeneration when entering the phase gap, all auxiliary loads running when entering the gap, and full auxiliary load call when exiting the gap.

b. Car speeds shall be varied to test the system when the time spent in the phase gap/system break is at a maximum, a minimum, and a point in between.

c. Minimum speed for testing transition of phase gaps shall include but not be limited to the following conditions:

(1) Just above the minimum speed required to maintain auxiliary power functionality with backup braking. This shall be used to demonstrate the correct operation of backup braking.

(2) That minimum speed required to avoid the train stopping in the gap, plus a small safety margin. This shall be below the speed required to maintain auxiliary power functionality with backup braking. It is anticipated that the APS will shut off when entering the gap and restart when exiting the gap. The response of the APS shall be monitored and verified for correct stop and restart operation.

(3) It is expected that several tests will be required to achieve the correct gap entry speed. Note that the availability of a second train for rescue purposes is advised in case the test train stops in the gap.

2. Perform a test to demonstrate system performance under conditions of intermittent power collection or poor contact with the overhead wire, as would occur during heavy ice. The setup and procedure for this test shall be agreed between the Contractor and SEPTA. The following shall be recorded at a minimum:

a. Input voltage and current

b. Performance parameters of propulsion subsystem

c. Performance parameters of auxiliary power subsystem

d. Condition of the wire before and after the test

e. Condition of the pantograph contact carbons before and after the test.

3. Perform a general test of power collection performance on revenue track while running a simulated revenue service profile, following successful completion of the first test and Approval of the gaps and intermittent power collection test reports.

15.8.8.11 Automatic Train Control Performance Test

A. Demonstrate that the ATC/PTC subsystem complies with the Specification requirements of Section 20, Automatic Train Control – Positive Train Control, when operating within the normal service environment. At a minimum, verify the following:

1. Cab signal sensitivity calibrations (if implemented)
2. Decelerometer calibration
3. Wheel wear calibration
4. Departure test
5. Speed sensor accuracy
6. Decelerometer accuracy
7. Decelerometer based speed performance
8. Cab makeup interface
9. Overspeed detection/protection
10. Alarm operations
11. Reverse operations
12. Stop & Proceed Mode operation
13. Acknowledgement
14. Brake interfaces
15. Vital power cut
16. Speed governor interface and function
17. Zero-speed
18. Brake assurance performance and accuracy
19. Variable brake assurance performance and accuracy
20. Manual cutout operation
21. Roll Away
22. Mode transitions
23. ADU commands and displays
24. Cab signal reception on entire cab signal alignment including all turnout conditions.

15.8.9 Spin Simulation Test

A. Perform a spin simulation test to verify that the propulsion subsystem controls tractive effort as required to correct wheel spin (see Section 10, Propulsion).

1. Perform the test with a single, empty (AW0) married pair.

2. The cars shall start to move from a standstill on the maximum grade specified in Section 2, Design and Performance Criteria, and continue to climb the grade in a smooth manner when motoring with at least 75% of the wheels spinning.

3. Perform the test using an approved wetting agent.

4. Confirm that the train's performance complies with the requirements stated in Section 2, Design and Performance Criteria.

15.8.10 Noise and Vibration Tests

A. Perform the noise and vibration tests on one complete married pair to validate compliance with the noise requirements and the vibration requirements of Section 2, Design and Performance Criteria, Section 5 Operator's Cab, and the vibration requirements of Section 11, Trucks.

1. Take static noise test measurements in an outdoor free-field type environment, with the test married pair stationary on the track at a location where reflected sound will not directly influence the measurements by more than 2 dB.

2. The ambient background sound level in the vicinity of the test measurement locations shall be 10 dB or more below the noise produced by the equipment being measured, when evaluated using the same scale or octave band.

3. Take noise level measurements with a meter complying with the requirements of Type 2 Sound Level meter of ANSI/ASA S1.4 Part 3.

4. Where octave band or 1/3-octave band measurements are specified, use an analyzer that meets the requirements for Class II Filters as given in ANSI/ASA S1.11 Part 1.

5. Perform car interior and exterior noise level tests with the car moving at a section of clean, smooth rail.

6. For these tests, record the following:

a. Description of noise or vibration source being measured, including pertinent performance data.

b. Description of the environment where the noise or vibration source is measured, including a sketch showing source and measurement positions

c. Operating conditions of noise or vibration source during measurements

d. Pertinent meteorological data

e. Locations and orientations of microphones with respect to noise source

f. Equipment used for making measurements

g. Description and measurements of ambient noises

h. Data obtained, including range of variation

i. Instrument settings, corrections, and calibration records.

7. Take all noise and vibration measurements with windows closed.

8. No noise measurements shall be undertaken during periods of mist, fog, snow, or rain as these have a detrimental effect upon the measurement equipment and the measured results.

15.8.11 Electromagnetic Compatibility Field Tests

15.8.11.1 General

A. Comply with the following:

1. Perform the following EMI/EMC tests to demonstrate compliance with the EMI/EMC requirements of Section 2, Design and Performance Criteria, at the car/train level in compliance with EN 50121-3-1 and other standards as defined in Section 2, Design and Performance Criteria:

a. Field Conducted emissions.

b. Field Inductive emissions.

c. Field Radiated emissions, including RF emissions.

(1) The test report shall identify the source of all narrow band emissions from 14 kHz to 6000 MHz.

2. The tests shall comply with the following requirements:

a. The entity conducting the testing, whether the Contractor or a dedicated subcontractor, shall be Approved.

b. Perform electromagnetic compatibility tests on three completely assembled married pairs.

c. Conduct electromagnetic compatibility tests on SEPTA-designated tracks by methods referenced for emission limits in Section 2, Design and

Performance Criteria, to ensure compliance with specified requirements and compatibility with SEPTA's traction power distribution and communications systems.

d. Confirm appropriate emissions limits as previously developed by monitoring the traction power distribution, railway signal, and communication systems functions.

e. Confirm compliance with the human health emissions limits as Approved in accordance with Section 2, Design and Performance Criteria.

f. Confirm immunity against emissions from radio frequency emissions from nearby equipment including, PTC transmitters, mobile and handheld radios, wireless computer networks, and cellular telephones that the equipment can encounter during normal passenger use or Railroads' operations.

15.8.11.2 Electromagnetic Emission Tests and Limits

A. Worst-case emissions testing shall be as specified in Section 2, Design and Performance Criteria.

B. For the field tests, vary the catenary voltage settings as allowed by the substation output adjustment capability at the test site.

15.8.11.3 Field Conducted Emissions Test

A. On SEPTA's tracks, test three married pairs by the methods specified for conducted emissions in Section 2, Design and Performance Criteria, for compliance with specified requirements and for compatibility with SEPTA's power distribution and train control, signal, and communication systems.

15.8.11.4 Line Current Harmonics Test

A. Compliance of the harmonic content of line current as defined in IEEE 519 as required in Section 2, Design and Performance Criteria, and as laboratory tested in section 15.6.11.5, shall be verified on-property contingent on the Railroad’s ability to find locations on the Railroad with suitably low ambient harmonic levels (i.e., 20dB or more below vehicle harmonic levels to be measured). It is noted that the overhead catenary system voltage will contain high voltage transients generated by wayside sources, vehicle loads, regeneration from other vehicles, lightning, and other transient generators.

15.8.12 Automatic Train Control / Positive Train Control Tests

15.8.12.1 Cab Signal Interference (CSI) Dynamic Type Test

A. Perform test on SEPTA and Amtrak territory under worst-case propulsion system emissions, which may be AW3, including operation of any or all train equipment alone or in combination, and in normal, abnormal, and failed conditions and under the full range of grade.

1. Demonstrate that worst-case propulsion system emissions are below the required emission limit as well as the ATC subsystem susceptibility threshold to provide the required 6 dB safety and reliability margins.

2. Demonstrate that the cars do not produce an equivalent rail current signal at the ATC subsystem track receivers exceeding the requirements for CSI in Section 2, Design and Performance Criteria.

15.8.12.2 Automatic Train Control / Positive Train Control Test

A. Conduct test runs on SEPTA and Amtrak territory to confirm compliance with the ATC/PTC requirements of Section 20, Automatic Train Control – Positive Train Control.

B. Perform a test of the ATC/PTC system in accordance with manufacturer and railroad requirements. Tests shall verify all modes of operation, including self-test.

1. Each input and output shall be demonstrated.

2. Calibration of pickup and drop out of each parameter of the carrier shall be demonstrated.

3. Interaction with the brake system to produce a brake application shall be demonstrated.

4. Overspeed, failure to acknowledge and overspeed with failure to acknowledge shall all be demonstrated.

5. Built-in diagnostics and data-logger shall be demonstrated.

C. Any deviations from SEPTA's type approved system shall be documented and field tested to demonstrate compliance with SEPTA’s PTC Approval via Docket No. FRA-2010-0036.

D. Instrument one operating married pair to measure the actual thermal profile of all temperature-sensitive components during the most severe operating conditions permissible within the requirements and design parameters of the Specifications.

15.8.13 Communications Tests

A. Perform communication subsystem tests, including all of the subsystems specified in Section 13, Communications, to validate conformance with Section 13, Communications, on one married pair and one train.

B. Conduct at least two end-to-end runs of each service of the Regional Rail System. These runs may be the same as those runs being used for other tests, as long as the

procedures for those tests do not affect the communication subsystem. Test the following at a minimum:

1. Initialize the route at the beginning of the route and proceed to the destination station of the SEPTA regional rail route.

2. Manually specify the location along the line at an arbitrary station.

3. Set the PIS route to a intermediate destination and verify correct subsystem behavior after the train passes that location.

4. Subsystem behavior when train location does not match the expected location (for example, if a train traverses to an alternative route without updating the PIS).

5. In addition to confirmation that standard content loads utilized by SEPTA routes, the full features and capabilities of the system – including templates, integration with wayside feeds,

6. Journey logs recorded by the onboard system shall be recorded and provided as a part of the communication system qualification tests.

C. Perform Automatic Passenger Counting (APC) system accuracy testing during revenue service on one married pair. Comply with the following:

1. Verify average accuracy of 95% or better with a valid statistical sample with a minimum confidence level of 99%. All statistical calculations shall use a 99% confidence level unless otherwise stated.

2. Record at least 1,000 boardings and 1,000 alightings.

3. The system shall be demonstrated to meet National Transit Database reporting requirements, and accurately determine the station stop 99.9% of the time when compared with manual observation, and accurately determine the number of alighting and boarding passengers per station to an accuracy of +/- 5% within 95% overall concurrence with manual observations.

    a. The percent difference of manual vs. APC Unlinked Passenger Trips shall be less than 5 percent.

    b. The percent difference of manual vs. APC Passenger Miles Traveled shall be less than 5 percent.

    c. Accuracy shall be maintained between steps.

4. Use raw data from the vehicle passenger counting equipment. Data shall not be electronically adjusted or manipulated, other than where corrected data is specified. The data shall be raw data from the Passenger Counting System; no processing of the core passenger counting data shall be undertaken in any part of the off-vehicle equipment without Approval.

5. All tests shall use the same downloaded passenger counting data file, and no passenger counting data shall be excluded. Initial accuracy tests shall include all passenger counting data unless the exclusion of exceptional and abnormal passenger behavior is Approved.

6. Collect data during both peak and non-peak service as well as any applicable variable factors related to SEPTA's operation.

7. Perform direct comparison of actual and recorded passenger data at each door type using video captures. The VSS system may be used if Approved. SEPTA retains all rights and ownership of video captures.

15.8.14 Simulated Revenue Service Test

A. Subject the first three married pairs to a simulated revenue service test.

1. The test shall begin only after completion of all other married pair design qualification tests and the issuance of safety certification. See the Safety and Security Certification requirements in Section 23, System Safety and Security.

2. Conduct testing throughout the entire Regional Rail System, including SEPTA and Amtrak territory, on all operating tracks in all directions, operating under the standard revenue service profile in between revenue service trains.

3. The test shall include operation of all onboard systems typical for revenue service, including, but not limited to doors, HVAC systems, communication system components including PEI, IC, and displays.

4. Perform testing with simulated AW3 loading.

5. Cycle doors at every passenger stop. The Contractor shall provide a means to ensure passengers do not inadvertently board the test train.

6. The Contractor may install instruments to provide more detailed monitoring of selected systems. Furnish all necessary tools, equipment, and personnel to execute this test.

7. Each day, the train shall receive a thorough inspection by Contractor and SEPTA personnel.

8. The duration of the test shall be a minimum of 40 hours with no chargeable failures.

9. Issues that require manual intervention or manual resetting are considered chargeable failures.

10. Maintain a daily log to record any issues experienced by the cars.

a. The daily log shall include downloaded records from the car, including fault log from the VMDS, Journey Log from the Communication System, and event recorder log.

b. Record all anomalies in car performance and communicate with SEPTA.

c. If a Chargeable Failure is observed, as defined in Section 1, General Topics and Definitions, the mileage count shall reset, and the test shall be repeated.

15.8.15 Revenue Service Preparation

A. The pilot train shall then have instrumentation arranged so that it can be carried securely in the non-active cabs of the train and not interfere with passengers or staff during revenue operation.

B. The intent will be to collect performance data of the cars during revenue operation with parameters to be measured that are jointly agreed up during Simulated Revenue Service testing.

15.8.16 Actual Revenue Service

A. The pilot train shall then be operated in revenue test service for a minimum of 4,000 miles.

B. During this period of operation, there shall occur a period of no less than 1,000 miles in duration without the occurrence of any chargeable failures. This additional operation shall not be a burden on other components or subsystems which successfully completed the first 4,000 miles.

C. The pilot train shall then be placed in unaccompanied and unrestricted revenue service with the Contractor continuing to closely monitor the car’s service record.

D. The Contractor shall present a complete report documenting the operational tests and accompanied by data recordings. This presentation shall include a detailed listing of all defects in the car design, materials, workmanship, or performance with specific recommendations by the Contractor for their resolution.

15.8.17 Reliability and Availability Demonstration Testing

1. Perform Reliability and Availability Demonstration Testing as described in detail in in Section 21, Reliability, Availability, and Maintainability.

15.9 Factory Routine Tests

15.9.1 General

A. Verify the performance of all car equipment through a series of functional and routine tests at the corresponding manufacturer's facilities prior to shipment to the Contractor's assembly plant.

1. Confirm that all tests performed by suppliers are in compliance with the Specifications and in accordance with the Approved Master Test Plan.

2. Ensure that electrical and electronic apparatus tests and insulation and high-potential testing are performed on the car equipment where applicable.

3. Submit test procedures and test reports. **(CDRL 15-10, Factory Routine Tests)**

15.9.2 Electrical and Electronic Apparatus Tests

A. Comply with the following:

1. Test each subsystem that is separately assembled, housed, and wired into a packaged unit prior to installation in a car or married pair, at its point of manufacture.

2. Electronic assemblies shall undergo Environmental Stress Screening (ESS) as part of routine test. Note that the ESS testing is required. ESS testing is not optional:

a. Subject the electronic production assemblies to temperature cycling in accordance with the Reliability Analysis Center, Reliability Design Toolkit: Commercial Practices Edition, Table 7.6.1-2, Baseline Temperature Cycling Regimen for Organizations Lacking ESS Experience.

(1) The temperature limits of the thermal cycling shall be the full range of temperatures specified in Section 2, Design and Performance Criteria.

(2) Conduct a minimum of 12 complete temperature cycles. The number of cycles can be reduced, with Approval, when a failure rate of less than 0.1% can be routinely met.

(3) All ESS shall be performed with the equipment operational, powered, and oriented as per its application in the car.

(4) The loading of the equipment shall simulate maximum normal anticipated power dissipation.

(5) Subject the equipment to a full functional test prior to commencing the ESS and following completion of all ESS thermal cycles.

b. If the equipment fails, the repaired equipment shall reenter the ESS process.

(1) The equipment shall undergo a full functional test followed by a minimum of 3 complete thermal cycles or sufficient cycles to ensure that the assembly has been subjected to 12 thermal cycles, whichever is the larger.

(2) Equipment shall be repaired and shall reenter the ESS process a maximum of two times.

(3) On the third failure, the equipment shall be set aside for further investigation by the Contractor's quality organization. The item shall be held separate from the production quantities and shall not be reinstated into the production deliveries without Approval by SEPTA.

15.9.3 Insulation and High-Potential Testing

A. Comply with the following:

1. Confirm the integrity of the electrical insulation by performing insulation resistance tests and high-potential tests on individual devices, systems, apparatus, and all wiring.

2. Semiconductor devices and capacitors may be protected against the test voltage by means of shorting jumpers if they are not inherently protected by the circuit in which they are used.

3. On items with double insulation, such as grid resistors mounted by insulators to a frame insulated from carbody, test each set of insulation individually, i.e., resistors to frame and frame to carbody.

4. Conduct insulation resistance testing on all circuits within a device or subsystem apparatus.

5. Conduct the high-potential ground insulation test in accordance with IEC 61133 and IEEE16. Perform the insulation impedance test both before and after the high-potential test. The test conditions shall be the same for both tests, and the impedance value measured by the test following the high-potential test shall not differ by more than 10% from that measured in the initial test.

6. Conduct insulation resistance tests to verify the state of the insulation to the equipment case, between wiring of different voltage classes, and between the input and output circuit of high-voltage line switches and circuit breakers.

7. The insulation resistance limits shall apply when all circuits on the car of a given voltage class are connected in parallel under all environmental conditions, including high humidity.

8. The test limits for individual devices or apparatus shall be higher than the above listed limits as appropriate for that hardware, so that limits for the completed car can be met.

9. Conduct a high-potential test after the first insulation resistance test is completed and passed.

10. Protect all components and subsystems while the high-potential tests are being performed. Jumper together the various wires in a subsystem to ensure that all parts of a subsystem are tested, and to prevent capacitive currents or fault currents from passing through and damaging low-voltage devices.

11. Conduct the high-potential test on all circuits within a device or subsystem. Conduct tests to verify the state of the insulation to the equipment case, between wiring of different voltage classes, and between the input and output circuit of high-voltage line switches and circuit breakers.

12. The high-potential test limits in IEC 61133 and IEEE16 shall apply.

13. Conduct the test by applying the test voltage, as specified below, for 1 minute across the insulation being tested. The high-potential test is passed if there is no insulation breakdown or excessive leakage current.

Nominal Circuit Voltage (dc or ac rms)	**Test Voltage (ac rms, 60 Hz)**
Low voltage data communication wiring, including Ethernet, CAN, MVB, etc.	500V
Below 300 V	Follow IEC 61133 and IEEE16
Equal to or above 300 V	Follow IEC 61133 and IEEE16

15.9.4 Traction Power Control Test

A. With control power connected and traction power disconnected, test the traction power control subsystem for correct recognition and initiation of all external interface signals including, but not limited to, all trainline and network commands, door and brake release interlocks, friction brake interface signals, and monitoring and diagnostics interfaces.

1. The external conditions necessary for this verification process may be simulated, as necessary.

2. Traction power subsystem shall pass all built-in low-voltage self-test routines, including but not limited to CPU and memory tests, contactor and relay operation tests, speed sensor tests, and all gate driver tests.

3. With traction power available, the subsystem shall undergo and pass all built-in high-voltage test routines, including but not limited to filter capacitance tests and power module self-tests.

4. Perform a momentary low-level power application ("bump test") to verify correct phase connections of traction motor cables.

15.9.5 Brake Equipment

A. Perform a series of tests to demonstrate proper operation of the brake equipment.

1. Furnish certificates of conformance for small components provided by sub-suppliers and third-party sources.

2. Conduct functionality tests and certify for performance all electrical and electronic assemblies in accordance with manufacturer's specifications and test codes, as Approved.

3. Test-rack test all valves and pneumatic/electro-pneumatic units and certify for performance in accordance with the manufacturer's specification and test codes, as Approved.

4. Test all air reservoirs and certify in accordance with ASME BPVC, Section VIII-1.

15.9.6 Trainline and Network Subsystem Test

A. Test the trainline and network subsystem to demonstrate the functionality and operation of all components making up the Trainline and Network subsystem.

1. Perform functionality tests and certify the performance of the entire Trainline and Network subsystem in accordance with manufacturer's specifications and test codes, as Approved.

2. This validation shall also include verification of the network's error rate during worst-case traffic conditions.

15.9.7 Communication Subsystems

A. Test the communication subsystems to demonstrate the functionality and operation of all components specified in Section 13, Communications.

1. All communication system components shall be subject to high potential voltage and insulation test, and integration testing.

B. Perform functionality tests and certify the performance of the communication subsystems in accordance with manufacturer's specifications and test codes, as Approved.

1. All digital input/outputs shall be verified.

2. Verify proper routing, volume levels and that the system is free of noise and distortion.

3. PA and PIS information audio and visual shall be verified.

4. Prerecorded and manual announcements functionality shall be verified.

15.9.8 Trucks

A. Test each fully assembled production truck and its components, in accordance with the agreed upon test plan, to confirm compliance with design requirements.

1. Validate the welds, bolster, and other primary structural members of the truck using either magnetic particle or dye penetration method, in accordance with ASTM E709 and ASTM E165/E165M respectively.

2. Perform weld validation on 10% of trucks chosen at random by SEPTA. Visually inspect all welds on all trucks.

3. Perform inspection of critical welds using radiography or by section and etch method, or as otherwise Approved, on every 10th truck randomly selected by SEPTA.

4. If defects are found during sampling inspection, positively locate the beginning of such defect in previous truck frames and apply appropriate corrective action.

5. Measure and confirm the lateral clearance requirements on every 10th fully assembled journal bearing.

6. Furnish axle inspection records.

7. Furnish wheel press records and axle set serial and heat numbers listed together with the serial numbers of the trucks to which they are installed.

    a. Furnish clearly defined acceptance (or rejection) limits for all press diagrams (wheels, bearings, and gear units), presented in an Approved format.

    b. Record the final seating tonnage (spike) as a part of a complete wheel fit pressure diagram.

    c. Make all press records (wheels, bearings, and gear units) available for review during car manufacturing and include in the Car History Books.

8. Measure and confirm the gauge dimension requirements on all fully assembled wheel-axle assemblies.

9. Measure and confirm the axle-run-out (concentricity) on all fully assembled wheel axles.

10. Measure and verify the lateral and radial tread-run-out on all fully assembled wheel axles.

11. Measure and verify the conformance of tram and axle parallelism on all fully assembled trucks.

12. Weigh the complete truck assembly.

15.9.9 Couplers

A. Perform a series of factory routine tests to demonstrate the proper operation of couplers and drawbars, including the following:

1. Tests to demonstrate mechanical coupling and uncoupling.

2. Tests to demonstrate automatic coupling and uncoupling of electrical heads, including validation of trainline signals and network connection.

3. Test to demonstrate coupling and uncoupling of pneumatic coupler features.

4. Tests to demonstrate centering of the coupler assembly.

15.9.10 Auxiliary Electric Motors

A. Comply with the following:

1. Each ac auxiliary motor and dc motor shall be given a routine test by the manufacturer in accordance with IEC 60349 or IEEE Std 11, or an alternative test standard used in the industry may be proposed. Submit the test procedure for Approval during design review.

2. Motor balance for all electric motors shall be dynamically tested in accordance with NEMA MG 1, Section 12.6, Mechanical Vibration.

15.9.11 HVAC Subsystem

A. Comply with the following:

1. Test each complete subsystem at the HVAC equipment manufacturer's facility in accordance with the recommendations of ASHRAE Guideline 23, Section 9.3, HVAC Production Conformance Test.

a. Dimensionally check each HVAC unit to ensure compliance to design drawings.

b. Test each complete HVAC unit for watertightness with the evaporator blower fans running and the fresh air dampers open, following the requirements of TS 15.10.3. Filters shall remain dry during this test.

c. Functionally check each HVAC unit in all operating modes, simulating temperature sensor inputs through the PTU, including high pressure operation. Test the unit in cooling mode for 1 hour followed by heating mode for one hour.

d. Test each output from the controller and feedback input signal.

e. Test all electrical controls for proper operation and record amp draw from all components. Verify proper operation of pressure transducers and switches.

f. Perform leak testing prior to shipment.

g. Perform all tests at nominal system voltages and at the rated design airflows.

2. Test each cab heater unit and floor heater unit at the equipment manufacturer's facility in accordance with the recommendations of ASHRAE Guideline 23, Section 9.4, Cab and Auxiliary Heater Production Conformance Test.

15.9.12 Auxiliary AC Power Supply

A. Perform a routine test on each auxiliary power supply in accordance with IEC 61287-1 to verify compliance with the Specifications.

B. Test all auxiliary circuits (APS) to confirm proper control, distribution, and voltage. Test all circuit breakers. Test the APS crossover function. APS load shed shall be tested as defined in Section 9.

15.9.13 Low-Voltage Power Supply

A. The manufacturer shall perform tests at its facility indicated as routine tests in IEC 61287-1.

15.9.14 Battery

A. Batteries shall be given a capacity test at the point of manufacture in accordance with IEC 60623.

1. Check all components of the battery subsystem for proper operation, including the operation of the load shedding subsystem.

2. Any battery subsystem that is not installed within one year of manufacture and factory charging, shall be discharged and charged following OEM procedures.

15.9.15 Propulsion

A. Subject the propulsion subsystem to a complete static test, including speed sensor verification, friction brake interface check, reduced power and bump tests, and low-voltage tests.

1. Traction Motors:

a. Each traction motor shall be tested by the manufacturer in accordance with IEC 60349-2, Section 7.2, Exhibit 1, Summary of Tests, for routine tests (Tests 9.4, Overspeed tests, and 9.6, Vibration tests (imbalance) are required).

b. Motor balance shall meet the requirements for motor balance in Section 10, Propulsion and HV System.

c. An inverter power supply may be used for all factory routine testing.

2. Propulsion Subsystem: Test all units as defined in relevant sections of IEC 60077, IEC 60322, and IEC 61287-1. All optional tests to be performed.

15.9.16 Gear Units

A. Test each traction gear unit using the manufacturer's factory routine test. The test shall include the following, at a minimum:

1. Check gear tooth mesh alignment, backlash, and shaft endplay to verify that it is within the manufacturer's tolerances before the gear unit is operated.

2. Test no load operation at maximum operating speed equivalent car speed for 10 minutes in each direction. Continuously monitor vibration produced by each gear unit and gear sump oil temperature.

B. Gear units that produce abnormal oil temperature or noise shall be rejected.

15.9.17 Automatic Train Control/Positive Train Control

A. A test shall be performed on each ATC/PTC System.

B. The system shall be interconnected to simulator(s) as required to simulate the connectivity on the vehicle in order to demonstrate proper operation as a system.

15.9.18 Cab Control Circuits

A. Verify Master Controller functions and all controls related to power distribution and control from the operating control areas.

B. Verify penalty brake functionality including from both deadman sources.

C. Verify all coupler control and operation functions.

15.9.19 Carbody Watertightness Test

A. For each bare carbody, as represented at the carbody FAI, all window, door, and equipment openings shall be plugged or sealed, and a complete watertightness test performed on all areas of the car sides, ends, roof, and undercar.

1. Complete the watertightness test before the installation of sound deadening material, thermal insulation, and interior finish.

2. The use of sealant not called out on the drawings is prohibited.

3. The test parameters shall be as follows:

a. Water shall be sprayed from nozzles which are spaced no more than 3 feet from, and aimed directly at, the roof and sides of the car, with the side wall nozzles continuing in a vertical plane to 1 foot above top of rail.

b. Not less than 0.625 gallon per minute shall be delivered to each square foot of surface being tested, and the nozzle velocity of the water shall not be less than 150 feet per second.

c. All spray applications shall run for 10 minutes before the inspection for leaks and shall run continuously during the inspection.

d. The detailed drawing of the watertightness test fixture shall be submitted with the test procedure for Approval.

4. Continue spray applications for 10 minutes before the inspection for leaks begins and run continuously during the inspection.

5. Inside the carbody, no trickles of water shall be present.

6. The Contractor may propose alternate methods for watertightness test of the carbody, subject to Approval.

15.9.20 Main Transformer Test

A. All tests shall be performed in accordance with ANSI Specifications numbers C57.12.00 and C57.12.90. Each transformer shall be given the standard Railroad tests. Testing in accordance with IEC 60310 may also be proposed, however test procedures and test levels shall be modified in accordance with values and details specified below and in Section 2, Design and Performance Criteria, and Section 10, Propulsion and High Voltage System.

B. A basic impulse insulation level (BIL) test shall be made on the first production transformer of all primary windings.

1. The primary winding configuration shall withstand a 110,000 volts basic impulse level test.

2. In the event this transformer fails to pass the impulse test, the next three production transformers shall also be given this impulse test. Should failure occur on any of these three transformers, then every transformer produced shall be given and must pass an impulse test.

C. Every coolant pump and heat exchanger fan shall receive the following tests:

1. Winding cold resistance measurement

2. Verification of motor rotation direction

3. Two-hour test run at rated voltage and full load, recording amperes and watts

4. Check of noise and vibration levels during test run

5. Winding hot resistance measurement

6. Low-frequency dielectric test.

The cable, top termination, and transformer connection shall be supplied as a complete assembly. All assemblies shall be subjected by the manufacturer to a routine overvoltage withstand and partial discharge test.

15.10 Pre-Shipment Routine Tests

15.10.1 General

A. Prior to shipment from the Contractor's manufacturing plant, perform a series of routine tests and inspections on each married pair, to ensure that all installed equipment complies with the requirements of the Specifications.

B. Submit test procedures and test reports. **(CDRL 15-11, Pre-Shipment Routine Tests)**

15.10.2 Clearance Outline

A. Perform dimensional inspection to verify the complete car meets the Amtrak clearance diagram as detailed in Section 2, Design and Performance.

1. Dimensional inspection may be performed via accurate manual or automated (e.g. laser) measurements, or by moving a car through a clearance outline “frame”.

15.10.3 Assembled Married Pair Watertightness Test

A. For each car within a married pair, perform a complete watertightness test on all areas of the car sides, ends, roof, , doors, windows, and undercar.

1. The use of sealant not called out on the drawings is prohibited.

2. All doors and windows shall be closed. The battery box vents for gases shall be plugged or sealed temporarily for the test.

3. The test parameters shall be as follow those stipulated in TS 15.9.19 for carshell watertightness test. The detailed drawing of the watertightness test fixture shall be submitted with the test procedure for Approval.

4. Continue spray applications for 10 minutes before the inspection for leaks begins and run continuously during the inspection. Test exterior equipment enclosures and interior equipment enclosures exposed to the outside as specified in this Section.

5. Subject the traction motor clamshell, external lead connections, and underfloor and exterior wire trays and junction boxes to a water test. The water flow rate and velocity shall be as specified above.

6. Inside the car, no trickles of water shall be present, though isolated drops on the door thresholds shall be permitted. Any water entering shall not affect the function of any door components. For undercar components, no water ingress shall be noted in closed compartments intended to be watertight. Fresh air inlets and areas within the HVAC unit shall be inspected for water tightness. No filter shall show any evidence of moisture. HVAC seals to the carbody shall be inspected.

7. The Contractor may propose alternate methods for watertightness test of the assembled married pair, subject to Approval.

15.10.4 Car Weighing

A. Weigh each car prior to shipment to verify car weight and balance.

1. Each production car's official car weighing shall be performed only after all car assembly, testing, and final inspections have been completed, and the car is officially ready for delivery.

2. Record the weight of individual trucks on each car separately.

3. Use a weighing device that provides a permanent record of the weight measurements, and submit those weight tickets SEPTA. Include copies in the Car History Book, or furnish in the form of an equivalent database.

4. Maintain the accuracy of weighing device within 0.2%.

5. Submit written verification that the weighing device has been calibrated at least once every 120 days if electrical or at every test if mechanical.

15.10.5 Car and Married Pair Wiring Test

A. Perform wiring routine tests on all completely assembled cars and married pairs.

1. The wiring tests shall include continuity and insulation checks on all fully assembled circuits.

2. During this test, isolate metallic backshells from carbody wiring.

3. Perform continuity tests on all circuits in both active and inactive states, to ensure continuity and correct polarity of equipment and devices.

4. Check frame grounds and terminal connections for proper termination and tightness.

5. Perform insulation resistance and high-potential testing on the insulation of all car circuits per the requirements of TS 15.9.3. For detachable car jumper cables, perform independent insulation resistance and high-potential tests.

6. For the insulation resistance testing, perform a separate test on the battery assembly for insulation from carbody. Measure each terminal of the battery to the metallic portion of the battery tray with a micrometer.

7. The Contractor may request permission to disconnect certain components likely to be damaged or which, if not disconnected, would render the result invalid, under any of the above tests. The test report shall detail all miswiring, component failures, and other anomalies.

15.10.6 Pneumatic Subsystem Leakage Test

A. Perform a pneumatic subsystem leakage test on each married pair.

1. The test shall include measurement of change in subsystem pressure over time to demonstrate compliance with the specified requirements.

2. Set all cutout-cocks in normal operating position.

3. Fully charge the air subsystem, including the suspension subsystem, leveling valves in the lap position, and adjust the compressor controls to normal operating pressures.

4. After the subsystem is fully charged, slowly bleed air from the main reservoir until the air compressor starts. Close the main reservoir bleed, and allow the compressor to recharge the subsystem. Inhibit the startup of compressor during the test period.

5. After the compressor cuts out and after any drain valve action has terminated, record the main reservoir test gauge reading and start the clock.

6. After the compressor cuts out, wait for 3 minutes (for temperature effect), and record the main reservoir test gauge reading.

7. Wait for 5 minutes and record the main reservoir test gauge reading.

8. Main reservoir pressure drop for the married pair shall not exceed a total of 5 psig (34.5 kPa) in the last 5 minutes of the test. The air compressor shall not be allowed to start during the timed test period.

9. If the subsystem fails to meet the specified performance, correct the leakage and related faults, and rerun the test.

10. The test report shall detail all component failures and other anomalies.

15.10.7 Trainlines and Network Subsystem

A. Perform tests to validate the operation of trainlines and network functions on each married pair, and comply with the following requirements:

1. Verify the trainline signals on each intercar trainline connection and coupler electric heads.

2. Use a network protocol analyzer to confirm that statuses of trainline and network signals correspond to the commands set by the married pair's controls.

3. Develop a set of standard worst-case conditions to allow uniform network tests. Simulation routines within the various connected subsystems may be used to provide the necessary traffic levels.

4. Develop the methodology and conditions for network tests as part of the Married Pair Networks Design Qualification Test. The test shall validate 100% functionality of the networks.

5. Include validation of coupler functionality in trainline and network tests.

6. Immediately notify SEPTA of failures during this test. The test report shall detail all component failures and other anomalies.

15.10.8 Operator Cab Control Functionality Verification

A. Perform a complete series of static functionality tests on each car making up the married pair, to validate the operation of car's subsystems and to certify that the train can be properly controlled from the Operator's console.

1. Conduct the tests with the married pair at each cab.

2. Ensure that all controls, switches, indicators, displays, electrical outlets and PTU connections function as described in this Technical Specification.

3. Testing shall include verification that the appropriate power and brake demand signals generated by the master controller and other operator control devices are correctly received at all propulsion converters and brake controllers through a married pair.

4. Check the Operator's and Observer's function.

5. After completion of each test, demonstrate that all discrepancies logged against the married pair during its construction and test period, by either the Contractor's inspection staff or SEPTA's inspectors, have been suitably resolved to the satisfaction of SEPTA.

15.10.9 Door Test

A. Before the water tightness tests, all doors and their operating systems shall be checked and adjusted on all cars to ensure proper fit, and function.

1. This shall also include all body end doors, cab doors, locker doors, access hatches and underfloor/roof enclosure covers.

2. The door test shall verify the proper functions of the door subsystem including panel alignment, smooth operation, opening and closing speeds, door announcements, cutout operation, crew switch operation, and proper functioning of controls, signals, and interlocks.

3. All passenger side doors shall be subjected to a minimum of 100 consecutive, successful cycles. Initiation of the door cycling shall be through the trainline external from the car.

4. Use the PTU to monitor door performance.

5. The door test shall confirm the door obstruction sensing feature and validate the proper opening and closing forces on every door before and after the 100 door cycle tests. These features shall operate properly, without the need for readjustment at the end of the cycling tests.

6. The door test shall be performed on a completely assembled married pair, resting on a level tangent track.

7. The door tests shall be completed with no fault found in operation of the door subsystem, either visually or as recorded by the door subsystem diagnostic subsystem or the car's VMDS.

8. Following this test, the door adjustment shall be rechecked. The test will fail if any adjustment parameter is found to be out of specification.

15.10.10 HVAC Subsystem

A. Perform a test to demonstrate the operation and function of the HVAC subsystem.

1. Conduct a complete functional test of the integrated air conditioning and heating system of each car, including temperature controls, protective heat and baseboard heat, with the HVAC system under PTU operation.

2. Maintain car exterior temperature at an ambient level above the cooling lockout point sufficient to allow full or partial cooling operation mode for a test duration of 1 hour. Operation may utilize the PTU to simulate conditions.

3. Record operating pressures (suction and discharge), temperatures (ambient temperature and supply air temperature), input ac voltage, motor current (evaporator blower, condenser fan, compressors in each mode), power consumption, moisture indicator condition and color, humidistat operation, communication with TOD, and verification of drainage from condensate drains. Record data on both HVAC units and include pass/fail criteria. Verify the two sight glasses on each unit are bubble free during cooling tests.

4. Operate full heating and all protective heat for a test duration of 1 hour. Operation may utilize the PTU to simulate conditions.

5. Verify functionality of the floor-level heat, overhead heat, door threshold heat, heated windshields, protective heat, and the cab heat systems, including the temperature regulation equipment.

6. Record power levels of all heating systems and verify correct operation of the ground fault system.

7. Verify that temperature sensors are correctly monitoring fresh air, return air, and supply air conditions.

8. Confirm mechanical and electrical interfaces of the HVAC subsystem with the car function as designed.

9. Verify the subsystem start-up including stagger starting, shutdown, pump-down, and all HVAC-associated operating modes.

10. Verify that no faults occur during testing. If a fault occurs, correct the fault, and successfully rerun the specific portion of the test where the fault occurred.

11. Verify fault or over-temperature conditions if the corresponding protective devices are located separate from the heat-producing equipment and were not tested as an integrated subsystem on the car during qualification testing.

12. Verify car air balancing devices are identical to the final arrangement established for the climate room test.

13. Verify function of smoke detector(s) and alarm on a complete car as required in Section 7, Heating, Ventilation, and Air Conditioning.

15.10.11 Lighting, Headlights, Auxiliary Lights, and Marker Lights

A. Perform tests to validate the operation of the married pair's lighting subsystem and controls.

1. Confirm the proper operation and functions of all interior and exterior lighting assemblies and respective control circuits.

2. Confirm the proper operation and self-test functions of the emergency lighting system and independent power sources.

3. Adjust the headlights, auxiliary lights, and marker lights on each car to the requirements specified in Section 8, Lighting.

15.10.12 Friction Brake Test

A. Perform a test to validate all of the functions and operation of the friction brake subsystem.

1. Tests shall include verifying feedback command and load-weigh signals and the appropriate response.

2. The test shall include verifying brake cylinder pressure settings, valves, control and indicator checks, and leakage tests.

3. The test shall include verifying the brake fault detection subsystem.

4. The test shall include validating emergency brake functions and proper operation of the air compressor.

5. Check the performance of all electrical and electronic assemblies for proper operation.

15.10.13 Pantograph Test

A. The pantograph, main transformer, and all high voltage apparatus including the primary circuit breaker and pneumatic ground switch, shall be tested and adjusted to provide proper operation, including response to fault conditions.

15.10.14 Traction Power Control Test

A. Test the traction power control to validate the operation of traction control subsystem.

1. Conduct the test with low-voltage control power connected, and traction power disconnected.

2. The test shall validate the self-test propulsion test including recognition and initiation of all trainline and network commands, door and brake cylinder pressure interlocks, interface signals to friction brake, and monitoring and diagnostics interfaces.

3. The external conditions necessary for this verification process may be simulated, as necessary. Each component that fails to function properly shall be repaired and the test repeated until successful before proceeding to the next sequence of the propulsion test series.

15.10.15 Communication Subsystem Test

A. Test the communication subsystems to demonstrate the performance of the subsystem, including all equipment specified in Section 13, Communications, on each married pair.

1. Test the train radio for power output, voltage standing wave ratio (VSWR), and for clarity of voice transmission and reception on all channels and modes.

2. Measure output power from the train radio at the antenna. Measured reflected power and calculated VSWR shall be less than 2.0.

3. Perform sound pressure level measurements of minimum and maximum gains at each doorway location using a test tone generator and adjust to meet predetermined criteria. See Section 13, Communications.

4. Test all communication input devices including IC, PEI, and communication control panel locations.

5. Test the performance of the audio inductive loop system throughout the car.

6. Test the communication equipment using the required guided self-test functionality.

7. Aim each video surveillance camera according to the approved camera coverage plan.

8. Functionally test the VSS subsystem, including the network video recorders.

9. Functionally test the APC system.

15.10.16 Vehicle Monitoring and Diagnostics Subsystem (VMDS) Test

A. Test the VMDS to validate its operation and functions.

1. The test shall validate the correct reporting of data to VMDS over the networks, including all required car subsystem events and signals.

2. The test shall validate the communication link to a wayside wireless access point.

3. Validate that VMDS logs and messages are properly configured, including the time synchronization with the master clock, and in accordance with the Specification requirements.

4. Validate the functionality of the TOD associated with the VMDS.

5. A subset of faults shall be deliberately introduced during the test, as agreed between the Contractor and SEPTA, and the response of the VMDS shall be monitored. For example, connectors may be deliberately misconnected or disconnected.

15.10.17 Event Recorder Test

A. Test the event recorder to validate its operation and functions.

1. The test shall validate the correct reporting of all faults and event data to the event recorder.

2. Validate that event recorder logs and messages are properly configured, including time synchronization with the master clock, and in accordance with Specification requirements.

15.10.18 Automatic Train Control/Positive Train Control Static Test

A. Perform static testing of the ATC/PTC subsystem on each married pair to validate the car and peripheral component interfaces, including track receivers, speed sensors, and ADU with manufacturer and railroad requirements.

B. Static testing shall include execution of the Departure Test.

C. The audio level of all cab alarms shall be tested to verify compliant loudness.

15.10.19 Automatic Train Control/Positive Train Control Dynamic Test

A. Perform dynamic or simulated dynamic testing of the ATC/PTC subsystem to verify cab signal reception and processing, overspeed functionality, and ADU operation.

1. Contractor may propose, for SEPTA review and Approval, simulated dynamic testing may be conducted using a code box with speed simulation capability and an associated cab signal loop.

2. Alerter functionality shall be tested.

3. In addition, the ATC and PTC subsystem speed sensor, GPS and decelerometer interfaces and installation shall be confirmed by a slight jogging of the car to momentarily prompt speed and decelerometer signals.

15.10.20 Height Control Test

A. Check and record height-control valve adjustments, measurement of carbody floor height, and air-spring heights for each car.

15.10.21 Propulsion and Brake Subsystem Dynamic Test

A. Perform dynamic propulsion and braking tests to validate the married pair performance and compliance with requirements of Section 2, Design and Performance Criteria.

1. Perform dynamic tests on each married pair under AW0 condition, up to the traction motor's base speed or test track speed limit, whichever is higher.

2. Test the Yard, Normal and Carwash functions, as defined in Section 10, Propulsion and High Voltage System.

3. Furnish test equipment and instrumentation, including recorders, sensors, pickups, wiring, and inverters. The equipment shall be compatible with the onboard LVPS subsystem specified in Section 9, Auxiliary Power, and otherwise not be damaged by the conditions specified in Section 9.

4. Internal combustion engines driving a generator or use of the car auxiliary inverter power the instrumentation is prohibited.

5. Provide isolation amplifiers as part of the instrumentation package to isolate the instrumentation wiring and equipment from high voltages; exposed terminals with potential differences greater than 50 volts are prohibited.

6. Gather test data using a multiple channel digital data acquisition system.

7. Submit all data in tabular and graphical format to allow comparison against the Specification requirements and datasets gathered during the On-Site Design Qualification Tests.

8. The test instrumentation used shall have the necessary accuracy and response rate to ensure that the data gathered may be used to verify compliance with the Specification requirements and design data.

9. Record the following parameters data:

    a. Acceleration

    b. Car speed

    c. Catenary voltage

    d. Catenary current for each car

    e. Traction motor currents on each truck (each motor if there is one inverter per motor)

    f. Traction motor torques on each truck (for verification of dynamic and friction brake efforts) (each motor if there is one inverter per motor)

    g. Propulsion trainline control signals

    h. Braking trainline control signals

    i. Brake cylinder pressure for each truck

    j. Distance

    k. Time.

10. Following the dynamic tests, download and analyze all VMDS faults. Include the fault log as part of the test report.

11. Make adjustments required as a result of the tests, to obtain values corresponding to the specified performance, prior to shipment to SEPTA and note the adjustments in the Car History Book.

15.11 Routine Tests at SEPTA

15.11.1 General

A. Upon delivery of the cars to SEPTA, perform a set of comprehensive routine tests on each married pair to validate the operation, performance, and readiness of each married pair for revenue service.

1. Furnish all test equipment, materials, qualified personnel, and other necessary means and resources to safely perform all of the required routine tests.

2. Perform all necessary adjustments and repairs on the test married pair before the initiation of routine testing.

3. Upon delivery of a completed married pair to SEPTA's property, the Contractor and SEPTA shall perform an unpacking inspection and incoming inspection.

4. Submit test procedures and test reports. **(CDRL 15-12, Routine Tests at SEPTA)**

15.11.2 Miscellaneous Body Tests and Adjustments

A. Complete all of required carbody tests and adjustments prior to starting dynamic tests, including the following:

1. Verify the car's height, overall dimensions, and truck clearances.

2. Verify the proper operation, level, and alignment of the couplers.

3. Adjust the air spring suspension subsystem within the specified air pressure design tolerance.

15.11.3 Pneumatic Subsystem Leakage Test

A. Perform a pneumatic subsystem leakage test to demonstrate compliance with TS 15.10.6.

B. If the pneumatic subsystem leakage checks do not pass the test requirements, correct the fault and retest the married pair until the requirements are met.

15.11.4 Static Functional Tests

A. Perform a comprehensive functional test of each married pair to verify proper operation of all subsystems under normal operating conditions.

1. Perform functional tests at a SEPTA facility on each married pair prior to main line track operation on SEPTA’s property.

2. Verify communication to the wayside via the TWDT as part of the functional tests.

3. Use PTUs to complete functional tests.

15.11.5 Dynamic Tests

A. Perform traction power, dynamic and friction braking, and auxiliary power test on each married pair to validate performance and compliance with the requirements of Section 2, Design and Performance Criteria. In addition, test basic ATC/PTC function during the dynamic tests, and ensure proper function of the pantograph as specified in Section 10, Propulsion and High Voltage System.

1. Perform the dynamic test over a SEPTA-designated test area, under AW0 loading.

2. Furnish three complete sets of test equipment including sensors, isolation amplifiers, pickups, inverters, wiring and cable assemblies, cabinets, power supplies and data acquisition equipment, including storage media, to allow recording and playback of parameters as specified below.

    a. The accuracy and response of the instrumentation shall be sufficient to determine the degree of compliance with the routine test requirements.

    b. Provide a high accuracy speed sensor for speed and distance measurements. Verify the provided hardware against the devices that are already Approved or used by SEPTA.

    c. The test equipment shall be compatible with the onboard LVPS subsystem specified in Section 9, Auxiliary Power, and otherwise not be damaged by the conditions specified in Section 9.

    d. Internal combustion engines driving a generator or use of the car auxiliary inverter to power the instrumentation is prohibited.

    e. Exposed terminals with potential differences greater than 50 volts are prohibited.

    f. No engineering and assembly work shall be required, other than to set the equipment into a car and to plug or connect the test cables into the car equipment and test equipment.

    g. Provide the necessary wiring diagrams, schematics, and procedures to permit the test equipment to be installed, calibrated, operated, maintained, and repaired.

3. Gather test data using a multiple channel digital data acquisition system.

    a. Provide sufficient recording media to store all records from the dynamic testing.

    b. Submit data in tabular and graphical format to allow comparison against the Specification requirements and datasets gathered during the on-site design qualification tests.

    c. Clearly annotate tables and graphs to allow easy identification of all test parameters.

d. All charts obtained from the recordings shall become the property of SEPTA.

4. Perform dynamic functional tests on the track test to observe, validate, monitor, and record operation of the following signals:

   a. Acceleration

   b. Car speed

   c. Catenary voltage

   d. Catenary current for each car

   e. Traction motor current on each truck (each motor if there is one inverter per motor)

   f. Traction motor torque on each truck (for verification of dynamic and friction brake efforts) (each motor if there is one inverter per motor)

   g. Propulsion trainline control signals

   h. Braking trainline control signals

   i. Brake cylinder pressure for each truck

   j. Distance

   k. Time

5. Perform a test to demonstrate the performance of auxiliary power supplies while negotiating overhead wire phase and system change power gaps.

   a. Gap testing may be combined with tractive power test.

   b. The power gap test shall include as a minimum:

      (1) A test at a selected phase gap location at a speed sufficient to verify the operation of backup braking, and the ability of the propulsion system to keep the APS operational when transitioning a phase gap. Load conditions shall include all auxiliary loads running when entering the gap.

      (2) A test at a selected phase gap location at a speed below the minimum threshold for backup braking to verify the correct shutdown and restart of the APS when transitioning a phase gap. Load conditions shall include all auxiliary loads running when entering the gap, and full auxiliary load call when exiting the gap.

6. Ensure interlock functionality of the overspeed control, and door/traction on the designated SEPTA track prior to Burn-In test. Use the PTU and VMDS to

verify that no faults occurred during the testing. A fault shall require rerunning that specific portion of the test where the fault occurred.

7. Make adjustments required due to failed test, or to obtain values corresponding to the specified performance, and retest prior to Acceptance.

15.11.6 Simulated Revenue Service Operational Burn-In Test

A. Perform burn-in testing after Approval of all qualification tests and all routine tests specified prior to the burn-in test; completion of SEPTA's Safety Certification; and Conditional Acceptance of the first three married pairs.

1. Test Purpose:

a. To confirm the reliability and availability of the cars and married pairs under actual service conditions.

b. To identify engineering changes required to improve car reliability so that the changes can be incorporated into the production cars at the Contractor's facility.

2. Test Setup:

a. The Contractor may install instruments to provide more detailed monitoring of selected systems. Furnish all necessary tools, equipment, and personnel to execute this test.

b. Each day, the train shall receive a thorough inspection by Contractor and SEPTA personnel.

3. Testing Performance:

a. Perform an instrumented 500-mile (805-km), simulated revenue service test with each married pair.

b. The test shall include operation of all onboard systems typical for revenue service, including but not limited to doors, HVAC systems, communication system components including PEI, IC, and displays.

4. Test Results:

a. Prepare a detailed daily test report immediately following each day's run so that the results may be analyzed prior to starting the next day's test. This report shall include VMDS fault logs, Journey Log from the Communication System, Event Recorder download and other fault logs as needed to evaluate the day's testing.

b. Maintain a daily log to record issues experienced by the cars. Record all anomalies in car performance and communicate with SEPTA. If a Chargeable Failure is observed, as defined in Section 1, General Topics

and Definitions, the mileage count for that married pair shall reset, and the test shall be repeated for that married pair.

c. Use the results from this test to modify car design and test procedures, as required, to ensure the as-delivered performance of the cars meets all requirements of the Specifications.

d. Following completion of all testing, submit a full report of the test, including recommended changes to test procedures. Reports shall include the following minimum information:

(1) Date of test

(2) Weather conditions

(3) Start and stop locations

(4) Test log recording of any anomalies encountered during the test

(5) Fault log summary from all six cars recording all faults, organized by subsystem

(6) Detailed fault log files from all systems.

15.12 Contract Deliverable Requirements List (CDRL)

The following contract deliverables have been identified in this section; however, the Contractor is responsible for providing and submitting anything necessary to fulfill the requirements of this contract, including those not identified by CDRL number.

CDRL 15-01, Master Test Plan 15-6
CDRL 15-02, Component Design Qualification Tests 15-10
CDRL 15-03, Carbody Structure Design Qualification Tests 15-31
CDRL 15-04, Carbody Structure Design Qualification Results 15-31
CDRL 15-05, Appendix F Design Qualification Test 15-46
CDRL 15-06, Appendix F Design Qualification Results 15-46
CDRL 15-07, Subsystem Design Qualification Tests 15-51
CDRL 15-08, Car and Married Pair Design Qualification Tests 15-67
CDRL 15-09, On-Site Design Qualification Tests 15-94
CDRL 15-10, Factory Routine Tests 15-119
CDRL 15-11, Pre-Shipment Routine Tests 15-128
CDRL 15-12, Routine Tests at SEPTA 15-138

15.13 CDRL Detail

This section lists the expected content for each CDRL required above. The lists provided for each CDRL are an outline only and should not be considered exhaustive, all CDRLs are subject to SEPTA review and approval.

CDRL 15-01 Master Test Plan:

1. Submit no later than 180 days after Notice to Proceed (NTP).
2. Identify tests by reference to the appropriate section of the Specifications.
3. Include procedure numbers and report numbers for all tests.
4. Include a detailed schedule showing the sequence, place/location, of each test to be performed.
5. Include all subcontractor tests to be completed at the subcontractor facilities, Contractor tests to be completed at its facilities prior to delivery, and testing to be conducted by the Contractor on SEPTA's property prior to acceptance and commissioning.
6. Where individual tests are best performed in combination with other tests, clearly detail the combined tests and limit the number of tests to be combined to keep the approval process/cycle manageable.
7. Provide monthly updates of the Test Plan to show submittal letter numbers and Approval status of all procedures and reports.

CDRL 15-02 Component Design Qualification Tests:

1. Submit test procedures and test reports, as specified in TS 15.3, for each separate component design qualification test to be performed and submitted.

CDRL 15-03 Carbody Structure Design Qualification Tests:

1. Submit test procedures, as specified in this Section, for each separate carbody structure design qualification test to be performed.

CDRL 15-04 Carbody Structure Design Qualification Test Results:

1. Submit test reports, as specified in this Section, for each separate carbody structure design qualification test performed.

CDRL 15-05 Appendix F Design Qualification Test

1. Submit test procedures, as specified in this Section, for each separate alternative trainset design qualification test to be performed.

CDRL 15-06 Appendix F Design Qualification Results

1. Submit test reports, as specified in this Section, for each separate alternative trainset design qualification test performed.

CDRL 15-07 Subsystem Design Qualification Tests:

1. Submit test procedures and test reports, as specified in this Section, for each separate subsystem design qualification test to be performed.

CDRL 15-08 Car and Married Pair Design Qualification Tests:

1. Submit test procedures and test reports, as specified in this Section, for each separate car and married pair design qualification test to be.

CDRL 15-09 On-Site Design Qualification Tests:

1. Submit test procedures and test reports, as specified in this Section, for each separate on-site design qualification test to be performed.

CDRL 15-10 Factory Routine Tests:

1. Submit test procedures and test reports, as specified in this Section, for each separate factory routine test to be performed.

CDRL 15-11 Pre-Shipment Routine Tests:

1. Submit test procedures and test reports, as specified in this Section, for each separate pre-shipment routine test to be performed.

CDRL 15-12 Routine Tests at SEPTA:

1. Submit test procedures and test reports, as specified in this Section, for each separate routine test to be performed at SEPTA.

15.14 Referenced Standards

The following standards are referenced in this Section:

40 CFR 201	Noise Emission Standards for Transportation Equipment; Interstate Rail Carriers
49 CFR 38.63	Between-car Barriers
49 CFR 213	Track Safety Standards
49 CFR 213.329	Curves; Elevation and Speed Limitations
49 CFR 213.333	Automated Vehicle Inspection Systems
49 CFR 213.345	Vehicle Qualification Testing
49 CFR 218	Railroad operating rules and practices

49 CFR 223, Appendix A	Certification of Glazing Materials
49 CFR 229	Railroad Locomotive Safety Standards
49 CFR 229 Appendix D	Criteria for Certification of Crashworthy Event Recorder Memory Module
49 CFR 231	Railroad Safety Appliance Standards
49 CFR 238	Passenger Equipment Safety Standards
49 CFR 238.111	Pre-revenue Service Acceptance Testing Plan
49 CFR 238.113	Emergency Window Exits
49 CFR 238.115	Emergency Lighting
49 CFR 238.211	Collision Posts
49 CFR 238.213	Corner Posts
49 CFR 238.221	Glazing
49 CFR 238.233	Interior Fittings and Surfaces
49 CFR 238, Appendix F	Alternative Dynamic Performance Requirements for Front End Structures of Cab Cars and MU Locomotives
49 CFR 239	Passenger Train Emergency Preparedness
AHRI Standard 210/240	Standard for Performance Rating of Unitary Air-conditioning & Air-source Heat Pump Equipment
ANSI B31.1.	Power Piping
ANSI/ASA S1.4 Part 3	Electroacoustics – Sound Level Meters – Part 3: Periodic Tests
ANSI/ASA S1.11 Part 1	Electroacoustics – Octave-band and Fractional-octave-band Filters – Part 1: Specifications
APTA PR-CS-S-011-99	Standard for Cab Crew Seating Design and Performance
APTA PR-CS-S-012-02	Door Systems for New and Rebuilt Passenger Cars
APTA PR-CS-S-016-99	Passenger Seats in Passenger Railcars
APTA PR-E-S-013-99	APTA Standard Emergency Lighting System Design for Passenger Cars

APTA PR-M-S-006-98	Parking Brakes for Passenger Locomotives and Cars
APTA PR-M-S-014-06	Standard for Wheel Load Equalization of Passenger Railroad Rolling Stock
APTA PR-PS-S-006-23	Emergency Egress/Access Signage and Low-Location Exit Path Markings for Passenger Rail Equipment
ASHRAE Standard 23	Methods of Testing for Rating Positive Displacement Refrigerant Compressors and Condensing Units
ASHRAE Standard 37	Methods of Testing for Rating Electrically Driven Unitary Air-Conditioning and Heat Pump Equipment
ASHRAE Standard 41.1	Standard Method for Temperature Measurement
ASHRAE Guideline 23	Guideline for the Design and Application of Heating, Ventilation, and Air-Conditioning Equipment for Rail Passenger Vehicles
ASME BPVC, Section VIII-1	Boiler and Pressure Vessel Code, Rules for Construction of Pressure Vessels Division 1
ASHRAE Load Calculations Application Manual	
ASTM D412	Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers-Tension
ASTM D573	Standard Test Method for Rubber-Deterioration in an Air Oven
ASTM D1149	Standard Test Methods for Rubber Deterioration-Cracking in an Ozone Controlled Environment
ASTM D3182	Standard Practice for Rubber-Materials, Equipment, and Procedures for Mixing Standard Compounds and Preparing Standard Vulcanized Sheets
ASTM D3183	Standard Practice for Rubber-Preparation of Pieces for Test Purposes from Products
ASTM D3190	Standard Test Method for Rubber-Evaluation of Chloroprene Rubber (CR)
ASTM E119	Standard Test Methods for Fire Tests of Building Construction and Materials
ASTM E165/E165M	Standard Practice for Liquid Penetrant Examination for General Industry

ASTM E709	Standard Guide for Magnetic Particle Testing
ASTM E1049	Standard Practices for Cycle Counting in Fatigue Analysis
EN 13597	Railway applications - Rubber suspension components - Rubber diaphragms for pneumatic suspension springs
EN 13802	Railway Applications – Suspension components – Hydraulic dampers
EN 13913	Railway applications - Rubber suspension components – Elastomer-based mechanical parts
EN 50121-3-2	Railway applications - Electromagnetic compatibility - Part 3-2: Rolling stock – Apparatus
EN 50121-3-1	Railway applications - Electromagnetic compatibility - Part 3-1: Rolling stock - Train and complete vehicle
EN 50124	Railway applications - Insulation coordination
EN 50155	Railway Applications – Electronic Equipment Used on Rolling Stock
GM/RC2641	Rail Safety and Standards Board Recommendations for Vehicle Static Testing
ISO/IEC 17025	General Requirements for the Competence of Testing and Calibration Laboratories
IEC 60077	Railway applications - Electric equipment for rolling stock
IEC 60268-16	Sound system equipment Part 16: Objective rating of speech intelligibility by speech transmission index
IEC 60310	Railway applications - Traction transformers and inductors on board rolling stock
IEC 60322	Railway applications - Electric equipment for rolling stock - Rules for power resistors of open construction
IEC 60349-2	Electric traction - Rotating electrical machines for rail and road vehicles - Part 2: Electronic converter-fed alternating current motors
IEC 60529	Degrees of Protection Provided by Enclosures (IP Codes)

IEC 60571	Railway applications – Electronic equipment used on rolling stock
IEC 60623	Secondary cells and batteries containing alkaline or other non-acid electrolytes - Vented nickel-cadmium prismatic rechargeable single cells
IEC 61133	Railway applications – Rolling stock - Testing of rolling stock on completion of construction and before entry into service
IEC 61287-1	Railway applications - Power converters installed on board rolling stock - Part 1: Characteristics and test methods
IEEE Std 11	Standard for Rotating Electric Machinery for Rail and Road Vehicles
IEEE Std 16	Standard for Electrical and Electronic Control Apparatus on Rail Vehicles
IEEE 1482.1	Standard for Rail Transit Vehicle Event Recorders
ISO 1996-2	Description, measurement and assessment of environmental noise
ISO 2631-1	Mechanical vibration and shock - Evaluation of human exposure to whole-body vibration - Part 1: General requirements
ISO 2631-4	Mechanical vibration and shock - Evaluation of human exposure to whole-body vibration - Part 4: Guidelines for the evaluation of the effects of vibration and rotational motion on passenger and crew comfort in fixed-guideway transport systems
NEMA MG 1	Motors and Generators
NFPA 130	Standard for Fixed Guideway Transit and Passenger Rail Systems
SAE J902	Passenger Vehicle Windshield Demisting and Defrosting Systems
UIC 541-3	Brakes – Disc brakes and their applications – General conditions for the certification of brake parts
UIC 541-5	Brakes – Specifications for the construction of various brake parts – Wheel Slide Protection device (WSP)

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MATERIALS AND WORKMANSHIP

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16.1 General

16.1.1 Scope

A. This Section defines the minimum performance requirements for materials to be used in the construction of vehicles, and establishes minimum guidelines for workmanship.

B. It identifies mandatory government requirements and industry specifications controlling the quality of specific materials and components and the construction methods.

C. Inclusion of a material or product in this Section does not imply Approval of its use in a particular application. See other sections for detailed requirements for specific car subsystems.

D. Safety Data Sheets (SDS) shall be submitted for all materials, including lubricants, used in the fabrication of the cars and brought onto SEPTA property except for non-hazardous metallic materials. Information shall be in a form compliant with ANSI Z400.1-1993.

16.1.2 Quality

A. Material and workmanship shall be in accordance with the stated specification or description, unless a substitution is Approved.

B. When a general material or method is specified in this Section 16, the Section 16 requirements shall be applicable; however, specific requirements specified in other sections of the Specifications take precedence over this Section.

16.1.3 Standards

A. Materials and workmanship shall conform to the appropriate industry standards for use on rail transit equipment:

1. These standards include Federal or Military specifications or standards, the specifications of the Aluminum Association, AAR, ANSI, AISI, APTA, ASME, ASNT, ASTM, FRA, IEEE, IEC, EN, NACE, NFPA, SSPC, or other standards and requirements as specified in this Section.

2. Where other or foreign standards are proposed by the Contractor, the Contractor shall submit documentation with a section by section comparison to demonstrate that the proposed standards are generally the equivalent of the foregoing standards and specifications for review and approval. Proposed substitute specifications shall be submitted in both English and the language of the country of origin. The most recent standards and specifications applicable at the time of issuance of the Notice to Proceed shall apply unless otherwise Approved.

16.1.4 Marking

A. All materials intended for use on these vehicles shall be marked or stored so as to be readily identifiable and shall be adequately protected during handling and storage. Rejected material shall be clearly marked and stored in an area specifically designated for that purpose which is not accessible to manufacturing staff.

16.1.5 Material Availability in the U.S.

A. All materials used shall be readily available in the United States from at least two suppliers, unless otherwise agreed by SEPTA.

16.1.5.1 Cleaning Agents

A. For each part of the car that is normally cleaned, materials proposed for use in that area shall have a manufacturer-recommended cleaning agent available and not prohibited in the U.S.

1. Submit a list. **(CDRL 16-01, Recommended Cleaning Agents)** SEPTA maintains a constantly-updated list of over 2000 materials and agents in use on its systems and assets, available at https://septa.sdsprohost.com. Submitted list shall contain only materials and agents already in use at SEPTA, unless Approved otherwise.

2. All recommended cleaning agents shall be safe for handling and use on any equipment or material anywhere on the car and throughout SEPTA.

16.1.5.2 Maintenance Materials

A. Fasteners, paint, lubricants, and other materials required for maintenance of the vehicles shall be available and not prohibited in the U.S.

16.1.6 Storage of Equipment and Materials

A. Ship and store equipment and material intended for use in these cars such that damage and reduction in life are prevented:

1. These requirements apply to equipment and material at the Contractor's facilities, at SEPTA's facilities, at suppliers' facilities, and to capital spare parts.

2. At a minimum, comply with the following:

a. Protect stored material subject to corrosion by waterproof covers or coatings. Store materials and equipment under cover and off the floor or ground.

b. Store equipment with ports, covers, and other enclosure openings closed to prevent entrance of dirt or moisture.

c. Clearly mark dated material with the expiration date; material shall not be used beyond this date.

d. Handle and store material with special handling or storage requirements according to the manufacturer's requirements.

(1) For equipment with special storage requirements, include storage and handling instructions with the equipment.

(2) Clearly mark and store material with appropriate nomenclature to prevent misapplication.

(3) Include instructions on how to prepare equipment for use after long periods of storage, where applicable.

3. Clearly mark rejected material as such and store in a separate controlled area specifically designated for that purpose and segregated for this program.

16.1.7 Prohibited Materials

A. Submit a list of prohibited materials with certification that no prohibited materials are used in the car **(CDRL 16-02, Certification of No Prohibited Materials)**

B. The following materials shall be prohibited from use on the railcars:

1. PVC

2. Asbestos

3. Cadmium (except for battery)

4. Lead, all applications, including in paint and coatings

5. PCBs

6. Carcinogenic materials as listed by current Publication of the American Conference of Governmental Industrial Hygienists (ACGIH)

7. CFC and HCFC compounds, including all Class I and Class II ozone-depleting substances as defined by the EPA, such as R-22 refrigerant

8. Urethane foam

9. Materials in the List of Highly Hazardous Chemicals, Toxics and Reactives, 29 CFR 1910.119, Appendix A.

16.1.8 Corrosion Control

A. All materials used shall be either inherently corrosion resistant, or suitably treated or coated to prevent and resist corrosion.

1. Submit a Corrosion Control Plan, documenting the methods used to preclude failure due to corrosion. **(CDRL 16-03, Corrosion Control of Materials)**

16.1.9 Material Reporting Requirements

A. Comply with the following:

1. Whenever a proposed commercial material is not covered by a specification or standard, it is to be submitted under this CDRL. **(CDRL 16-04, Proposed Materials Not Covered by Specification or Standard)**

2. Submit as a CDRL any Safety Data Sheets (SDS) for chemical materials (paints, solvents, adhesives, etc.) used in the manufacture of the car or used on SEPTA property as part of an FMI. Also, furnish SDS information as requested by SEPTA for any questionable material. SDSs shall comply with 29 CFR 1910.1200 (g). **(CDRL 16-05, Safety Data Sheets)**

3. Maintain records that trace all materials to their manufacturers and production lots, thereby verifying compliance with quality standards specified or cited in this Section.

16.1.10 Dissimilar Materials

A. Dissimilar materials, as defined in the Specifications, are materials that may corrode or otherwise become damaged when in contact with each other.

1. Connection of dissimilar materials is permitted only at permanent connections and with Approved electrochemical isolation.

2. Electrochemical isolation treatments shall be permanent and not require maintenance or replacement for the life of the car.

3. Dissimilar materials are not permitted at electrical connections or connections requiring disassembly for maintenance or for removal and replacement of equipment.

16.1.11 Material Handling

A. The Contractor shall use care in handling all materials used in the manufacture of these cars. SEPTA reserves the right to require the Contractor to change material handling methods and procedures that are not deemed adequate and appropriate for the work.

16.2 Standards of Workmanship

16.2.1 Workers

A. Comply with the following:

1. Car components shall be constructed by workers experienced in the appropriate trades.

2. Provide worker training and supervision to ensure that manufacturing control requirements are satisfied.

16.2.2 Use of Drawings and Procedures

A. Comply with the following:

1. Design and construction drawings and procedures, including welding procedure specifications (WPS), shall be readily available at each manufacturing site, and shall be used by workers to accomplish and verify their tasks.

2. Ensure that workers are always using the current revision.

3. Ensure that workers use tooling as defined by the design, construction, or assembly drawings.

4. Work not expressly detailed on the Contractor's drawings, such as internal standards or documents, shall conform as a minimum to the standards of workmanship in this Section, and are subject to the same review and Approval standards as the drawings.

16.2.3 Use of Manufacturing Tools and Interchangeability

A. Comply with the following:

1. Attachment points in the car and on subassemblies shall be located by jigs, fixtures, laser levels, and similar methods to ensure accurate placement and per-design tolerances.

2. Like components shall be constructed to the same dimensions and tolerances, hole and subassembly locations, materials, and finishes, and shall be interchangeable in the car and between cars without modification.

16.2.4 Prohibited Practices

A. The following are prohibited:

1. Cut-to-fit, match drilling, filing, and other hand-fitting practices, unless Approved. Where such practices appear necessary, perform a prompt review of design and construction methods, and implement corrections to avoid these practices.

2. Modification of OEM or subcontractor equipment, including minor modifications such as replacement of wire terminations.

3. Modification of Contractor equipment without following Approved procedures.

4. Use of sealant, unless required by the Specifications or Approved.

5. Re-use of fasteners.

16.2.5 Metal Fabrication

A. Comply with the following:

1. Flat plates shall be sheared or cut using modern metal-cutting technology such as laser cutting or waterjet cutting.

2. Structural shapes, pipe, and tube shall be cut to length using band saw or cold cut blade saw. Cut to length by handheld torch is not permitted.

3. Holes shall be drilled or die punched. Bolt holes shall not be burned by hand torch. Holes 1.5 in (38 mm) and larger may be cut by modern metal-cutting technology such as laser cutting or waterjet cutting.

4. Spacing of holes on connection plates shall have a tolerance of maximum 1/32 in (0.8 mm).

16.2.6 Machining

A. Comply with the following:

1. Machine fits shall adhere to ASME B4.1.

2. Surfaces receiving power machine cutting or profiling shall have a surface finish of 125 microinches (3.175 µm) rms.

3. Shafting shall have the ends squared by facing off in an engine lathe.

4. Chamfers shall be machined on shaft edges and at edge of bore of press on parts.

5. Cut edges shall be de-burred.

16.3 Joining

16.3.1 General

A. Certain combinations of materials require particular care in joining to help prevent corrosion. Isolating and moisture-proofing materials, appropriate to the materials being joined, shall be used at all times where these combinations exist and shall be detailed in the Corrosion Control Plan.

16.3.2 Joint Fitting

A. Comply with the following:

1. Joints shall be properly fitted, whether exposed or concealed.

2. Gaps between joints:

    a. Shall be held to a minimum and be uniform in width.

    b. When not otherwise indicated in the Drawings or Specifications, gaps between joints shall be held to a dimension not greater than 10% of the thinner material being joined, or 0.002 in (0.05 mm), whichever is greater.

3. The edges of panels shall have a smooth, finished appearance.

4. Where excessive gaps (greater than those permitted by Approved drawings or standards) are found to exist at the faying surfaces of structural bolted or riveted connections, comply with the following requirements:

    a. Metal shims of the same material as that of the deficient part may be used, but only with the written permission of SEPTA.

    b. Shims, if used, shall be permanently fastened to one of the base parts being joined. The use of epoxy or other plastic filler at such locations is expressly prohibited.

16.3.3 Metal-to-Metal Connections

A. Comply with the following:

1. Metal riveted or bolted to metal:

    a. Contact surfaces shall be free of dirt, grease, rust, and scale.

    b. Coat with an epoxy primer as specified below in TS 16.19, Paints and Coatings.

    c. Epoxy primer may be omitted for like-stainless steel to like-stainless steel joints.

2. Aluminum: Metal-to-metal connections shall be as specified below in TS 16.5.5.2.

16.3.3.1 Slotted Joints

A. All secondary structures shall be permanently attached by welds or Huck bolts and not slotted. Any slots shall only be used with written permission of SEPTA on an individual exception basis only and shall not be a part of any application design.

16.4 Fasteners

16.4.1 General

16.4.1.1 Scope

A. Fasteners include threaded fasteners, associated nuts, tapping plates, and washers; quick-release fasteners; rivets; and locking pins. Submit a design package. Structural tapping plates for aluminum designs shall be individually detailed and illustrated. **(CDRL 16-06, Fasteners Design Package)**

16.4.1.2 Design

A. Comply with the following:

1. All fasteners shall conform to inch standards. However, use of ISO metric-standard fasteners will be permitted for back-shop operations only for suppliers for which using inch fasteners would require a redesign of products. In these limited cases only, provide corresponding labels near the fasteners.

2. Select fastener types, sizes, styles, lengths, materials, grades, and finishes that will satisfy the requirements of the design and meet the requirements of the Specifications.

3. Minimize the number of different sizes and styles of fasteners used.

4. Undercar equipment shall not be supported by bolts in tension.

16.4.1.3 Material

A. Comply with the following:

1. Bolts, screws, nuts, washers, and other related fastening devices shall be plated steel or stainless steel unless otherwise Approved.

2. Aluminum fasteners are prohibited except where specifically Approved.

3. Except for fasteners internal to electrical or electronic components, plastic screws, bolts, nuts, or other plastic fastening components shall not be used.

16.4.1.4 Plating

A. Comply with the following:

1. Carbon steel, alloy steel, and martensitic stainless steel fasteners shall be plated with zinc, unless specifically waived by SEPTA. Zinc plating shall conform to ASTM B633, Type II (if RoHS compliant), V, and VI and SC2, SC3, or SC4.

2. Plating materials other than zinc, and plating of any type on high strength fasteners, are subject to Approval.

3. Cadmium plated fasteners are not permitted.

16.4.1.5 Prohibited

A. The following are prohibited:

1. Protruding screws, mounting bolts or similar items on the car interior or exterior, except for those appointments that cannot be built into the structure in any other manner.

2. Rivnuts, Self-drilling and self-tapping screws, except where Approved.

3. Tapped holes in structure, brackets, and other car assemblies. Tapping plates shall be used when installing fasteners into car structure or subassemblies.

4. Fasteners installed into blind holes, unless Approved.

5. Thread-sealing compounds, except for anti-vibration treatments (for example, Loctite) where Approved.

6. Use of elastic stop nuts for electrical connections.

7. Use of self-tapping fasteners unless Approved.

16.4.2 General Requirements for Threaded Fasteners

16.4.2.1 Standards

A. Threaded fasteners shall conform to Industrial Fastener Institute (IFI) latest standards.

16.4.2.2 Head Types

A. Comply with the following:

1. General: Shall be hex heads or hex socket-heads.

2. Where specified, tamper-resistant fasteners shall be pin-in-head hexalobular internal (aka 6lobe, star drive or "Torx"), size 15 or Approved others.

3. Prohibited: Philips, flat head, or other designs, except in off-shelf parts or where Approved.

16.4.2.3 Identification

A. Comply with the following:

1. Inch fasteners: Shall be identified as required by the referenced U.S. standards.

2. Metric fasteners: Shall be identified as required by the referenced ISO standards.

16.4.2.4 Maintenance Access

A. The design shall provide access for maintenance or replacement of threaded fasteners and nuts. When bolts are used to secure apparatus where the bolt head is inaccessible, provide a reusable mechanical locking device to prevent the bolt head from turning when the nut is being turned.

16.4.2.5 Thread Projection

A. Comply with the following:

1. Minimum thread projection shall be 1.5 full screw threads beyond any portion of the nut, at proper torque.

2. Maximum projection shall be as follows:

a. With elastic stop nuts projection shall be 0.25 in (6 mm), regardless of bolt diameter.

b. Without elastic stop nuts:

(1) 0.25 in (6 mm) diameter or less: Projection shall be 1.5 full threads plus 0.25 in (6 mm)

(2) Greater than 0.25 in (6 mm) diameter: Projection shall be eight full threads, unless otherwise Approved.

16.4.2.6 Bolt Hole Size

A. Bolt hole clearances shall not exceed the recommendations of Industrial Fasteners Institute (or ISO 273).

16.4.2.7 Tapping Plates

A. If tapping plates are used, comply with the following:

1. Minimum Thickness: Shall be equal to diameter of the bolt for which the tapping plate is intended.

2. Strength: Shall meet the same standards as the equivalent nut.

3. Installation:

a. Attach to the structure with mechanical fasteners unless otherwise Approved.

b. Drill a clearance hole in the structure for the bolt.

4. Structural tapping plates shall be reported per Section 16.4.1.1.A.

16.4.3 Special Requirements for Structural Fasteners

16.4.3.1 Scope

A. This section applies to structural and load carrying bolts:

1. It includes structural bolts for undercar and roof equipment.

2. It includes fasteners used on the side sill to attach heavy equipment brackets.

16.4.3.2 Material and Grade (or Property Class)

A. Comply with the following:

1. Structural or load-carrying bolts shall be medium carbon steel or stainless steel.

2. Inch (or metric) bolts and nuts shall conform to minimum requirements as indicated in Table 16-1, including markings. Stronger fasteners shall be used if required for the application.

3. Nuts shall have a material proof strength equal to or greater than the material ultimate tensile strength of the fastener with which it is used. For applications where this is not achievable, submit specific calculations showing that the nut is stronger than the bolt to prevent undetected internal thread stripping.

Table 16-1, Structural or Load Carrying Bolts: Minimum Grade

	Standard	Grade (Property Class)
Bolts	SAE J429 or ASTM A449 (ISO 898-1), Alloy group 1 condition CW1, property marking C.	5 (8.8)
Nuts	SAE J995 (ISO 898-2)	According to bolt strength

16.4.3.3 Minimum Size

A. Bolt diameter shall be minimum 3/8 in (10 mm), regardless of design load.

16.4.3.4 Required Documentation

A. Structural fasteners shall have documentation with the following information available for examination by SEPTA at the Contractor's QA department:

1. Identification of manufacturer

2. Location or country of manufacture

3. Purchase specifications

4. Fastener material or grade

5. Finish, including plating material and specifications, when applicable

6. Obtain and hold the documentation for a period not ending before expiration of the last car's warranty period, whether the buyer is a subcontractor, supplier, or the Contractor.

16.4.3.5 Additional Requirements for Safety-Related Fasteners

A. Comply with the following:

1. Scope:

a. Safety-related fasteners include, but are not limited to, those applied to carbody structure, trucks, bolsters, brake equipment, couplers, and power collection devices.

b. A fastener is safety related if failures cannot be tolerated; that is, if even a single fastener fails, there is a possibility of unacceptable failure, derailment, or accident, to be analyzed in FMECA.

2. Testing for Conformance to Purchase Specifications:

a. Have a representative sample of each production lot of fasteners tested for conformance to purchase specifications by an independent laboratory accredited by the American Association for Laboratory Accreditation (A2LA), or Approved equal.

b. A production lot is defined as one size of fastener, from one manufacturer, and produced during one continuous production run. Fasteners not meeting this definition of production lot shall be treated as separate lots.

c. Testing shall be performed using sample quantities as proposed by the Contractor and Approved.

d. Tests conducted shall confirm that fastener material meets specified chemistry and strength requirements.

e. Obtain certified test results from the testing laboratory and hold the documents for a period not ending before expiration of the last car's warranty period.

3. Testing for Hydrogen Embrittlement:

a. Safety-related fasteners that are plated or chemically cleaned shall have certification of hydrogen-embrittlement testing.

b. The certification shall be based on a representative sample of actual production fasteners or test pieces that have been tested by the original equipment manufacturer, Contractor, or a supplier for hydrogen embrittlement following SAE USCAR 7 procedures. The plating process shall be certified to ASTM F519 procedures.

c. An ASTM F606/F606M wedge-test sample may be used in place of the ASTM F519 standard samples.

d. Test loads shall be a minimum of 80% of ultimate tensile strength or 100% of proof load and held for a minimum of 168 hours. Any failures shall result in the rejection of the entire lot.

e. Obtain certified test results from the testing laboratory and hold the documents for a period not ending before expiration of the last car's warranty period.

4. Where applicable, safety related fasteners shall comply with all requirements of 49 CFR 231.

16.4.4 Self-Locking Nuts

A. Self-locking nuts (locknuts) shall be used throughout and shall comply with the following:

1. Type: Prevailing-torque, nylon-insert type, regular-height, self-locking elastic stop nuts.

2. Alternate type: All-metal; use only where there is insufficient clearance to install elastic stop nuts, or where the locknut is exposed to temperatures above manufacturer's recommended maximum temperature.

3. Standard: Conform to inch fastener standards found in ASME B18.16.6 or in NASM21044.

4. High Temperature: Nylon insert lock nuts shall not be used near heat sources that will exceed the locknut manufacturer's recommended maximum temperature.

5. Identification: Shall have identification markings for grade and source as defined in IFI-108.

6. Non-self-locking nuts with lock washers: Shall be used only in non-structural applications upon Approval, or where required by the Specifications.

7. Self-locking nuts shall be used only one time. If disassembled, the self-locking nut shall be replaced.

16.4.5 Washers and Retention Devices

A. Comply with the following:

1. Shall be suitable for the application and matched with the fastener grade (or property class) of the bolt with which it is used.

2. Where high-strength fasteners (above Grade 5 (Class 8.8)) are applied, washers shall be hardened and be in accordance with ASTM F436.

3. Washers shall comply with inch fastener standards found in the IFI Inch Fastener Standards Book (or ISO standards found in the Industrial Fasteners Institute (IFI) ISO Standards Handbook).

4. If used, lock washers, shall conform to ASME B18.2.6.

5. Use Requirements: Provide washers under the heads of all bolts and under all nuts.

6. Use Restrictions:

    a. Split-ring lock washers are prohibited except where Approved.

    b. Lock washers shall not be used in structural applications or in fatigue applications where the fastener must be torqued and marked. If applicable, prevailing torque nuts shall be used for these applications.

    c. Other types of washers, including Belleville washers, may be used for special applications with Approval.

7. If Approved, cotter pins shall be in accordance with ASME B18.8.1, extending prong type, and shall be plated. All other pins are subject to Approval.

8. Lock wire shall be Approved, shall be stainless steel or monel, shall meet the requirements of AIA/NAS NASM20995, and shall be one of the following diameters, 0.020, 0.032, or 0.041 in (0.5, 0.8, or 1.0 mm).

16.4.6 Coatings other than Zinc

A. Comply with the following requirements for alternate fastener coatings (other than zinc):

1. Alternate fastener coatings shall be RoHS compliant.

2. Alternate fastener coatings are permissible only if Approved. If Approved, they shall be qualified by testing per ASTM B117 with no red rust or visible corrosion products after 96 hours of exposure.

3. Test for hydrogen embrittlement in accordance with the Testing for Hydrogen Embrittlement paragraph in TS 16.4.3.5, as specified below:

    a. Fasteners less than Grade 5 (or Property Class 8.8): If the coating has the possibility of causing hydrogen embrittlement, each lot shall be tested for hydrogen embrittlement.

    b. Fasteners of Grade 5 (or Property Class 8.8) or higher: Each lot shall be tested for hydrogen embrittlement regardless of the coating's propensity for hydrogen embrittlement, including OEM plated zinc or yellow bolts.

4. If the proposed coating results in a change in the K-value for the plated fastener to outside the range of 0.13-0.15, as defined by IFI-543, comply with the following requirements:

    a. Use the alternate coating on all fasteners within the particular line replaceable unit (LRU).

    b. Provide an indelible label identifying the coating type used within the LRU and the required torque values for each size fastener used.

    c. Fasteners internal to a subcomponent within an LRU may use the standard coating if they are not subject to removal during maintenance activities.

16.4.7 Torquing

A. Comply with the following:

1. Specify fastener torque value on the Shop production and Assembly drawings.

2. Torque threaded fasteners to the value assigned by the designer or to standard torque values recommended by the fastener manufacturer as appropriate to the application.

3. Torque safety-related fasteners, including truck and brake equipment bolts and all fasteners exposed to fatigue loads, to a minimum preload equal to 75% of their proof load and "torque stripe" after torquing by paint, torque seal lacquer, or other Approved means.

4. Calculate fastener installation torque for standard oiled or waxed bolts with standard or heavy hex nuts from Industrial Fasteners Institute equations in "Torque Book for Fasteners." Use the following values for coefficient of friction, "K", unless another coefficient of friction was established during qualification of an alternate thread plating or coating:

    a. Unplated threads: K = 0.18

    b. Plated threads: K = 0.15

5. Torque self-locking nuts in accordance with their manufacturer's recommendations, or conduct tests to determine the proper installation torque.

6. Perform torquing only by calibrated torque wrenches.

7. For those nuts or bolts requiring "torque striping," SEPTA may require bolt torque-tension tests to verify that installed preload is equivalent to 75% of proof loads.

16.4.8 Other Fasteners

16.4.8.1 Quick-Release Fasteners

A. Quick release fasteners may be quarter-turn type or other types, as Approved:

1. Quarter-turn fasteners:

a. Shank diameter: Minimum 0.25 in (6.35 mm)

b. Strength: Adequate for the application

c. Manufacturer: Southco, or Approved equal

2. Head type: Philips, tamper-resistant, hex socket, or hex head.

16.4.8.2 Rivets and Lock Bolts/Lockpins (Huck Bolts)

A. Comply with the following:

1. Rivets and lock bolts/lockpins shall meet the following requirements:

a. Exposed to passengers: Austenitic stainless steel or aluminum as appropriate to the materials being joined.

b. Exposed heads: Concentric with the shank and free from rings, fins, pits, and burrs.

c. Structural steel rivets: Shall conform to ASTM A502 or ANSI B18.1.2.

2. Comply with the following requirements for installation:

a. Rivets:

(1) Driven hot: May be hand driven and shall completely fill the rivet holes.

(2) Driven cold: Shall be mechanically driven.

(3) Removed and replaced: Ream holes to the size required such that the next larger rivet may be driven securely.

(4) Blind rivets: May be used subject to Approval. Shall be stainless steel, or plated carbon steel with plated steel or stainless steel mandrels compliant with IFI-114 or Approved other standard.

b. Huck-bolt-type fasteners:

(1) Two-part swage-locking rivets, consisting of a pin and collar fasteners, shall conform to MIL-P-23469.

(2) Machine or grind smooth any rough surfaces of the collar ends accessible to passengers, crew, or maintenance personnel performing routine maintenance functions. SEPTA will make the

final determination whether surface is hazardous to maintenance personnel.

(3) Apply paint to the exposed end of shank after pin has sheared at collar.

16.4.9 Location- and Application-Specific Requirements

16.4.9.1 Interior - Exposed to Passengers

A. Comply with the following:

1. Install such that the fastener head is flush with the mating surface.

2. Match the surfaces being joined using bright or finished fasteners:

a. General use: Austenitic or plated martensitic stainless steel.

b. For stanchions: Austenitic grade stainless steel.

3. Use screws, bolts, and nuts only if Approved.

16.4.9.2 Exterior - Exposed to Passengers

A. Comply with the following:

1. Stainless steel carbody: Austenitic stainless steel.

2. Aluminum carbody: per TS 16.5.5.2.

16.4.9.3 Access Required

A. For access panels, equipment box covers, or other areas requiring access, comply with the following:

1. Fasteners shall be captive to the panel or cover in which they are used.

2. Where Operator or maintenance access is expected provide quarter-turn fasteners or similar quick-release fastener. Where greater clamping force is required, such as for EMI containment, alternate fasteners may be proposed.

3. Where accessible to passengers, tamper-resistant type fasteners shall be used, in compliance with the requirements of TS 16.4.2.2.

16.4.9.4 Heat Producing Equipment

A. When making connections to heat-producing apparatus, take into consideration the thermal expansion of the components for selection of fastener materials:

1. If the joined components are high-expansion alloys such as copper or austenitic stainless steel, use austenitic stainless steel fasteners.

2. If the joined components are low-expansion materials such as carbon steel or ferritic stainless steel, use zinc plated carbon steel fasteners of minimum Grade 5 (or Class 8.8).

3. Use only fasteners rated by fastener manufacturer for maximum ambient temperatures.

16.5 Metal

16.5.1 Stainless Steel

A. Mill Certification reports for all materials used in construction of the Carshell shall be provided. This applies to sub-suppliers and encompasses all possible material lots that have been utilized in the construction of all components of the Carshell. **(CDRL 16-07, Carshell Mill Certification Reports)**

16.5.1.1 Austenitic Stainless Steel

A. Comply with the following:

1. General requirements for delivery:

a. As required by the Certification Provisions of ASTM A666.

b. Structural applications: Test for susceptibility to intergranular corrosion in accordance with ASTM A262:

(1) Practice A: Shall be used to accept material only.

(2) Practice E: Required for final determination of acceptance or rejection of material that is not acceptable by Practice A.

2. Structural components assembled by fusion or resistance welding:

a. Specification and composition:

(1) AISI type 201L, 301L, 301LN or SUS301L (with Nitrogen), 316L.

(2) Conform to the requirements of ASTM A666 except that the carbon content shall not exceed 0.03% and type 301LN and SUS301L (with Nitrogen) shall not exceed 0.25% nitrogen.

b. Austenitic stainless steel used in structural applications covered by the Specifications shall also conform to paragraph (f) from Section 2 of AAR "Specifications for the Construction of New Passenger Equipment Cars" and APTA PR-CS-S-004-98.

3. Other stainless steels conforming to ASTM A666 are acceptable for non-welded applications.

4. Use:

    a. Comply with uses as permitted throughout the Specifications.

    b. Austenitic stainless steels may be unpainted.

    c. Unpainted austenitic stainless steels exposed to passengers shall be a single grade in which both the color and surface finish of abutting pieces shall match, except where the design specifically calls for contrasting appearance.

16.5.1.2 Ferritic Stainless Steel

A. Comply with the following:

1. General requirements: As specified in ASTM A480/A480M.

2. Used in welded construction:

    a. May be used only with Approval.

    b. Shall contain stabilizing element(s) to prevent sensitization during welding.

    c. When specified, ferritic stainless steel conforming to ASTM A240/A240M may be used for sheeting up to 0.2-in (5-mm) thickness.

    d. Base material shall have a ductile-to-brittle transition temperature (DBTT) or nil-ductility temperature (NDT) below 0°F (-18°C).

    e. Weld heat-affected-zones shall also have a DBTT or NDT below 0°F (-18°C).

    f. Shall have a balanced composition (low carbon and suitable titanium content) that will, for all conditions of fabrication and assembly into the carbody, inhibit formation of martensite and limit chromium depletion in weld heat-affected-zones, such that material meets ASTM A763 requirements for resistance to inter-granular corrosion.

    g. Where ferritic stainless steels are welded to other structural steels, the less-noble steel shall be painted with weld-through primer.

3. Use: Ferritic stainless steels shall be painted where exposed to passengers or the weather.

16.5.1.3 Duplex (Austenitic-Ferritic) Stainless Steel

A. Duplex stainless steel may only be used if the Contractor can demonstrate experience with its use in a service-proven passenger railcar design.

B. Comply with the following:

1. General requirements: As specified in ASTM A480/A480M.

2. Used in welded construction:

a. May be used only with Approval.

b. When specified, duplex stainless steel conforming to ASTM A240/A240M may be used for sheeting up to 0.2-in (5-mm) thickness.

c. Base material shall have a ductile-to-brittle transition temperature (DBTT) or nil-ductility temperature (NDT) below 0°F (-18°C).

d. Weld heat-affected-zones shall also have a DBTT or NDT below 0°F (-18°C).

e. Structural applications: Test for freedom from detrimental intergranular phases in accordance with ASTM A923.

(1) Test Method A (Etch Test for Rapid Screening): Shall be used to accept material only.

(2) Test Method C: Shall be used for final determination of acceptance or rejection of material that is not acceptable by Test Method A.

f. Duplex stainless steels may be unpainted.

g. Unpainted duplex stainless steels exposed to passengers shall be a single grade in which both the color and surface finish of abutting pieces shall match, except where the design specifically calls for contrasting appearance.

16.5.1.4 Stainless Steel Testing

A. Submit a test and inspection plan of stainless steel to be used in welded applications. **(CDRL 16-08, Stainless Steel Test and Inspection Plan)**

B. The tests and inspections shall verify that the stainless steel conforms to specified requirements.

16.5.2 High-Strength Low-Alloy Steel (HSLA)

A. Comply with the following:

1. Structural shapes, plates, and bars:

a. Shall comply with ASTM A588/A588M.

b. Plate steel: May alternatively conform to ASTM A710/A710M, Grade A, Class 1, 2 or 3.

c. Delivery: General requirements per ASTM A6/A6M.

2. Cold and hot rolled HSLA sheet and strip:

a. Minimum standard: ASTM A606/A606M, Type 4.

b. Delivery: General requirements per ASTM A568/A568M.

3. Welded HSLA steel: Shall develop 20 ft-lb (27.1 J) Charpy V Notch impact strength in the CGHAZ (Coarse grain heat affected zone 1 mm from fusion area) at -20°F (-29°C) or the lowest specified operating temperature.

4. Application:

a. HSLA steels shall be applied according to their specification properties.

b. Hot rolled or formed structural shapes conforming to ASTM A36/A36M may be used for non-structural applications, including equipment supports, jack pads, and clip angles.

c. The Contractor may propose for Approval the use of alternative HSLA steels for structural applications in which corrosion resistance properties may be deemed unnecessary.

5. Testing:

a. Submit a test and inspection plan for acceptance of structural steels in accordance with the requirements of this Section. **(CDRL 16-09, HSLA Steel Test and Inspection Plan)**

16.5.3 Steel Castings

16.5.3.1 General

A. Comply with the following:

1. Contractor is responsible for selecting casting grade, composition, strength, heat treatment, finishing, and design best suited for the intended application.

2. Marking: Apply pattern and serial numbers in a manner that does not impair their strength.

3. Disposal of Non-Conforming Castings: If castings are found to be non-conforming to requirements determined by the design qualification castings, the material shall be repaired, retested, and re-inspected or destroyed at the Contractor's expense.

16.5.3.2 Design Qualification

A. Comply with the following:

1. Before castings are produced: Required acceptance levels for the design qualification radiographic examinations are given in TS 16.5.3.3. Any deviations from those requirements are subject to Approval.

2. Steel castings used in the carbody structure and truck assemblies shall meet AAR Specification M-201, latest revision, Grade "B." These castings shall be heat treated to develop a minimum tensile strength of 75,000 psi, a minimum yield strength of 48,000 psi, elongation of not less than 25 percent in two inches, and reduction of area of not less than 50 percent. Also, steel castings used for coupler, drawbars, and anchors shall meet AAR Specification M-201, latest revision, grade "C" or "E" quenched and tempered.

3. Qualification Test:

a. Conduct on one casting selected by SEPTA from the first lot of production castings to test the casting design:

(1) Perform radiographic examination to determine material soundness using reference radiographs to ASTM E446, and mechanical testing, as required.

(2) Radiographs shall meet the requirements of ASTM E94/E94M and ASTM E1030/E1030M and the quality level in the area of inspection shall be at least 2% (2-2T).

(3) Radiographs resulting from the Qualification Test shall be made available to SEPTA for review.

b. Submit a Qualification Test report **(CDRL 16-10, Steel Casting Qualification Test Report)**.

4. After Qualification: Once a design is qualified and accepted by SEPTA, no changes shall be made in the casting pattern, technique, heat treatment, or material composition without re-qualification in accordance with the requirements of this Section.

16.5.3.3 Quality

A. Comply with the following:

1. Structural castings shall be equal to or better than the design qualification castings in all respects.

2. Test, inspect, and accept castings in accordance with procedures described in AAR M-201.

3. Perform the inspections below and furnish a test report for each lot of castings produced:

a. Magnetic particle inspections:

(1) Conduct on all surfaces of each casting according to ASTM E709. Testing personnel shall be certified to NAS 410.

(2) For structural castings, including coupler castings, the maximum permissible magnetic particle indications shall be 0.25 in (6.35 mm) in the direction transverse to the usual direction of loading, and 0.75 in (19 mm) in the direction parallel to the usual direction of loading.

4. Radiographic inspection:

a. Conduct according to ASTM E94/E94M and ASTM E1030/E1030M, using reference radiographs to ASTM E446.

b. Propose a sampling frequency and submit **(CDRL 16-11, Steel Castings Radiographic Inspection Sampling Frequency)**.

5. Radiographic inspection of structural castings:

a. Shall not exceed Severity Level 3 of ASTM E446 in critical areas and shall not exceed Severity Level 5 in other areas of the castings.

b. During demonstration that the stated severity level requirements of ASTM E446 have been met, re-inspect successively-produced castings by radiography in the defective areas shown in the prior radiographic inspection.

c. Sampling frequency:

(1) After severity levels have been proved, 1 casting out of each 10 produced.

(2) If no castings are rejected by radiographic inspection, 1 casting in 25.

(3) Unacceptable castings found during sampling shall require 100% inspection of other castings from the lot/heat, or before and after in sequence (if sequentially cast) until the extent of the unacceptable condition(s) is determined.

(4) If the reason for the failure has been isolated, based upon SEPTA review, sampling may return to 1 casting in 10, and then, if no failures are found, to 1 in 25.

6. To control the internal solidity of the couplers, yokes, and knuckles castings, the sectioning method defined in the AAR M-211 Standard (Section 4, Coupler and Drawbar) shall be used instead of doing radiographic inspection. The control plan for casting internal solidity shall be as follows:

   a. Capability of meeting internal solidity requirement shall be established at the beginning of production and every six months thereafter by sectioning three specimens from each design group listed in paragraph 4.2.1 of standard AAR M-211. Each specimen shall be from a different heat. However, if any design group production is less than 1,000 during this frequency period, no test is required. In any case, at least one test is required per year for each design group. After two years of successful sectioning results, the manufacturer may reduce the frequency of sectioning to one casting each year per design group. Castings will also be sectioned whenever significant changes are made in foundry practices. If a test fails, the manufacturer will be required to reestablish the base of two years of successful tests before going to the reduced frequency of testing.

   b. Note: The solidity test shall be performed as per Standard AAR-211, Sections 4.2.3.2, 4.2.3.3, and 4.2.3.4. The inspection method for this test shall be as per AAR M-211 by comparison with acceptance criteria of paragraph 4.2.3.5 where the "F" type criteria shall apply for the coupler head, coupler shank, and yoke, and the "E" type criteria shall apply for the knuckle.

   c. Fracture toughness tests and other tests on coupons shall be done once every two months as per AAR M-211 Section 4.3.

   d. Visual inspections on all couplers, knuckles, and yokes shall be done. Acceptance criteria shall be per AAR M-211 Section 13.2.

   e. Hardness tests on each heat lot shall be done for couplers, yokes, and knuckles as per AAR M-211 Section 4.3.

   f. Dimensional checks shall be performed on each piece with AAR gages.

16.5.3.4 Specific Applications

A. Comply with the following in the specified application:

1. Truck and carbody structures:

a. Meet AAR M-201.

b. Heat-treat castings to develop the following:

(1) Minimum tensile strength: 75 ksi (517 MPa)

(2) Minimum yield strength: 48 ksi (331 MPa)

(3) Elongation: Minimum 25% in 2 in (51 mm)

(4) Reduction of area: Minimum 50%

2. Truck side frames and bolsters:

a. Comply with the referenced standards:

(1) Bolsters: AAR M-202

(2) Side frames: AAR M-203

3. Coupler, drawbars, and anchors: Meet AAR M-201, Grade "C," quenched and tempered.

4. Cast steel to ASTM A27/A27M, grade 65-35, plus 2% Ni, may be used for truck structure, bolster and center bearing arrangements as an alternative to the AAR M-201 material specified above.

5. Material meeting other specifications than those stated above can be proposed for Approval, though such Approval (if given) will not absolve the Contractor from meeting the other stated requirements for these materials.

16.5.3.5 Repair Welding and Cast-Weld Design

A. Comply with the following:

1. Welding of castings:

a. Permitted, provided the casting supplier performs repair welds in accordance with an Approved written procedure and uses welders qualified to ASTM A488/A488M or AWS D15.1/D15.1M.

b. Castings requiring repair or modification by welding after completion of heat treatment may be stress relieved locally by using electrically controlled heating to not greater than 1,150°F (621°C), followed by slow cooling. Manual torch stress relief shall not be permitted.

2. For cast-weld designs, the entire length of all assembly welds on any welded assembly of several separate castings selected for design qualification shall be radiographically inspected to ASTM E94/E94M using reference radiographs from ASTM E390.

16.5.4 Steel Forgings

16.5.4.1 General

A. The Contractor is responsible for selecting forging material grade, composition, strength and finishing that will meet the intended application.

B. Forgings not welded shall have adequate toughness for their intended application.

16.5.4.2 Steel Forgings

A. Steel forgings shall comply with requirements of ASTM A668/A668M, or as proposed by the Contractor and Approved.

16.5.4.3 Specific Applications

A. Comply with the following in the specified application:

1. Steel forgings used for axles shall conform to ASTM A729/A729M or AAR M-101.

2. Steel forgings used for wheels shall conform to ASTM A504/A504M, AAR M-107/208 or APTA PR-M-S-012-99 with residual element limits as specified in AAR M-107/208.

3. Steel forgings used for the truck structure, bolster, center-bearing arrangement or carbody structure shall be weldable and shall meet the impact properties specified in TS 16.5.3.4, for welded steel structure at the lowest specified operating temperature.

16.5.4.4 Design Qualification of Structural Forgings

A. Perform a qualification test of the forging design on one forging, selected by SEPTA from the first lot of production forgings.

1. Qualification tests shall include section and etching for verification of flow pattern, magnetic particle examination for surface imperfections of all surfaces, and radiographic examination for internal soundness.

2. Mechanical testing shall include static and fatigue load testing, as appropriate for the intended usage.

3. Acceptance levels for the design qualification radiographic examinations shall be selected by the Contractor as appropriate for the service intended, subject to Approval before additional forgings are produced.

4. Radiographs shall meet the requirements of ASTM E94/E94M and the quality level in the area of inspection shall be at least 2% (2-2T).

5. Submit a qualification test report. **(CDRL 16-12, Structural Forgings Design Qualification Test Report)**

    a. The production of any forgings before receipt of Approval of this report shall be at the Contractor's risk.

    b. All radiographs that resulted from the qualification test shall be made available to SEPTA for review.

6. Once a design is qualified and accepted by SEPTA no changes shall be made in the forging dies, technique, heat treatment, or material composition without re-qualification in accordance with the requirements of this Section.

16.5.4.5 Quality of Structural Forgings

A. All forgings supplied shall be equal to or better than the design qualification forgings in all respects. The forging supplier or Contractor shall test, inspect, and accept forgings in accordance with an Approved written process. A written report of the results of the tests and inspections shall be furnished for each lot of forgings produced.

16.5.5 Aluminum

16.5.5.1 General Requirements

A. Aluminum shall comply with the following:

1. Aluminum-alloy mill products:

    a. Shall be identified by designations prescribed by the Aluminum Association.

    b. Shall conform to specifications contained in the Aluminum Association's publication "Aluminum Standards and Data."

2. Finish: Shall be painted or powder coated, and may also be anodized.

3. Fabrication: such that the strength and corrosion resistance of the aluminum shall not be impaired, nor the surface finish permanently marred or discolored during construction.

4. Conform to the requirements of ALCOA Technical Report No. 524, "Specification Covering Use of Aluminum in Passenger Carrying Railway Vehicles," except as otherwise specified.

5. The use of aluminum for door thresholds is prohibited.

16.5.5.2 Connections to Aluminum

A. Take specific measures, based on a suitable method that can be adapted to the design involved, to prevent the risk of direct metal-to-metal contact and resultant possible galvanic or electrolytic corrosion. The measures shall be included in the Corrosion Control Plan and Approved.

B. Comply with the following minimum requirements for connections to aluminum unless they conflict with recommendations by the aluminum manufacturer:

1. Provide protection at the contact surface of connections to aluminum.

2. Carbon steel fasteners (including washers and nuts):

a. Shall be zinc plated.

b. Zinc primer or zinc-chromate paste shall be applied on the faying surface. The head and unthreaded portion of the shank of the bolt shall be in contact with the aluminum part when secured in place, where possible. Suitable bushings may be used in place of zinc chromate paste or primer.

C. Comply with the following requirements for connections to aluminum alloy:

1. Surfaces shall not be secured to, nor make direct contact with the surfaces of

a. Wood; or

b. The following metals:

(1) Copper or copper bearing aluminum alloy

(2) Brass or bronze

(3) Silver

(4) Nickel and nickel plated parts or nickel alloys

(5) Tin

(6) Ferrous materials.

2. Aluminum alloy to aluminum alloy: Surfaces of parts shall be protected by painting with zinc chromate primer before securing.

3. Aluminum alloy to steel: Surfaces of parts shall be protected as follows:

a. With a one-part polysulfide sealant.

b. Alternatively, use an Approved insulation joint material, such as mica, that completely covers the faying surfaces. The material shall be non-hygroscopic and, if fibrous, shall be impregnated with bitumen or some other Approved water and moisture-repellant substance.

c. Prime and paint fasteners with red oxide or aluminum paint after installation.

d. Rivets driven hot may be considered as covered by a protective oxide coating due to the heating, but the method of riveting shall, if possible, always be with the formed rivet head in contact with the aluminum alloy.

4. Aluminum alloy with stainless steel or zinc plated carbon steel fasteners. Surfaces shall be protected as follows:

a. Shall be coated with zinc chromate paste or Approved equal before installation.

b. Where possible, only the head and shank of the bolt shall be in contact with the aluminum part when secured in place.

c. Suitable Approved bushings may be used in place of the zinc-chromate paste.

16.5.5.3 Specific Applications

A. Comply with the following in the specified application:

1. Aluminum extrusions: Shall conform to ASTM B221

2. Interior Trim: Where unpainted aluminum is exposed to contact by passengers, it shall have a clear (natural) anodic finish. The finish process shall be Type-II anodic coating followed by nickel acetate sealing with a minimum coating thickness of 0.0004 in (0.01 mm) and a minimum coating weight of 21 mg/in² (3.3 mg/cm²), or Approved equal process.

16.5.5.4 Design Qualification

16.5.5.4.1 Aluminum Castings

A. Comply with the following:

1. Qualification Test:

a. Conduct on one casting selected by SEPTA from the first lot of production castings to test the casting design:

(1) Perform radiographic examination to determine material soundness using reference radiographs to ASTM E155, and mechanical testing, as required.

(2) Radiographs shall meet the requirements of ASTM E94/E94M and ASTM E1030/E1030M and the quality level in the area of inspection shall be at least 2% (2-2T).

(3) Radiographs resulting from the Qualification Test shall be made available to SEPTA for review.

(4) Perform liquid penetrant examination of all surfaces for imperfections to the requirements of ASTM E165.

b. Submit a Qualification Test report. The production of any parts before receipt of Approval of this report shall be at the Contractor's risk.

2. After Qualification: Once a design is qualified and accepted by SEPTA, no changes shall be made in the casting pattern, technique, heat treatment, or material composition without re-qualification in accordance with the requirements of this Section.

16.5.5.4.2 Aluminum Forgings and Extrusions

A. Comply with the following:

1. Qualification Test:

a. Conduct on one of each forging or extrusion design selected by SEPTA from the first lot of production pieces to test the design, with requirements as appropriate for the design, with the minimums per below and subject to Approval

(1) Perform section and etching for verification of flow pattern to the requirements of ASTM E340.

(2) Perform liquid penetrant examination of all surfaces for imperfections to the requirements of ASTM E165.

(3) Radiographic examination or ultrasonic examination for internal soundness to the requirements of ASTM E94/E1742 or ASTM B594; the quality level in the area of inspection shall be at least 2% (2-2T).

(4) Perform static load testing to the requirements of ASTM B557.

(5) Submit for approval fatigue load testing, as appropriate for the intended usage.

(6) Radiographs resulting from the Qualification Test shall be made available to SEPTA for review.

b. Submit a Qualification Test report. The production of any parts before receipt of Approval of this report shall be at the Contractor's risk.

2. After Qualification: Once a design is qualified and accepted by SEPTA, no changes shall be made in the forging dies, technique, heat treatment, or

material composition without re-qualification in accordance with the requirements of this Section.

16.5.5.5 Quality

A. All aluminum castings, forgings, and extrusions supplied shall be equal to or better than the design qualification part in all respects. The supplier or Contractor shall test, inspect, and accept parts in accordance with an Approved written process. A written report of the results of the tests and inspections shall be furnished for each lot produced.

B. Testing of structural castings shall conform to ASTM B26, ASTM B85, or ASTM B108 for, respectively, sand, die, or permanent mold castings.

C. Should repair welding of castings be deemed necessary and Approved, heat treated aluminum castings shall be repaired before heat treatment or fully heat treated after repair.

16.5.5.6 Aluminum Testing

A. Submit a test and inspection plan for acceptance of structural aluminum in accordance with the requirements of this Section. The plan shall include qualification testing, mill certification testing, routine testing, and quality inspection plans. **(CDRL 16-13, Aluminum Test and Inspection Plan)**

16.6 Welding and Brazing

16.6.1 General

16.6.1.1 Scope

A. This section applies to welding and brazing performed on car structural elements and on equipment and subsystems provided for use on the car, unless waived by SEPTA.

16.6.1.2 Quality

A. Control the quality of welding and brazing, including that performed by subcontractors.

B. Cleaning prior to welding shall be in accordance with applicable parts of MIL-HDBK-132, Section 2, "Protective Finishes" or EN 15085 or AWS D.1.1.

C. Before performing work under this Contract, welders shall be tested to confirm their ability to operate the welding equipment and to make the types of welds required by the design or this document.

16.6.2 Welding and Brazing Prohibitions

A. The following weld process and material restrictions shall apply in car structure welding:

1. High-iron-powder flux-type rods such as E6024, E7024 and rods known as "jet rod" may not be used.

2. Galvanized steel shall not be welded to stainless steel.

3. Brazing shall not be used to join stainless steel to itself or to other metals unless Approved.

16.6.3 Welding

16.6.3.1 Alternative Welding Standards

A. Alternative EN welding standards can be used in leu of the following AWS requirements if equivalency is proposed by the Contractor and Approved.

16.6.3.2 Structural Welding

A. Comply with the following:

1. Structural welding practices not specifically covered in other sections of the Specifications shall be in accordance with the following AWS standards. Requirements for cyclically loaded structures shall be applied:

a. AWS C7.4/C7.4M

b. AWS D1.1/D1.1M, for steel 1/8 in (3 mm) and thicker

c. AWS D1.2/D1.2M

d. AWS D1.3/D1.3M, for steel thinner than 1/8 in (3 mm)

e. AWS D1.6/D1.6M

f. AWS D15.1/D15.1M

g. AWS D17.2/D17.2M, for resistance welding

h. AWS Welding Handbook

2. The use of laser welding shall be supported with the appropriate design and process control documentation, and shall be subject to Approval.

a. Prior to conducting any AWS C7.4/C7.4M Procedure Qualifications, submit for Approval the tests that are proposed for those qualifications and the technical justification for those tests.

b. If laser welding is used in place of resistance weld connections, the static and fatigue strength of the laser welds shall be equal to or better than the resistance welds.

3. Structural welding of stainless steel by the fusion-arc process shall be governed by the following standards:

   a. AWS D15.1/D15.1M

   b. AWS D1.6/D1.6M

   c. ASME BPVC, Section IX

   d. ASME BPVC, Section VIII-1, Part UHA, "Requirements for Pressure Vessels Constructed of High Alloy Steel"

4. Other requirements:

   a. AISI 201L and 301LN stainless steels shall be treated as P-No. 8, Group-No. 3 category for reference to ASME BPVC requirements.

   b. Weld heat-affected zones (HAZ) and weld metal shall be limited to maximum allowable stress values in ASME BPVC, Section VIII-1, Table UHA-23 for UNS S20100 stainless steel and Table UW-12 rating of welds, regardless of strength level of the base metal.

   c. Ferrite number for welds shall be between WRC 4 and WRC 10, or as proposed by the Contractor and Approved.

   d. Procedure Qualification Records (PQRs) for dissimilar metal, steel-to-stainless welds shall include a microhardness profile traversing both HAZs, to demonstrate that the hardness does not exceed 400 HV (also known as Vickers or Diamond Pyramid Hardness (DPH)) on either side of the weld.

5. Additional information on definitions, processes or other questions pertaining to welding shall be referred to the AWS Welding Handbook.

6. The use of AWS-B2.1 shall not be permitted and shall not be included or referenced in Welding Procedure Specifications (WPS) and Procedure Qualification Records (PQR).

16.6.3.3 Welding Procedure Qualification

A. Comply with the following:

1. WPSs shall be qualified by the Contractor, accompanied by procedure qualification records (PQRs) containing welding test results, and subject to Approval. Submit WPSs along with PQRs. **(CDRL 16-14, Welding Procedure Qualification)**

2. Use of prequalified WPSs is prohibited unless Approved.

3. WPSs shall be identified on shop drawings or traceable on a weld map.

4. Perform general welding, not specified elsewhere, in accordance with the standards of AWS D1.1/D1.1M and AWS D15.1/D15.1M.

16.6.3.4 Welder Qualification and Identification

A. Comply with the following:

1. Welders shall make only those welds for which they have been qualified in accordance with the following:

a. Requirements for welder qualification found in the appropriate AWS code or standard, or ASME BPVC, Section IX.

b. As an alternative, the requirements of the applicable standards in the ISO 156xx series, except that SEPTA may enforce AWS or ASME requirements at its discretion if the alternate standards are more permissive.

2. Records of welder qualification tests shall be made available for review upon SEPTA's request.

3. Stamp carbody critical welds, as defined in Section 3, Carbody, with an identifying symbol that can be traced to the welder who performed the work.

4. For trucks, a means shall be provided by the truck manufacturer to positively identify the work of each welder.

16.6.3.5 Weld Type Requirements

A. Comply with the following:

1. All WPSs shall be qualified to the requirements of AWS D1.1/D1.1M:2020, Clause 6, AWS D1.3/D1.3M:2017, Clause 6, or AWS D1.6/D1.6M:2018, Clause 6, as applicable for the steel type. AWS D15.1/D15.1M:2019 Clause 10 (plate) or Clause 18 (sheet) may also be used for procedure qualification.

2. Complete Joint Penetration (CJP) welds:

a. Shall be required for all structural welds, unless otherwise Approved.

b. Shall conform to the prequalified joint details of AWS D1.1/D1.1M for CJP welds.

c. Shall be evaluated for static or fatigue stress or both using the allowable stresses of the appropriate welding code clauses (from AWS D1.1/D1.1M or D1.6/D1.6M) applying to CJP weld categories.

3. Partial Joint Penetration (PJP) welds:

    a. May be used where CJP welds are not required, with Approval.

    b. Shall conform to the prequalified joint details of AWS D1.1/D1.1M for PJP welds.

    c. Shall be evaluated for static or fatigue stress or both using the allowable stresses of the appropriate welding code clauses (from AWS D1.1 or D1.6/D1.6M) applying to PJP weld categories.

4. Fillet welds:

    a. May be used only as permitted by Sections 3, Carbody, and Section 11, Trucks, and with Approval.

    b. Shall be evaluated for static or fatigue stress or both using the allowable stresses of the appropriate welding code clauses (from AWS D1.1 or D1.6) applying to fillet weld categories.

    c. Intermittent weld spacing shall not exceed 5 in (127 mm) for 2 in (51 mm) weld length (40% minimum). Exceptions to avoid warping in thin sheets will be considered, but shall be Approved.

16.6.3.6 Weld Inspection

A. Comply with the following:

1. Visually inspect each structural weld in accordance with the referenced AWS requirements, using personnel meeting the AWS requirements:

2. First production welds:

    a. Inspect visually in accordance with the specified AWS welding code requirements.

    b. Inspect by nondestructive surface inspection methods (dye penetrant or magnetic particle, as appropriate and Approved), regardless of whether the assembly was presented for First Article Inspection.

3. For complete joint penetration (CJP) welds, comply with the following:

    a. On the first structure, inspect nondestructively, volumetrically all CJP welds (ultrasonic or radiographic methods), according to the applicable code or standard.

    b. For subsequent CJP welds, submit a random sampling plan for volumetric inspection. (**CDRL 16-15, Production Weld Inspection Plan**)

c. The weld sampling plan shall constitute not less than 1 ft (305 mm) in 200 ft (61 m) of weld length.

(1) The proposed test welds shall be selected from among welds that are most critically loaded as decided by calculations or load test results.

(2) With Approval, destructive sectioning and metallurgical examination may be substituted for some or all of the required volumetric inspection requirements for production welding.

4. Partial joint penetration (PJP) and fillet welds may be used in the design only with Approval.

a. On the first structure, inspect all PJP and fillet welds visually and with surface NDT methods (magnetic particle, liquid penetrant, or Approved alternative).

b. Submit a sampling plan for production PJP and fillet welds. **(CDRL 16-16, Production PJP and Fillet Weld Sampling Plan)**

5. If ring welds are used, on the first structure, inspect all ring welds nondestructively by magnetic particle or dye penetrant methods, in addition to visual inspection.

a. Submit a random sampling plan for additional nondestructive examinations of ring welds for Approval as part of the Weld Inspection Plan.

b. The minimum acceptable sampling plan shall require inspection of one ring weld sample for every 300 production ring welds made. **(CDRL 16-17, Ring Weld Sampling Plan)**

16.6.3.7 Weld Cleaning Requirements

A. All welds, regardless of their location, shall be cleaned and free of flux residue, spatter, slag, or other debris that may impair the function or appearance of the welded area.

B. Heat tint on stainless steel welds not exposed to passenger view need not be removed.

16.6.3.8 Welding Rod or Wire

A. Comply with the following:

1. Purchase to AWS specifications.

2. Where special materials are required that are not covered by these or other applicable AWS welding material specifications, submit the purchase specifications for Approval.

3. Purchase welding filler materials in packages of convenient size, marked with the manufacturer's name and the specification, diameter, and net weight of the material.

4. Store the material in accordance with referenced AWS recommendations to protect it from damage, and so that it can be easily identified.

5. Issue and handle material in such a way as to prevent it from being mixed with that of another filler metal type and specification.

16.6.3.9 Special Welding

A. Comply with the following:

1. Submit procedures for structural welding of stainless steel to HSLA, or other combinations of metals or conditions not covered by AWS specifications or codes, for Approval.

2. Use austenitic stainless steel electrodes or wire (typically 309L or 312) to join carbon or HSLA steels to stainless steels.

16.6.3.10 Resistance Welding

A. Comply with the following:

1. Weld stainless or carbon steels in accordance with AWS D17.2/D17.2M:

a. Structural applications: Class B

b. Non-structural applications: Class C

2. Obtain Approval for desired deviations from AWS D17.2/D17.2M including, but not limited to weld nugget diameter, tension shear strength, and minimum spacing, before inclusion in the design or in production procedures.

3. Submit welding machine qualification records and welding procedure schedule certifications. **(CDRL 16-18, Welding Machine Qualification Records and Welding Procedure Schedule Certifications)**

4. Control current, time, electrode size, shape, and tip force to produce uniform welds of specified strength that are not subject to intergranular stress-corrosion cracking.

5. Arrange welds to avoid tension or "peeling" forces on the welds under anticipated loading condition.

6. Surface indentation:

a. Not exposed to passenger view: Maximum 20% of material thickness (t) or 0.01 in (0.254 mm), whichever is greater

b. Exterior areas exposed to passenger view: Maximum 10% of t or 0.005 in (0.127 mm), whichever is greater.

7. Remove surface burn and discoloration by an Approved method.

16.6.3.11 Resistance, Spot Weld and Intermittent Weld Spacing

A. Spacing of resistance and spot welds shall be appropriate to the design:

1. Structural applications: Maximum spacing shall be 44t, but not to exceed 2 in (51 mm) plus twice the weld nugget diameter for any structural application, including carbody side sheets, where "t" is the thickness of the thinnest outside sheet being welded.

2. Non-structural applications: Maximum weld spacing shall be 60t, but not to exceed 3 in (76 mm) plus the weld nugget diameter.

16.6.3.12 Toughness of Welded Assemblies

A. Prove that all safety-related welded structures have adequate toughness for the specified environmental exposure, including, but not limited to end underframes, fabricated truck frames and bolsters, and welded coupler components:

1. Weld heat affected zone (HAZ) and base metal shall resist service impact loads at the lowest specified operating temperature.

2. Criteria for acceptance, if other than as specified, shall be shown by the Contractor to be adequate.

3. Charpy V-notch specimen impact value: Shall meet the minimum requirements specified in TS 16.5.2, in the absence of prior operating history, and if no analysis requires greater toughness.

16.6.4 Torch Brazing

A. Comply with the following requirements for brazing (above 840°F (449°C)):

1. Follow the recommendations in AWS Welding Handbook, Volume 2.

2. Qualify procedures and personnel in accordance with AWS B2.2/B2.2M.

3. Brazed joints shall present a workmanlike appearance in accordance with AWS C3.4M/C3.4.

4. Protect inner surfaces of air conditioning tubing from oxidizing contaminants during and after brazing operations.

16.6.5 Torch Soldering

A. Comply with the following requirements for soldering (below 840°F (449°C)):

1. Follow the recommendations in the AWS Welding Handbook, Volume 2.

2. Qualify procedures and personnel through preparation and testing of samples, as follows:

a. Copper Piping into Fittings:

(1) Each worker designated to perform this work shall prepare three copper piping connections in the vertical position.

(2) The sample joints shall present a smooth, consistent appearance, without excess solder reinforcement.

(3) Each joint shall be pressure tested using a water or air subsystem to confirm that it is leak-free.

b. Stainless Steel Lap Joints (Trim Seams):

(1) Each worker designated to perform this work shall prepare one typical trim seam sample, using the same stainless steel materials, finish, and thicknesses as used on the actual car.

(2) The seam for evaluation shall be minimum 36 in (914 mm) in length, and shall be set up in the horizontal position during soldering.

(3) Specimen width shall be selected, or the test setup arranged, so that premature overheating of the joint does not occur.

(4) Finished samples shall be saw-cut into four pieces so that eight cross-sections of the joint may be examined.

(5) Exposed solder surfaces shall display a uniform, smooth contour and shall meet or exceed all applicable AWS quality standards.

16.6.6 Welding Terms, Symbols and Definitions

A. Welding terms and definitions shall be as determined in AWS A3.0M/A3.0 unless otherwise Approved.

B. Weld symbols shall be in accordance with AWS A2.4 unless otherwise Approved. The fabrication drawings shall show the applicable welding symbol and identify which WPS is used to make the weld.

16.7 Elastomers

16.7.1 General

A. Comply with the following:

1. Elastomeric parts shall be of neoprene, or Approved equal, unless otherwise specified.

2. The elastomer shall be compounded and cured to perform satisfactorily in the temperature range specified in Section 2, Design and Performance Criteria.

3. The elastomers shall have high resistance to ultraviolet radiation, weather, all SEPTA car washing fluids, and the longest possible life consistent with the other characteristics specified. Elastomeric parts shall be resistant to ozone, oxidation, heat, oil, grease, and acid.

16.7.2 Application-Specific Requirements

16.7.2.1 Neoprene

A. The following elastomeric parts shall be of neoprene unless otherwise specified or Approved:

1. Door Seals

2. Door Nosing

3. Isolation Tapes/Pads

4. Other parts exposed to the outdoor ambient environment, except where otherwise specified.

5. Seals:

a. Glazing strips shall be of neoprene conforming to ASTM C542, or Approved equal material.

b. For door mating edges, door and window seals, and glazing strips, the durometer hardness shall be 70, +/- 5, measured with a Shore Type "A" durometer at a temperature between 70°F and 90°F (21°C and 32°C).

16.7.2.2 Natural Rubber

A. The following elastomeric parts shall be of natural rubber unless otherwise specified or Approved. The individual component manufacturers shall specify the recommended shelf life of their product(s), subject to Approval.

1. Resilient mounts and elastomeric truck components shall be of natural rubber. Synthetic rubber compounds may be substituted for natural rubber only when Approved for a specific application.

2. Truck bumpers, snubbers, and the exterior surfaces of air springs shall be made of natural rubber or Approved equal. They shall be compounded to be resistant to abrasion, oil, grease, and acid.

16.7.3 Tests

A. All tests shall be conducted according to the latest revisions of the specified ASTM test procedures, unless otherwise specified.

B. Test resilient, natural rubber mounts and elastomeric truck suspension components in accordance with the flammability, smoke emission, and toxicity testing requirements of Section 23, Safety and Security, and submit the results under Section 23.

1. The performance of only these truck suspension elastomers will not be bound by the Flammability and Smoke Emission performance requirements for elastomers.

2. See Section 15, Test Program, for testing requirements.

16.7.4 Life Expectancy

A. For all parts made by vulcanizing an elastomer to metal, any premature failure (less than 7 years) between metal and the elastomer or in the elastomer, occurring when the parts are used in normal service (as expected from the duty cycles specified in Section 2, Design and Performance Criteria) and according to the provisions of the Specifications, shall be considered as having been caused by defect of materials or workmanship.

16.7.5 Metal Parts

A. Metal parts to which elastomeric material is vulcanized shall be made of SAE 1020 or SAE 1045 hot-rolled steel except for brass or brass alloys internal air brake components or as otherwise Approved.

16.7.6 Bonding

A. Joining of elastomeric pieces shall be done by the hot vulcanization process. Bonding of elastomers shall not be allowed unless the Contractor submits the application, bonding procedure, and bonding agent technical data for Approval prior to the purchase of materials.

16.8 Glazing Materials

16.8.1 Safety Glass

A. Safety glass shall meet the requirements of ANSI Z26.1, Table 1, Item 1.

B. Laminated safety glass used in the F-end of the car, including that in the end door, shall be certified as having been tested and having met the 49 CFR 223 and 238 FRA Type I requirements. Side window and non F-end glazing shall meet 49 CFR 223 and 238 FRA Type II requirements and ANSI Z26.1. Requirements for specific window types can be found in Table 14-1, Window Characteristics.

16.8.1.1 Type

A. Safety glass shall be of the laminated sheet type and shall consist of a minimum of two sheets of glass bonded with an Approved interlayer of plasticized polyvinyl butyral resin in the form of a membrane approximately 0.045 in (1.1 mm) thick, and resistant to degradation from ultraviolet or visible light and heat.

16.8.1.2 Quality

A. Safety glass shall meet the following requirements:

1. Flatness: When an individual piece of glass is laid on a truly flat surface, such as a surface plate, the glass shall not indicate a bow of more than 0.030 in (0.8 mm) per linear foot (305 mm).

2. Dimension Tolerance: The overall dimensions of individual pieces as supplied shall be held within 0.060 in (1.5 mm) of the dimensions ordered.

3. Overlap Tolerance: The overlap of one laminate of the piece with respect to the other, at an edge, shall not exceed 1/32 in (0.8 mm). Corners and burrs shall be ground smooth, and all edges treated in accordance with SAE J673, Edge No. 4.

4. Color: The color of the glass shall be as required by Section 14, Interior and Exterior Appointments. When new, there shall be no more than +/- 4% variation in the color of individual pieces of laminated sheet glass when examined over a white background.

5. Haze: All the laminates of the safety glass shall be so nearly free from haze that the glass shall have approximately the same clarity as a piece of the same nominal thickness of plate glass when viewed against a north light.

6. Specks and Scratches: Occasional specks of foreign material and scratches are permissible, provided such specks do not exceed 0.020-in (0.5 mm) in greatest dimension, a maximum of 0.75 in (19 mm) in length, and scratches do not exceed a total sum of 3 in (76 mm) in length and neither are within the central three-quarters area of the light.

7. Optical Quality: Shall be in accordance with ANSI Z26.1, Test No. 15, Article 5.15.2.2. Under the specified procedure, no light or dark patches shall appear in the shadow of the unmasked area of the specimen before the specimen shall have been moved a distance of at least 14 in (356 mm) from the screen. Protective covering shall be marked to permit orientation of extrusion grain horizontal to the installed light.

8. Bond Separation: The bond between two sheets of glass and the membrane shall be of such quality that when the glass is broken by twisting or by direct impact, there will be no separation between the glass sheets. Lights that contain unbonded areas ("let-go's") shall not be used.

16.8.1.3 Marking

A. All safety glass shall be marked with proper identification in accordance with ANSI Z26.1, and appropriate FRA-Type designation per 49 CFR 223 and 238 by the supplier. The identification marking legible 0.10 inch high lettering shall be located in the lower right hand corner as viewed from the interior of the car. The identification shall be no closer than 3/4 inch to the edge. The identification shall give the product name, manufacturer, serial number, and FRA Type I or II designation. Marking shall be legible and permanent for this application and shall be applied in such a manner so as not to reduce the integrity of the coating. The window light shall be installed so that the identification marking can be read from the inside lower right-hand corner.

16.8.2 Plastic Glazing Prohibited

A. Plastic glazing shall not be used.

16.9 Floor Materials and Coverings

1. Floor coverings shall meet all applicable industry standards, such as APTA, ADA, ASTM, and FRA, as well as all safety requirements as described in Section 23, System Safety and Security.

2. Where specified to be non-slip, anti-skid, or otherwise of increased adhesion, the materials of floors, steps, thresholds, etc. shall be:

    a. Permanently texturized by means of plasma metal spray on exposed top surface.

    b. Static coefficient of friction: Minimum 0.6 measured in accordance with ASTM D2047, using leather and rubber shoe materials meeting these requirements:

        (1) Leather shoe material: Federal Specification KK-L-165C

        (2) Rubber shoe material: ASTM D1630

3. Documented to last 20 years of service

4. Shall be fully homogenous throughout and shall meet the requirements of ASTM F 1344.

16.10 Wood and Panels

A. Wood, lumber, plywood, and plymetal shall only be used when directly specified or as Approved.

16.10.1 Lumber

A. Lumber shall be thoroughly air seasoned or kiln dried before using and shall be dressed on all surfaces to full dimensions. Lumber shall be straight-grained, free from dry rot, knots, checks, and other defects that may impair its strength and durability or mar its appearance.

16.10.2 Plywood

A. Plywood shall be NIST PS 1, panel grade Structural I, or Approved equal.

1. Each plywood panel shall be formed from one piece. Scarf or finger jointed panels are not allowed.

2. Plywood shall be sealed with two coats of an epoxy paint, or Approved equal on all edges and cutouts as soon as possible after fabrication.

3. Exposed edges of the panels: Joints between panels, fastener heads, and openings of panels used in areas accessible to moisture shall be treated prior to installation in the car as follows:

a. Before sealing edges, splits showing on edges shall be plugged with wooden wedges dipped in adhesive conforming to Federal Specification MMM-A-181.

b. Seal the exposed edges with an Approved epoxy or polyurethane moisture barrier coating.

c. Allow minimum 24 hours drying time between each coat.

4. Plywood shall be stored under cover.

16.10.3 Panel Contour Tolerance

A. Surfaces exposed to passengers shall not deviate from the specified contour by more than 3/32 in (2.4 mm) in any 36-in (914-mm) distance. The slope of any such deviation shall not exceed 3/32 in (2.4 mm) in 12 in (305 mm).

16.10.4 Plymetal

A. The term "plymetal" as used in the Specifications means metal-faced plywood. All plymetal panels shall be tested in accordance with ASTM C273/C273M and Table 16-2.

1. Codes and standards other than those referenced in the Specifications may be submitted for Approval.

2. The submittal shall include technical justification demonstrating that the proposed substitution meets or exceeds the codes and standards referenced in the Specifications.

Table 16-2, Plymetal Testing Requirements

Mechanical Properties	Minimum Metal to Wood Average Shear Value or 80% Wood Failure
Dry shear	250 lbf/in² (1,724 kPa)

Boil shear; 3-hour boil; tested wet at room temperature	150 lbf/in² (1,034 kPa)
Soak shear; 48-hour soak wet at room temperature	150 lbf/in² (1,034 kPa)
Creep or cold flow; under static load for 48 hours; at room temperature	250 lbf/in² (1,724 kPa)

B. The metal face of the plymetal panel that is faced with melamine shall be constructed in accordance with TS 16.10.7, prior to the melamine-faced metal panel being laminated to the plywood core.

16.10.5 Honeycomb Panels

A. The term "honeycomb panels" as used in the Specifications refers to an assembly of honeycomb material bonded to melamine-faced metal panels, to composite panels or to metal panels.

1. Honeycomb material shall be commercial-grade 3003 aluminum honeycomb meeting the requirements of SAE AMSC 7438.

2. Bonding shall be sufficient to develop the full strength of the honeycomb material.

3. No other honeycomb materials are permitted.

16.10.6 Melamine-Faced Aluminum

A. Melamine-faced aluminum panels shall be constructed by laminating melamine to aluminum sheets:

1. Minimum thicknesses:

a. Melamine and required binder sheets: 0.013 in (0.330 mm), +/- 0.005 in (0.1 mm).

b. Aluminum sheet, when used as facing on plywood: 0.025 in (0.635 mm).

c. Aluminum sheet, when not laminated to a substrate such as plywood: 0.081 in (2 mm).

2. Construction:

a. Aluminum sheets shall be properly cleaned by etching, sanding, or other Approved process to ensure full, permanent adhesion.

b. Melamine-impregnated papers shall be directly molded to the aluminum sheets at minimum 270°F (132°C) and 1,000 psi (6,900 kPa).

c. The use of contact adhesives to bond the melamine sheets to the aluminum backing is prohibited.

3. The surface characteristics, after manufacture, shall be minimum that required of NEMA LD 3, type GP (General Purpose).

4. The bond between the melamine and aluminum sheets shall, as a minimum, meet the requirements in Table 16-3.

Table 16-3, Melamine to Aluminum Bond Requirements

Mechanical Properties	ASTM Method	Condition	Value
Internal bond	ASTM D952		2,600 lbf/in² (18 MPa)
Flexural strength (S)	ASTM D790	With grain:	26,500 lbf/in² (183 MPa)
		Crossgrain:	25,300 lbf/in² (174MPa)
Modulus of elasticity (E)	ASTM D790	With grain:	2.8×10^6 lbf/in² (19,000 MPa)
		Crossgrain:	3.1×10^6 lbf/in² (21,000 MPa)
Tensile strength	ASTM D638	With grain:	22,300 lbf/in² (154 MPa)
		Crossgrain:	20,300 lbf/in² (140 MPa)

16.10.7 Phenolic Cored Panels for Flooring

A. Phenolic cored panels shall mean panels constructed of top and bottom skins laminated on each side of foam coring:

1. Panel skins:

a. Shall be fiberglass-reinforced, phenolic resin matrix, comprised, at a minimum, of 24 oz/square yard (814 g/m²) bi-axial and 9 oz/square yard (305 g/m²) mat.

b. The corresponding minimum skin thicknesses shall be 0.050 in (1.27 mm) thick.

c. The thickness of the phenolic resin matrix skins shall be increased, if necessary, to meet the strength requirements below.

2. Foam core shall be closed-cell, phenolic-reinforced, polyisocyanurate.

3. The panel structure shall contain a dense fiberglass-reinforced phenolic resin close-out core to provide support for all edges, cut outs and holes. Fastener holes shall be pre-drilled and countersunk to accommodate the Approved fasteners.

4. The panel shall be manufactured using the matched die molding process with the application of heat and pressure. Production techniques shall ensure that the glass fiber reinforcement is uniformly distributed throughout the final product in such a manner as to avoid resin rich or resin starved sections.

5. With the car floor loaded to simulate a uniformly distributed AW3 passenger load plus interior equipment, such as seats, interior liners, and equipment boxes, the following conditions shall be met:

   a. The floor panels shall not deflect more than 1/250 of the shortest span between supports, up to a maximum of 1/16 in (1.6 mm). The floor shall not take a permanent set when the load is removed. An analysis shall be submitted demonstrating compliance to deflection requirements.

   b. The floor panels shall sustain no permanent deformation under normal use (passenger portion of AW3 distributed uniformly along the car) during the design life of the car, and shall be designed to withstand the specified loading without exceeding 50% of the yield stress of the flooring material.

   c. The maximum stress in the floor beams shall be less than 50% of the critical buckling stress or 50% of the yield strength of the material, whichever is less.

   d. A stress analysis shall be performed to confirm that the construction of the manufactured panel is adequate for its intended purpose and meets the specified strength requirements. The panel shall meet the following requirements:

Table 16-4, Phenolic Cored Panel Properties

Mechanical Properties	ASTM Test	Requirement
Flexural Properties	ASTM C393/ C393M	For a span of 15 in (381 mm), failure load greater than 155 lb/in (27 N/mm)
Flatwise Tension	C 297	Strength greater than 1300 psi
Flatwise Compression	C 365	Strength greater than 1210 psi
Flatwise Shear	C 273	Strength greater than 310 psi

6. The phenolic composite floor panels shall be designed to withstand the following physical requirements with no visible or audible indications of delamination of the panel skin from the core and permanent deformation of the top surface and shall be less than 0.010 inch unless otherwise specified. There shall be no puncture or damage to fibers of the top surface. There shall be no separation of any internal core from the top or bottom skin. There shall be no fracture of the core. All test results are required to be submitted. **(CDRL 16-19, Phenolic Composite Floor Panel Test Results)**

   a. Indentation Resistance

      (1) The floor panel shall withstand a concentrated load of 300 pounds applied to a test dowel that has an overall 0.375 square inch surface area with a 0.0625 inch radius on the bottom edge of the test dowel.

b. Static Load Test – Average Loading

(1) A representative sample section of the flooring (without rubber floor covering attached) shall be supported on beams spaced at the maximum spacing used on the car using production bonding and fastening techniques. A uniformly distributed load in accordance with the crush loading requirements of Section 2, Design and Performance Criteria, shall be applied to both sides of the joint (butt and/or shiplap). There shall be less than a 0.088 inch deflection.

c. Static Load Test – Maximum Loading

(1) Using the identical floor panel-mounting configuration as described above, a uniformly distributed load of 200 lb/ft^2 shall be applied to both sides of the joint (butt or shiplap).

d. Small Area Static Load Test

(1) Using the identical floor panel mounting configuration as described above, a 300 pound load shall be applied to a 1.0 inch x 3.0 inch contact area directly over the midspan 6 inches from the outer carbody sidewall edge. The footprint shall be machined flat within 0.010 inch and the edges shall have a radius of not more than 0.125 inch. There shall be less than 0.200 inch deflection as a result of the load applied.

e. Small Object Impact Test

(1) Using the identical floor panel mounting configuration as described above, a 16 pound standard bowling ball shall be raised directly over the mid-span 24 inches from the edge of the panel and dropped from a height of 60 inches. Permanent deformation of the top surface shall be less than 0.063 inch. Some core damage and some skin separation, radiating outward in a circular pattern with an approximate radius of 6.5 inches from the center of impact, shall be allowed.

f. Large Object Impact Test

(1) Using the identical floor panel mounting configuration as described above, a 150 pound load shall be dropped upon a 3.0 inch x 8.0 inch contact "footprint" pad located directly over the midspan 24 inches from the edge of the panel and dropped from a height of 12 inches. The "footprint" pad shall have a rubber pad on the downside surface with a Shore D 70 minimum at a (one) 1 inch thickness machined flat within 0.060 inch with edges having a radius of not more than 0.030 inch. Permanent deformation of the

top surface shall be less than 0.030 inch. Some damage to the top phenolic composite skin is allowed in a 6.5 inch diameter.

g. Rolling Load Test

(1) Using the identical floor panel mounting configuration as described above, a four (4) wheeled cart with a load of 200 pounds per wheel shall be rolled on the panels laterally, longitudinally, and in a circular path with a 2.0 foot radius. The wheels shall be 3 inches in diameter 1 inch wide with a 0.125 inch radius on each edge with a Shore A durometer of 80.

h. Smoke and Flammability

(1) When tested to ASTM E162-98, the maximum $I_S \leq 5$. No flaming or dripping pieces are permitted. When tested to ASTM E119, latest version, a floor panel sample shall pass all test criteria and achieve an endurance rating of 30 minutes and in addition shall not exceed a surface temperature of the unexposed side (top surface) of 120^{o}F during the test. When tested to ASTM E662-97, the following maximum values shall be obtained:

D_S (1.5) ≤ 0.4 (non-flaming) D_S (1.5) ≤ 4.5 (flaming)

D_S (4.0) ≤ 16.5 (non-flaming) D_S (4.0) ≤ 55.4 (flaming)

i. Toxic Gas Generation

(1) Composite floor panel samples shall be tested to BSS 7239 and meet the requirements of:

HCN	< 150 ppm
CO	< 3,500 ppm
NO/NO2	< 100 ppm
SO2	< 100 ppm
HF	< 200 ppm
HCL	< 500 ppm

16.11 Seat Cushion Materials

16.11.1 Cushion

16.11.1.1 Material

A. Seat cushion fill material shall be low-smoke flexible silicone foam. Supplier may recommend polyurethane foam as an alternative with Approval.

B. The material shall have a polymerized or vulcanized homogeneous (free from foreign material), cellular structure with a porous surface and open cells. The cells shall be interconnecting and uniform in size.

C. Cellular material may be molded in one piece or may be assembled by laminating to achieve the required thickness. Laminated cushions shall be bonded together.

D. The thickness and density shall be Approved during design review.

E. Cushion material shall be properly cured to prevent any objectionable odor.

F. Seat bottom cushions shall meet the following requirements:

Table 16-5: Seat Bottom Cushion Requirements

Mechanical Properties	ASTM Test	Requirement
Abrasion Resistance	ASTM D3884	CS-10 wheel, 1000 gm wt. 150 cycles @ 50% wear through
Tear Resistance	ASTM D2261	15 lbf (in both the warp and fill directions)
Burst/Puncture Resistance	FTMS 191A Method 5122	200 lbf

16.11.1.2 Physical Properties

A. Flexible foam shall meet the following physical property criteria when tested without upholstery material:

1. Tensile Strength: 8.0 lbf/in² (55 kPa) minimum when tested to ASTM D3574 Test E

2. Elongation: 140% minimum when tested according to ASTM D3574 Test E

3. Compression Set at 50% deflection, 22 hours, 70°F (21°C):

    a. 2% maximum when tested according to ASTM D3574, Test D

4. Constant Force Pounding Thickness/IFD loss: 15% maximum when tested according to ASTM D3574 Test 13.

5. Tear Strength: 2.5 lbf/in² (17 kPa) minimum when tested according to ASTM D3574, Test F.

6. Thickness Loss: In accordance with ASTM D1055.

16.11.2 Upholstery

16.11.2.1 Material

A. Vinyl used for Operator seat upholstery shall be made of woven transportation grade fabric-backed vinyl with a minimum weight of 23 oz/yd² (780 g/m^2).

B. Cloth fabrics used for seat upholstery shall be made of woven, transportation grade fabrics of wool, wool/nylon blend (90/10, 85/15), or an Approved flame-resistant polyester. The maximum fabric shrinkage shall be 2% in either the warp or fill direction.

C. Synthetic leather, if used, shall be Lantal or Approved equal with a light texture that meet the following requirements detailed in Table 16-8.

16.11.2.2 Physical Properties

A. Fabric-backed vinyl upholstery material shall be subjected to the physical tests of textile products required by the following methods, and the results shall not be less than the following values. Values shown are minimum allowable for testing in both warp and filling directions.

Table 16-6, Fabric-Backed Vinyl Physical Tests

Test No.	Description	Criteria
ASTM D751	Seam Strength	85 lb (378 N)
ASTM D751	Tensile Strength	Warp: 80 lb (356 N) Fill: 90 lb (400 N)
ASTM D751	Tear Strength (Tongue)	Warp: 6 lb (27 N) Fill: 7 lb (31 N)
ASTM D1117	Tear Strength (Trapezoid)	Warp: 18 lb (80 N) Fill: 20 lb (89 N)
AATCC 16.2	Color Fastness – 200 hours	No change
ASTM D751	Adhesion of Coating	10 lb (44 N)
ASTM D4157	Wyzenbeek Abrasion Test – No. 8 duck, 100,000 cycles	No significant wear

B. Wool/nylon blend seat upholstery material shall be subjected to the physical tests of textile products required by the following ASTM methods, and the results shall not be less than the following values:

Table 16-7, Wool/Nylon Blend Physical Tests

ASTM Test No.	Description	Criteria

ASTM D3776/ 3776M	Fabric Weight	15.5 oz/sq yd (526 g/m²) without back coating
ASTM D3775	Fabric Count	Warp – (ends) 88 epi (3.46 ends per mm) Fill - (picks) 40 to 72 ppi (1.57-2.83 picks per mm)
ASTM D5034	Breaking Strength and Elongation	Warp – 200 lb (890 N) Fill – 200 lb (890 N)
ASTM D2261	Tear Strength (Tongue)	Warp – 20 lb (89 N) Fill – 20 lb (89 N)
ASTM D4034	Yarn Slippage	Warp – 30 lb (133 N) Fill – 40 lb (178 N)
ASTM D3597	Color Fastness	Water – Class 4 min. Solvent – Class 4 min. Crocking – Class 4 min. Light – Class 4 min.
ASTM D4966	Martindale Abrasion Test	20,000 cycles – no breaks

C. Synthetic Leather seat upholstery material shall be subjected to the physical tests of textile products required by the following ASTM methods, and the results shall not be less than the following values:

Table 16-8, Synthetic Leather Physical Tests

ASTM Test No.	Description	Criteria
ASTM d-3884	Abrasion	1000 cycles, 500g H-18 wheels. No wear through
AATCC 8	Colorfastness	Dry/Wet grade 5
ASTM D-4705	Tear Strength	23.85 lbf. Warp/Weft average

16.12 Fiberglass-Reinforced Plastic

16.12.1 General

A. Fiberglass-reinforced plastic (FRP) shall be a glass-fiber-reinforced, laminated material, composed of a gel coated surface, fiberglass reinforcement, and an Approved resin.

B. FRP shall withstand, without any physical deformation or structural damage, the environmental conditions in Section 2, Design and Performance Criteria; and be resistant to acids, alkalis, and cleaning solutions recommended by the Contractor.

16.12.2 Components

A. Comply with the following:

1. Resin:

a. Resin shall be of good, commercial grade, thermosetting material selected to meet the physical properties of the Specifications and molding process requirements.

2. Reinforcement:

a. The fiberglass reinforcement shall be mat, fabric, woven roving, continuous roving, chopped spun roving, or swirl mat as required to meet the physical properties of the Specifications and the molding process requirements.

b. The glass content shall be confirmed through testing to ASTM D2584.

3. Gel Coat:

a. Minimum thickness shall be 0.016 in (0.4 mm) and maximum thickness 0.032 in (0.8 mm).

b. If the surface of the FRP panel is to be painted, a primer gel coat shall be used and the part shall be painted in accordance with TS 16.19.

c. If the FRP panel does not receive paint, then the gel coat shall be pigmented to match the color selected by SEPTA.

d. Gel coat shall be resistant to scuffing, fire, weather, and cleaning agents.

e. Finished gel coated surfaces shall have a minimum gloss value of 85 when measured with a 60-degree gloss-meter and shall exhibit no print-through of the reinforcements or have any appreciable orange peel.

4. Additives:

a. Additives, fillers, monomers, catalysts, activators, pigments, fire retardants, and smoke inhibitors shall be added to the resin mixes to obtain finished products with the required physical characteristics of the Specifications.

b. Mineral filler shall not exceed 28% of finished weight for any preformed matched die molding process.

c. Antimony trioxide is prohibited.

16.12.3 Construction

A. Comply with the following:

1. FRP shall be manufactured by either open molding, hand layup, or the matched die molding process.

2. Production techniques shall ensure that the glass fiber reinforcement is distributed throughout the final product in such a manner as to avoid resin-rich or resin-starved sections.

3. FRP parts shall have a greater thickness at attachment points and edges. Exposed sharp edges will not be allowed on any parts.

4. A stress analysis shall be performed to confirm that the construction method chosen is adequate for its intended purpose and meets the specified strength requirements.

5. FRP panels shall not be integrally colored.

16.12.4 Repair

A. Repair procedures shall be provided for all FRP products **(CDRL 16-20, FRP Repair Procedures)**.

16.12.5 Strength Requirements

A. Independent laboratory tests shall be performed on test coupons that are trimmed from production parts.

1. Test specimens shall be conditioned in accordance with ASTM D618.

2. Independent laboratory test reports shall be provided (**CDRL 16-21, FRP Performance Test Certificates)** confirming that the reinforced plastic material complies with the requirements of the following standards.

Table 16-9, FRP Minimum Strength Requirements – Interior Components

Mechanical Properties	ASTM Test	Open or Match Die Moldings
Tensile Strength	ASTM D638	10,000 lbf/in² (69 MPa)
Compressive Strength	ASTM D695	18,000 lbf/in² (124 MPa)
Flexural Strength	ASTM D790	15,000 lbf/in² (103 MPa)
Impact Strength	ASTM D256	6 ft-lb/in (0.32 J/mm) of notch
Hardness	-	45 Barcol

Table 16-10, FRP Minimum Strength Requirements – Exterior Components

Mechanical Properties	ASTM Test	Open or Match Die Moldings
Tensile Strength	ASTM D638	18,000 lbf/in² (124 MPa)
Compressive Strength	ASTM D695	24,000 lbf/in² (165 MPa)
Flexural Strength	ASTM D790	30,000 lbf/in² (207 MPa)
Impact Strength	ASTM D256	8 ft-lb/in (0.43 J/mm) of notch
Hardness	-	45 Barcol

16.13 Thermoplastic Sheet

16.13.1 General

A. Thermoplastic sheet used in construction of the car shall withstand, without any physical deformation or structural damage, the environmental conditions specified in Section 2, Design and Performance Criteria, and shall be resistant to SEPTA's cleaning solutions.

B. The color and surface finish of parts manufactured from this material shall be Approved prior to the production run of any parts.

16.13.2 Material/Construction

A. Comply with the following:

1. Thermoplastic sheet shall be homogeneous and extruded from virgin stock that does not include any regrind of vacuum formed parts.

2. The exposed surface of this material shall conform to the color, texture, and gloss of the interior panel.

3. Only UV stabilized pigments shall be used to create the specified color of the thermoplastic sheet.

4. Thermoplastic sheet shall be used as extruded or vacuum-formed.

16.13.3 Quality

A. Comply with the following:

1. The finished parts shall be free of waves and quilting on both sides.

2. Degraded polymer in the sheet shall not be allowed, and if present, shall be cause for rejection of the piece.

3. Voids, lumps, and contamination shall also be cause for rejection of parts if the defects are larger than 0.010 in (0.254 mm), and the population of these defects is greater than one defect in 4 ft^2 (0.37 m^2).

16.13.4 Strength Requirements

A. Independent laboratory test certificates shall be provided stating that the thermoplastic sheet complies with the requirements of the following standards. Extruded sheet in the surface finish specified shall be used for testing.

Table 16-11, Thermoplastic Sheet Strength Requirements

Mechanical Properties	ASTM Method	Value
Specific Gravity	ASTM D792	1.20 to 1.45
Tensile Strength	ASTM D638	7,000 lbf/in^2 (48 MPa) minimum
Flexural Strength	ASTM D790	11,000 lbf/in^2 (76 MPa) minimum
Flexural Modulus	ASTM D790	4.5×10^5 lbf/in^2 (31.0 MPa)
Hardness Rockwell “R” Scale	ASTM D785	90 to 110

Heat Shrinkage; 15 minutes at 350°F (177°C)	-	10% maximum
Heat Deflection (annealed) at 264 lbf/in² (1.82 MPa)	ASTM D648	190°F (88°C) minimum
Impact Strength, Fabricated Parts; Gardener Dart Drop 0.5-in (13-mm) diameter ball at 73°F (23°C)	ASTM D5420 ASTM D5628	360 in-lb (40J) minimum

16.14 Piping and Tubing

16.14.1 General

A. Comply with the following:

1. Piping, valves, fittings, installation methods, and testing shall be in accordance with the ASME B31.1.

2. Pipe routing and support shall be planned and accomplished in an efficient, organized manner to keep the total length and number of fittings and bends to an absolute minimum.

   a. Pipes shall be supported throughout their length and at all connections to prevent vibration or noise and to limit stresses in the pipe to less than 50% of the pipe's fatigue endurance limit.

   b. Support and clearances provided between adjacent pipes and between pipes and surrounding structure, equipment or other appurtenances shall be sufficient to prevent chafing or contact due to any combination of car loading and deflection, car dynamics, and thermally induced movement. The minimum clearance shall be 0.25 in (6.35 mm).

   c. Changes in direction shall be accomplished by bending the pipe to a radius of not less than specified by AAR MSRP, Section E, Standard S-400, and not with fittings.

   d. Direction change fittings shall not be permitted in the trainline brake pipe or in the brake cylinder pipe.

   e. Joints shall be easily accessible.

   f. Pipes and their connections shall not interfere with the removal and replacement of other components.

3. Piping or tubing passing through holes in the floor, bulkheads, structure, or any fixed member:

   a. Pipes shall be rigidly clamped to protect against possible damage or noise due to bearing, abrasion, or car dynamics-induced rattling.

b. Clamps shall not be welded, brazed, or otherwise permanently fastened to any pipe or tubing.

c. Pipe and tubing interfaces with clamps shall be insulated with an elastomeric or woven non-asbestos mineral fabric tape material to protect and sound-insulate the pipe or tubing.

d. Pipes and tubing shall have a gap of 1/8 in (3.2 mm) between the pipe and the clearance hole to prevent chafing

4. Connections to vibration-isolated or rotating equipment such as the air compressor and air conditioning compressor-condenser unit:

   a. Clamps shall be of a suitable material for the application.

   b. Provide Approved flexible vibration eliminators.

   c. The pipe connection at either end of the flexible elements shall be rigidly clamped no farther than 2 in (51 mm) from the flexible elements.

   d. All pipe clamps shall be inherently rigid and shall be firmly attached to car structure. Cantilevered clamps or clamp supports that are weaker than service-proven designs will not be accepted.

5. Cut-out cocks or other manually operated valves shall be locking type with provisions for safety wire.

6. Pipe glands shall be properly sized and rated to secure piping and prevent the travel of moisture through the pipe route. The use of sealants is prohibited.

7. Following installation:

   a. Piping shall be cleaned to remove dirt, metal chips, oily contamination, and moisture.

   b. After cleaning, piping shall be pressure tested in accordance with ASME B31.1.

   c. Leaks shall be repaired and the piping recleaned and retested until leak-free.

8. Prior to constructing the cars:

   a. The Contractor, in cooperation with the manufacturers and suppliers, shall make a thorough analysis of the design of the pneumatic systems proposed for the cars to assure that every reasonable precaution has been taken in design and installation to prevent the cars from disablement in service as the result of adverse winter conditions.

   b. Before being granted permission to commence construction, the Contractor shall submit the details of this analysis and of any special

preventative measures he proposes to incorporate in the design. **(CDRL 16-22, Pneumatic System Design Analysis)**. The design layout, installation, hanging methods, etc., shall be jointly inspected and reviewed with.

16.14.2 Air Piping, Tubing, and Fittings

16.14.2.1 Type, Size, and Gauge

A. Comply with the following:

1. The main reservoir pipe and brake pipe shall conform to ASTM A53, Schedule 80, seamless pipe. The application of the ASTM A53 pipe shall comply with the requirements of AAR Specification No. 2518 and Standard 400.

2. Stainless steel piping and flare fittings in accordance with EN 10305-1 (tubing), DIN 25570-1 (bend radius) and DIN/EN/ISO 8434-1 (tubing connections) including truck piping may be proposed by the carbuilder for approval.

3. Stainless steel tubing cannot be used for the final end connections for the brake pipe and main reservoir pipe which must conform to the ASTM A53 and AAR Specification 2518. All other installation requirements contained in TS 16.14. are applicable.

4. Type "K" annealed copper tube per ASTM B88, latest revision, may also be used provided it is installed no lower than two inches below the floor sheet or structural member and is protected by means of equipment or approved steel guards from any potential impact damage from rail debris especially in the truck and outboard of the bolster areas. All copper piping shall be brazed. Where suitable protection in damage prone areas is not possible or practical, approved steel piping sections shall be provided. Where the use of copper tube is approved, its installation shall comply with the requirements of AAR Specification No. 2518.

5. Hose and hose fittings used within the air subsystem shall be in compliance with the following AAR MSRP standards:

   a. Section E, M-601

   b. Section E, M-618

   c. Section E, M-620

   d. Section E, M-927.

6. Hose fittings shall be of the reusable type AAR approved reusable fittings conforming to the requirements of AAR Specification M-927.or Approved equal.

7. Hose assemblies shall have a minimum initial storage life of seven years and associated extended storage life of three years as defined by ISO 2230.

8. Air pipes shall be sized in accordance with the function intended. The diameter of the main reservoir pipe shall meet the brake supplier's requirements; however, in no case shall these pipes be less than 7/8-in (22 mm) OD.

9. Tubing gauge shall be as follows:

    a. 1/2-in (13 mm): Minimum 18 gauge.

    b. 3/4-in (19 mm): Minimum 16 gauge.

    c. 7/8-in (22 mm): Minimum 14 gauge.

16.14.2.2 Installation

A. Comply with the following:

1. Air piping shall be installed in a manner to provide drainage away from devices, or branch pipes leading to devices, when the function of those devices could be impaired by the accumulation of water or ice. Piping and hosing shall not be supported by other pipes or hoses.

2. Truck piping:

    a. Low spots (traps) are strictly prohibited on trucks.

    b. Truck piping shall not be run on the bottom of truck side frames, transom, or bolster.

    c. Air piping on the trucks shall be 1/2 inch ASTM A53, Schedule 80, or Approved equal.

3. Connections and joints where disassembly for service may be required shall use hydraulic piping-style, bevel seal fittings with threaded retaining nuts.

4. The use of tape is prohibited.

5. Air piping connections shall be accessible without removing any undercar equipment or components.

6. Use of threaded fittings, where the threaded connection is used to retain piping pressure integrity, is expressly prohibited.

7. Pneumatic piping shall be retained by clamping devices with rubber inserts and a minimum of two fasteners. Single fastener clamps, e.g. P-clamps, are expressly prohibited.

8. Cut-out cocks shall be of the vented type, except where function prohibits. Cut-out cock handles and their arrangements shall be as specified in Section 12, Friction Brake.

9. Air piping shall comply in all respects with the air brake supplier's design and installation requirements and AAR Standard S-400.

10. Prior to manufacture of production cars, submit a report containing written approval from the air brake supplier of the Contractor's air brake piping fabrication, installation, and design concept. (**CDRL 16-23, Air Brake Supplier's Written Approval**). Include the following information in the report:

    a. All critical line sizes and materials including the main reservoir pipe and the brake cylinder piping.

    b. The installation details of the above critical lines including routing, total length and volume, elevation, and slopes, and major joint and direction change locations. A list of all proposed bend radii shall also be provided.

    c. Pipe processing details including welding, brazing, cleaning, and fabrication methods, as required by TS 16.6.

    d. Locations of all major air brake control, relay, and emergency venting devices, and the proposed location and volume of all reservoirs.

    e. An air consumption analysis justifying the proposed air storage subsystem design.

16.14.3 Air Conditioning Subsystem Piping, Tubing, Fittings, and Installation

16.14.3.1 Type and Size

A. Comply with the following:

1. Tubing shall be refrigeration grade, cleaned and sealed with plugs at the mill, in accordance with ASTM B280.

2. The suction line shall be sized for 3 psig (20.7 kPa) maximum subsystem pressure drop. Liquid line piping shall be sized to limit pressure loss under full load conditions to a value that will not cause flashing in the liquid line.

16.14.3.2 HVAC Piping Installation

A. Follow the procedures of ASME B31.5 and the recommendations of the HVAC subsystem's manufacturer regarding the design and installation of refrigerant lines.

1. Air conditioning refrigerant lines shall be of seamless copper tubing, Standard ASTM B280, and condensate drain lines shall be seamless copper tubing, Standard ASTM B88 type K or Approved stainless steel tubing.

2. Keep joints and fittings to a minimum. Inaccessible tubing runs shall be without joints.

3. Tubing shall be bent where necessary and practical by means of a tubing bending tool designed specifically for bending the tubing to be used.

4. Piping and pipe subassemblies shall be deburred, cleaned, dried, and capped with tight fitting plastic caps, or Approved equal on all openings after fabrication. Prevent dirt from entering the refrigerant lines during fabrication. Caps shall remain in place until immediately prior to incorporation into the final assembly.

5. Design and install suction lines without traps. Horizontal traps in the suction line are prohibited.

6. Provide vibration isolation where refrigerant line attaches to a resiliently mounted assembly and to the refrigerant compressor.

    a. Vibration isolators beneath the car floor shall have an Approved waterproof jacket to prevent icing of the flexible elements and damaged to the isolator braid.

    b. Install vibration isolators in accordance with the manufacturer's recommendations.

7. Support refrigerant lines adequately to prevent vibration, chafing, fatigue, and stressing of joints.

8. Vibration eliminators shall be used in piping connections to the compressor.

9. Design tubing installations to allow any single length of tubing to be replaced without dismantling or removing surrounding equipment, piping, wiring, or other appurtenances.

10. Insulate refrigerant liquid and suction lines both above and below the floor using closed-cell foam insulation meeting the flammability, smoke emission, and toxicity testing requirements of Section 23, System Safety and Security. Apply Approved joint sealant between lengths of insulation.

11. After fabrication, thoroughly clean the refrigerant lines of all dirt, moisture, and foreign matter, and seal and purged with dry nitrogen.

12. When the piping installation is complete, thoroughly test the entire subsystem to ensure that it is pressure-tight; no leaks will be permitted. Leak test, evacuate, and charge the subsystem according to procedures Approved by the HVAC subsystem supplier and by SEPTA.

16.14.4 Brazing and Soldering of Piping, Tubing and Fittings

A. Brazing and soldering shall comply with the applicable parts of TS 16.6, and the following requirements:

1. Unless Approved otherwise, all refrigerant piping and air subsystem copper tubing shall be joined using silver solder conforming to AWS B2.2/B2.2M, BAg-5 or BCuP-5.

2. Refrigeration piping and tubing shall be internally swept with a continuous flow of a non-oxidizing gas such as dry nitrogen during brazing.

3. Condensate drain tubing shall be joined using 95-5 solder or Silver Solder as above.

4. Solder joints shall be wiped and have flux cleaned from tubing and fittings after soldering.

5. After fabrication, clear the refrigeration and air subsystems of all dirt and foreign matter, flush with a degreasing agent, and dry, all according to an Approved written procedure.

16.14.5 Hydraulic Piping, Tubing and Fittings

16.14.5.1 Type, Rating, and Size

A. Comply with the following:

1. Type:

a. Exposed tubing, piping, or fittings shall be stainless steel complying with SAE AMST6845 or SAE AMS5567.

b. Tubing, piping, or fittings protected from under-car exposure may be either stainless steel or carbon steel complying with SAE J524 or SAE J356.

c. Hose used within the hydraulic subsystem shall comply with SAE J517 and hose fittings shall comply with SAE J516.

d. Hose shall be supplied clean and with both ends capped.

2. Rating:

a. All hose shall be rated to withstand four times the maximum operating pressure without bursting.

b. Hose application limits shall comply with SAE J1273, SAE J343, and SAE J1405. Hose shall not be used in locations where the temperature may exceed 200°F (93°C).

3. Size:

a. Hydraulic pipes, tubing, and fittings shall be sized for the function intended without experiencing a pressure drop of more than 15% from control to function.

b. Wall thickness shall be Schedule 80 for truck-mounted piping and sufficient to maintain a safety factor of 6 at the maximum subsystem pressure.

c. Wall thickness in other locations shall be sufficient to maintain a safety factor of 6 at the maximum subsystem pressure.

16.14.5.2 Installation

A. Comply with the following:

1. Truck piping shall not be run on the bottom of truck sides, frames, transom, or bolster.

2. Bending:

a. Tubing shall be bent using a bending tool designed specifically for bending of the tubing to be used.

b. Bent tubing shall have a uniform bend free of kinks.

3. Tubing and piping shall be deburred after cutting.

4. Tubing, fittings, and subassemblies shall be cleaned and capped on all openings after fabrication. Caps shall remain in place until immediately prior to incorporation into the final assembly.

5. Joints:

a. Joints for tubing or piping shall use fittings of the same material as the tubing or piping.

b. Joints shall be welded, brazed, flared to 37-degrees in accordance with SAE J533, or made with compression fittings, Swage-Lock, or Approved equal.

c. There shall be no inaccessible joints.

6. Connections:

   a. Connections to manifold ports, valve bodies, and other hydraulic subsystem components shall use straight thread fittings with separate O-ring seals.

   b. Quick connect couplings shall be of the double shutoff type with valves built into both mating parts of the coupling.

7. Service and Isolation Devices: Shall provide means to safely isolate or otherwise relieve all stored energy from a portion of the subsystem requiring service, without loss of fluid or accumulator gas (if so equipped).

16.15 Pressure Vessels

A. Pressure vessels shall conform to ASME ASME Boiler and Pressure Vessel Code for Unfired Pressure Vessels, Section VIII-1. Test reports shall be furnished **(CDRL 16-24, Pressure Vessel Test Reports)** for each pressure vessel, and each pressure vessel shall be stamped to document the test.

16.16 Air Filters

16.16.1 HVAC and Equipment Ventilation Filters

A. Filters used for either the passenger compartment HVAC system or the Operator's cab system shall comply with the following:

1. Filters shall be selected in accordance with the manufacturer's recommendations for the specific equipment involved, shall be designed to meet the performance requirements of each installation, and shall be Approved.

2. Type:

   a. Filters shall be the disposable, pleated media type, 2-in (51 mm) thick, with an integral cardboard frame, complying with UL 900. Reusable filters may be Approved for specific applications where throw-away filters are not available.

   b. The filter frame shall have airflow directional arrows showing.

   c. Air filters shall be unmodified, commercially available standard catalog sizes available from multiple suppliers or coincide with those sizes already used by SEPTA. Specialty filters with protective coatings applied to the filter media and those available only from a single manufacturer are prohibited.

   d. The average efficiency shall be a minimum of 70% at a constant velocity of 300 ft/min (91 m/min) up to 0.5-in water gauge (124 Pa) pressure drop as tested in accordance with ASHRAE 41.3.

e. HVAC filters that filter recirculated air shall be rated MERV 8 or higher.

3. Filter holders shall be provided to hold framed filters.

   a. The filters and filter holders shall be sealed at their edges to prevent filter air bypass.

   b. Support of the filter elements shall be provided to prevent blowout of the filter elements under clogged filter conditions.

   c. Filters shall be secured in place using spring loaded toggle.

4. Application:

   a. Filter area shall be such as to limit filter face air velocity to a maximum of 300 ft/min (91 m/min).

   b. Initial clean filter pressure drop shall be a maximum of 0.09-in water gauge (22 Pa).

   c. Fresh air filters shall not be used as part of the water elimination subsystem and shall not become wet under any circumstances.

      (1) Some dampness of the filter will be permitted. However, the final weight or percentage of wetness after a 10-minute test shall conform to the manufacturer's recommendations and filter performance.

      (2) The Contractor shall be able to demonstrate through a one-time qualification test that removal of the fresh air filters does not allow the inclusion of water through the fresh air intakes.

5. Maintainability:

   a. Maintenance personnel shall have full and unconstrained filter access allowing use of both hands to remove and replace fresh air filters without the need to remove or move any components after opening the return air grille.

   b. HVAC air filters shall be readily accessible for replacement from inside the car through the hinged recirculated-air grille.

   c. The replacement interval shall be mileage-based and the minimum replacement interval shall be 8,000 mi (12,875 km).

16.16.2 High Pressure Air Filters

A. Comply with the following:

1. Provide air filter assemblies with replaceable filter elements in the air line that connects each subsystem to the air supply subsystem.

a. The air filter filtering capability, flow rate capability, and overall size shall be appropriate for the application so that the filter replacement interval is greater than one year.

b. It shall be possible to gain access to the filter element for replacement without requiring any pipe fittings to be disconnected or loosened.

2. Provide filters for each of the following subsystems and any others operated from the air supply subsystem:

a. Each air brake control assembly

b. Input and output of each height control valve

c. Coupler controls

d. Door controls

e. Horn

16.16.3 Low Pressure Air Filters

A. Low-pressure air filters shall be replaceable media type filters with the following properties:

1. Resin-bound, spun-glass fiber materials having an uncompressed thickness not less than 3.5 in (89 mm).

2. Non-absorptive of fluids and gases.

3. Material density shall increase progressively from air inlet to air exit side.

4. Filter shall be coated with not less than 24 g/ft² (258 g/m²) of a dust-retaining, viscous adhesive film, which shall be stable at temperatures up to 150°F (66°C).

5. The filter medium shall be cut to a minimum of 0.5-in (13-mm) oversize to ensure adequate sealing between the edge of pad and its integral frame.

16.17 Lubrication Fittings

A. All lubrication fittings shall be easily accessed, and lubrication shall be possible through the use of standard, commercially-available grease guns without any disassembly of surrounding components.

16.18 Decals

A. Preparation and application of all decals shall be in accordance with the manufacturer's instructions.

B. Vinyl decals used on the car shall be 3M Controltac, or approved equal, and shall utilize appropriate inks recommended by the manufacturer for application.

C. Where appropriate, decals may be impeded in the paint system and shall be processed so as not to void any warranties from the paint or decal manufacturers.

D. Edge seal shall be used on applications where the decal is not impeded in the paint to protect the decal and its adhesive from cleaning solutions and automatic washing brushed.

E. Decals shall conform shall be provided with a permanent, pressure-sensitive positionable adhesive.

F. Decals and marking shall be durable, readable and permanent.

G. All doors, cover plates, or barriers providing direct access to high voltage equipment shall have bold warning decals and shall conform to 49 CFR 229.85.

H. All required SEPTA and FRA decals, including safety related markings, and signage shall be provided and installed.

16.19 Paints and Coatings

16.19.1 General

A. The exterior portion of the carbody receiving paint shall be painted as required by the Specifications and in accordance with the specified color scheme, lettering, and numbering.

1. Apply paint to the carbody and to components in accordance with the paint manufacturer's recommendations.

2. Furnish a touch-up procedure and ensure that a continuing supply of touch-up paints in colors used on the car, suitable for spot application by spray roller or brush, will continue to be available in the United States.

3. Test paint performance in accordance with this Section.

16.19.2 Materials Not to be Painted

A. Austenitic stainless steel portions of the carbody shall not be painted, unless otherwise specified by SEPTA for cosmetic reasons.

B. Equipment or parts of equipment that would be damaged or suffer impaired operation from painting shall not be painted and shall be corrosion resistant, including but not limited to the following:

1. Flexible conduit and fittings
2. Copper tubing, piping, and fittings
3. Wire and cable
4. Power resistors
5. Heat transfer surfaces
6. Electrical insulators
7. Elastomeric devices
8. Grounding pads
9. Wearing surfaces
10. Coupler
11. Fittings
12. Truck-Related Items:
    a. Wheels
    b. Axles
    c. Elastomeric parts
    d. Grease fittings
    e. Linkages
    f. Threaded parts used for adjustments
    g. Electrical equipment
    h. Wearing surfaces.

16.19.3 Paint Materials

16.19.3.1 General

A. Comply with the following:

1. Painting materials for all surfaces shall be a high quality finishing system resistant to corrosion (per ISO-9223, C4 for exterior and C3 for interior), chipping, and fading and shall retain the gloss level.

2. Paint and filler materials which are to be superimposed to form a finish shall be mutually compatible and shall be warranted for use as a system by the manufacturer of the components.

3. Paint materials shall be used at the consistency recommended by the paint supplier. If thinners or reducers are necessary, they shall be Approved by the paint manufacturer and shall be used only to the extent recommended.

4. See Section 14, Interior and Exterior Appointments, for paint colors.

16.19.3.2 Paint Data

A. Submit paint manufacturer's data. (**CDRL 16--25, Paint Manufacturer's Data**). As part of the mock-up specified in Section 25, Program Management and Commissioning, paint shall be evaluated for color, gloss, adhesion, finish, and orange peel characteristics for each type of paint used.

16.19.3.3 Primers

A. Where specified, primers shall comply with the following:

1. Wash (etch) primer: A primer with anti-corrosion properties for application as a first coat on metal surfaces, as recommended by the manufacturer of subsequent primer and top coat.

2. Epoxy primer: Compatible with the polyurethane top coat.

3. Truck primer: Compatible with truck paint.

4. The primer color shall contrast the finish color to ensure complete top coat coverage.

16.19.3.4 Top coats

A. Where specified, top coats shall comply with the following:

1. Polyurethane: Two-part, high-solids, low-VOC, polyurethane paint system with a solids content between 50% and 70%.

2. Alternate paint systems, such as base coat-clear coat systems, or direct-to-metal paint systems will be considered if the paint performance equals or exceeds two part polyurethane.

3. Anti-skid: . The use of anti-skid paint is prohibited, plasma spray/Darkar shall be used for ant-skid applications.

4. Truck paint: Select truck paint that will not hide structural cracks.

16.19.3.5 Powder Coat

A. Where specified, powder coat shall comply with the following:

1. Interior applications: Thermosetting, resin based, polyester, fluoropolymer or epoxy powder tailored to the individual application.

2. Exterior applications: Not Approved for use.

16.19.4 Preparation and Application

16.19.4.1 General

A. Preparation of the painted surface and application of painting materials for brushing or spraying shall be in accordance with the paint supplier's recommendations.

16.19.4.2 Paint Process Documentation

A. Submit a paint coating and application document. (**CDRL 16-26, Paint Preparation and Application**)

B. This document shall be made part of the maintenance manuals.

16.19.4.3 Applicator Qualifications

A. Painting shall be done only by experienced and fully trained personnel, using proper equipment under competent supervision.

16.19.4.4 Carbody

A. Comply with the following:

1. Metal portions of the carbody not constructed of austenitic stainless steel shall, after fabricating, be prepared for painting by one of the following methods:

a. Grit blast, then immediately after grit blasting, apply epoxy primer within a time frame suggested by the manufacturer.

b. Wash with an alkaline solution, properly rinse, phosphate coat or paint with a coat of wash (etch) primer, and then coat with epoxy primer.

2. Hidden aluminum or ferrous materials, except austenitic stainless steel, shall be given one coat of epoxy primer and one topcoat.

3. In addition, comply with the following requirements for the locations indicated:

a. Concealed surfaces capable of rusting or oxidation: Shall be properly cleaned, receive a wash primer, then shall coated with epoxy primer, and painted with polyurethane or other Approved coating suitable for the car design life.

b. Where arc welding is performed on joints between stainless steel and other materials, de-scale and clean the joint, apply wash primer, apply epoxy primer, and apply polyurethane topcoat.

16.19.4.5 Exterior Not Visible to Passengers

A. Surfaces that are on the exterior of the car but not visible to passengers shall be prepared as specified above for the carbody, and painted as follows:

1. After erection of the framing structure and body sheets, all undercar metal, except stainless steel, shall be coated with an epoxy primer and polyurethane topcoat.

2. Underfloor apparatus (motors, control boxes, junction boxes, brake valves, and other equipment as specified) shall be coated with epoxy primer and one polyurethane topcoat.

3. The exterior surfaces of undercar equipment enclosures and apparatus, other than propulsion control equipment, made from carbon steel shall be coated with epoxy primer and one polyurethane topcoat.

4. The interior and exterior surface of all propulsion control equipment enclosures shall be coated with an Approved insulating, thermosetting, resin-based, powder coating or Approved equal. The interior of the boxes shall be white, and the exteriors shall match the undercar paint scheme.

5. Parts of undercar equipment enclosures made from plastic or fiberglass shall be painted in accordance with the above requirements for metal portions except that the paint system shall be compatible with the plastic used, and an insulating coating need not be applied.

6. Equipment control groups shall be coated with epoxy primer and one polyurethane topcoat. The color shall be as Approved.

16.19.4.6 Trucks

A. Comply with the following:

1. All truck components to be painted shall be given a full coat of primer prior to assembly. Machined surfaces shall be protected during the painting process.

2. Following assembly, all exposed surfaces of each truck, including machined mounting surfaces not used, shall be cleaned by blowing off with compressed air and solvent-wiped to remove all dirt and grease.

3. All truck components not listed as materials not to be painted shall then be given one coat of truck paint and air dried.

16.19.4.7 Exterior Visible to Passengers

A. Comply with the following:

1. Preparation: Before painting car surface that is exposed to view, all dents, gashes, nicks, roughness, or other surface imperfections or depressions shall be removed as follows:

a. Remove imperfections so far as possible by straightening and properly prepare to receive the filler material.

b. After straightening, wash prime the surface, fill remaining imperfections with an Approved epoxy-based filler, and sand smooth.

c. The maximum allowable filler thickness shall be as recommended by the filler manufacturer for the environment and service to which it is to be exposed, but in no case shall it exceed 1/8 in (3.2 mm).

2. Painting: Apply epoxy primer and two polyurethane topcoats. The paint shall be uniformly applied over all surfaces to be covered. Painting shall be done in a clean, dry atmosphere at an ambient temperature as recommended by the paint manufacturer.

3. Surface appearance:

a. The finished exterior shall present a high-quality appearance free from sags, drips, scratches, variations in gloss, and other imperfections.

b. The gloss level shall be greater than 80 as measured with a 60-degree gloss-meter, unless specified to be semi-gloss which shall be greater than 20 as measured with a 60-degree gloss-meter.

c. The exterior finish shall have a minimum allowable surface smoothness (orange peel index) of 7 as measured with the ACT Laboratories Orange Peel Standard.

16.19.4.8 Stainless Steel

A. Comply with the following:

1. Exterior austenitic stainless steel shall be cleaned with an Approved alkaline cleaning solution, which shall not damage any previously painted surfaces.

2. Where stainless steel is painted, procedures shall be as recommended by the paint manufacturer for the application, and surfaces shall be properly prepared to ensure adhesion.

16.19.4.9 Interior Painting

A. Comply with the following:

1. Exposed interior surfaces, including molding and trim, shall be as specified in Section 14, Interior and Exterior Appointments.

2. Interior surfaces requiring painting shall be coated with an Approved thermosetting powder coating. Parts which are to be powder-coated shall be cleaned and prepared in accordance with the recommendations of the powder supplier.

3. Furnish a touch-up procedure and ensure that a continued supply of touch-up paint in the proper colors suitable for spot application will continue to be available in the U.S.

16.19.4.10 Testing

A. Submit a test procedure and report for testing the final painted surface on the first car. (**CDRL 16--27, Paint Testing on First Car**)

B. Test according to the following criteria:

1. Hardness: Pencil Hardness tests shall be performed according to ASTM D3363. The range of acceptance shall be between H and 2H and shall be the average of ten readings taken from typical surface locations. This is a destructive test and shall require the tested surfaces to be repaired.

2. Adhesion: Adhesion shall be tested per ASTM D4541 and achieve a minimum rating as provided by the paint manufacturer. This is a destructive test and shall require the tested surfaces to be repaired.

3. Thickness: The minimum and maximum dry film thicknesses shall be provided by the paint supplier. Dry film thicknesses beyond the manufacturer's minimum and maximum recommendations shall not be accepted. Non-destructive testing shall be performed to verify final dry film thickness.

4. Paint Cure: Perform a solvent rub test per ASTM D5402. The test procedure requires no less than 50 double finger rubs with a cloth wetted in acetone or methyl isobutyl ketone to the painted surface. No paint color shall transfer to the cloth. After 72 hours the painted surface shall retain all original characteristics such as gloss and hardness.

5. Surface Appearance:

a. Make a visual inspection of car surfaces for uniform gloss and no visible orange peel effect.

b. Using a DOI (Distinctness of Image) meter, take measurements at multiple locations.

c. Verify that average readings comply with specified limits in Section 14, Interior and Exterior Appointments.

6. Repeat tests during production on cars randomly chosen by SEPTA.

16.19.5 Acoustical Insulation

A. Apply acoustical insulating materials to properly cleaned underframe, sides, ends, roof, and floor sheets, as required in Section 14, Interior and Exterior Appointments, to the supplier's recommendations.

1. The materials shall be resistant to dilute acids, alcohols, grease, gasoline, aliphatic oils, and vermin. The material shall be unaffected by sunlight and ozone and shall not become brittle with age.

2. The product shall be an Approved viscoelastic, sprayable-liquid sound damper.

3. The Contractor may propose alternative insulation. The alternative acoustic insulation shall be service proven for commuter rail application and shall demonstrate compliance with the design and performance requirements specified.

16.20 Flammability, Smoke Emission, and Toxicity Requirements

A. All combustible material used in construction of car shall satisfy the flammability, smoke emission, and toxicity requirements specified in Section 23, System Safety and Security, 49 CFR 238, and NFPA 130.

16.20.1 Floor Assembly Fire Resistance Testing Criteria

A. The Contractor shall test the cab floor, lower and the intermediate floor assemblies in accordance with ASTM E119 to demonstrate a 15 minute endurance rating, per requirements in Section 15, Test Program. The comprehensive test report, which shall include the test procedure, test facility, test results, and "before and after" photographs, shall be submitted for review and approval prior to procurement of any flooring material for vehicle production. **(CDRL 16-28, Floor Fire Test Report)**

B. The following test criteria shall be met:

1. The test specimens shall be a full width vehicle section of each level including side sills or that portion of the wall which extends below the floor. Each specimen shall have a minimum exposed area of 100 square feet. If Approved, the exposed area may be reduced to meet a length limitation imposed by the size of the test furnace, but the length shall not be less than 11 feet. No less than one (1) typical penetration of each type spaced at a distance from each other no greater than that which will exist in actual construction shall be included in the test specimen. The specimens shall include typical floor splice configurations.

2. The test specimens shall be loaded to simulate "crush" passenger loading conditions. Concentrated loads shall be applied to simulate underfloor and overhead mounted equipment as applicable.

3. The test specimens shall include at least three typical transverse supports for each level.

4. The test specimens shall represent the actual construction utilized in production. This shall include the floor covering, floor boards, floor structure, thermal and acoustic insulation, and floor pans.

5. The conditions of acceptance for this test shall be those required for unrestrained assembly.

6. Drawings of the floor fire test sample shall be submitted for approval prior to construction and testing of the sample. Any deviations from the Approved configuration shall require approval and retesting. **(CDRL 16-29, Floor Fire Test Drawings)**

16.20.2 Electrical Fire Safety

A. Electrical equipment shall conform to NFPA 130 except where more restrictive requirements are imposed by this Specification.

16.21 Raceways and Junction Boxes

16.21.1 Scope

A. This section applies as follows:

1. Raceways include conduit and wireway, both nonmetallic and metallic.

2. Junction boxes are boxes that are part of the raceway installation, and include pull boxes and boxes for electrical connections.

16.21.2 General Requirements

A. Comply with the following:

1. Locate raceways and junction boxes to avoid mechanical damage.

2. If the installation of raceways or junction boxes causes the connection of dissimilar materials, the installation shall comply with the requirements for dissimilar materials in this Section.

3. Raceways and their installation in exterior locations, or in interior locations exposed to water or other liquids, shall be watertight to an IP66 rating, in accordance with ANSI/IEC 60529.

16.21.3 Conduit

16.21.3.1 Permitted Conduit Types

A. Comply with the following:

1. Flexible Non-Metallic Conduit:

a. Use: May be used where flexibility is required but not where subject to physical damage.

b. Aluminum conduit and flexible non-metallic nylon conduit, which meet the requirements of this Section, may be proposed for approval for carbody interior locations on a case by case basis. Use of flexible conduit for enclosure connections may be submitted for approval on a case by case basis.

c. Conduit: Material meeting the flammability, smoke emission, and toxicity requirements of this Section.

(1) Interior use: Rated IP64, in accordance with ANSI/IEC 60529, with fittings

(2) Exterior use: UV resistant and rated IP66 with fittings

d. Terminations: Manufactured by the conduit manufacturer for the conduit selected and suitable for the application.

e. Fittings to secure conduit:

(1) For corrugated-exterior-wall type: Clips manufactured for the purpose by the conduit manufacturer and designed to restrain longitudinal motion.

(2) For smooth-exterior-wall type: Two-hole, heavy-duty galvanized steel straps, manufactured for the size of conduit they are used to secure.

2. Liquidtight Flexible Metal Conduit:

a. Use: May be used in the same locations as flexible nonmetallic conduit, except where exposed to accidental impact damage, such as under the car ends.

b. Core: Flexible galvanized steel with a continuous copper bonding conductor spiral wound between the convolutions.

c. Jacket: Extruded liquid-tight plastic or neoprene meeting the flammability, smoke emission, and toxicity requirements of this Section; moisture- and oil-proof. If used in exterior locations, jacket shall be UV resistant and rated IP66 with fittings.

d. Terminations: Zinc-coated steel.

e. Fittings to secure conduit: Two-hole, heavy-duty galvanized steel straps, manufactured for the size of conduit they are used to secure.

3. Rigid Metal Conduit:

a. Use: May be used where flexibility is not required.

b. Conduit, elbows, nipples: Steel, hot-dip galvanized inside and out after threading, UL listed, complying with ANSI C80.1.

c. Couplings and Terminations: Steel, galvanized, threaded type.

d. Bushings: Nylon insulated, metallic.

e. Fittings to secure conduit: Two-hole, heavy-duty galvanized steel straps, manufactured for the size of conduit they are used to secure.

16.21.3.2 Conduit Installation

A. Comply with the following:

1. General:

a. Install conduit to prevent moisture traps and arrange to gravity-drain toward control boxes or an open end.

b. Install conduit such that wire and cable may be installed after conduit installation without using power equipment and without exceeding the allowed wire or cable pulling tension or sidewall tension.

c. Conduit shall be securely clamped with all runs electrically grounded to make a continuous ground. Conduit installation shall not create situations of dissimilar metals.

d. Conduit clamps and supports shall be attached to carbody or truck brackets; the use of other pipes or conduit as a sole support for a conduit clamp is prohibited.

e. Conduit shall be color coded: grey for those carrying circuits above 100 volts and black for those carrying circuits under 100 volts.

2. Flexible Nonmetallic Conduit: Install conduit in accordance with the requirements of NFPA 70, Article 356, Liquidtight Flexible Nonmetallic Conduit, including but not limited to the number of bends in one run, bend radii, and securing and supporting conduit.

3. Liquidtight Flexible Metal Conduit: Install conduit in accordance with the requirements of NFPA 70, Article 350, Liquidtight Flexible Metal Conduit, including but not limited to the number of bends in one run, bend radii, and securing and supporting conduit.

4. Rigid Metal Conduit:

    a. Install conduit in accordance with NFPA 70, Article 344, Rigid Metal Conduit, including but not limited to how bends are made, the number of bends in one run, bend radii, reaming and threading, securing and supporting conduit, and use of bushings.

    b. After threading, clean to remove threading oil and protect from corrosion with minimum two coats of brushed on cold galvanizing compound.

    c. If conduit is terminated at floor level, extend minimum 1 in (25 mm) about the floor to prevent entrance of liquid.

    d. Clean conduit after installation by pulling through a brush or swab.

16.21.4 Size and Fill

A. Comply with the following:

1. Conduit shall be sized such that the sum of the wire cross sectional areas (including conductors, insulation, jacketing, etc.) does not exceed 40 percent of the inner cross sectional area of the conduit for three or more conductors.

2. For two conductors, a limit of 31 percent shall be used while for a single conductor a limit of 53 percent shall be permitted.

3. Where conduits having a length not exceeding two feet and without bends of more than 15 degrees are used between enclosures, a maximum fill of 60 percent shall be permitted.

16.21.4.1 Conduit Connections to Boxes and Enclosures

A. Comply with the following:

1. Conduit connections to boxes and enclosures shall be configured as follows:

    a. So that structural, electrical, and environmental integrity is maintained.

    b. To facilitate removal and replacement of the equipment enclosure. Conduit entries into removable equipment boxes shall be secured by means of a bolt-on watertight access panel.

2. Conduit shall be connected to underfloor and roof equipment enclosures using watertight connectors. The entrance of conduit into the top and bottom of equipment boxes is prohibited.

3. All fittings and junction boxes for car wiring shall be metal as manufactured by the Contractor or by a supplier of a comprehensive line of fittings and boxes. The Contractor shall submit the proposed product line for approval **(CDRL 16-30, Electrical Fitting and Junction Box Product Line).**

16.21.5 Wireway

16.21.5.1 Scope

A. Wireway includes wire duct, trough, channel, or other means, not including conduit, used to contain electrical wire, electrical cable, or communications cable.

16.21.5.2 General Requirements

A. Comply with the following:

1. Use restrictions: Shall be used only where it will remain permanently accessible, such as where installed in electrical lockers or behind removable panels.

2. Under no circumstances shall leads be dropped over the edge of the wireways with or without wireway edge protection. In underfloor locations, covers shall have sufficient engagement to prevent the entry of car washer chemicals.

3. Design and installation: Ensure that wire and cable can be installed without damage:

   a. Surfaces and edges: Designed to prevent damage to wire and cable insulation.

   b. Wire entry and exit points: Provide additional wire protection and support.

4. Wire management: Provide means to securely fasten wire and cable within wireways to prevent movement and chafing, but allow changes to be made throughout the lifetime of the car.

5. Wireway elbows, couplings, and similar fittings as well as all internal fastener heads shall be flush with the interior surface. Fasteners shall not be directed toward the interior of wireways.

6. All wireways shall be routed such that they avoid sources of heat, wheel splash areas, and areas along the vehicle where the trays may be subject to foreign object damage. The wireways shall be located such that it will be possible to reach the harnesses contained within for maintenance activity.

7. Barriers: If used for conductors of different voltages, provide circuit separation as specified in TS 16.21.5.2.

16.21.5.3 Interior

A. Interior wireway may be non-metallic or metallic, as appropriate for the application:

1. Non-metallic wireway:

a. Material shall be low-smoke, halogen-free, complying with requirements for flammability, smoke emission, and toxicity in this Section.

b. Wireway shall be designed for the intended purpose and may be solid or slotted.

c. Provide a removable cover.

d. Attach securely to car structure using specified fasteners; adhesive fasteners are not permitted. Secure at intervals complying with NFPA 70, Article 378, Nonmetallic Wireways.

2. Metallic wireway: Shall meet the requirements for exterior metal wireway.

16.21.5.4 Exterior

A. Exterior wireway shall be metallic, unless otherwise Approved, and shall comply with the following requirements:

1. Material: Stainless steel, or steel primed and painted in accordance with the requirements of this Section.

2. Drains: Provide to prevent accumulation of water, unless made with perforated material.

3. Covers: Removable.

4. Installation: Shall be attached securely to car structure using specified fasteners. Shall be secured at intervals complying with NFPA 70, Article 376, Metal Wireways.

16.21.6 Junction Boxes

16.21.6.1 General

A. Comply with the following general requirements for interior and exterior junction boxes:

1. Manufacturer: Shall be the Contractor or a regular manufacturer of electrical junction boxes.

2. Interior finish: Shall be primed and painted white.

3. Covers: Shall be gasketed and retained by spring-type latches or captive screws as agreed by the Owner on a location-by-location basis. Fasteners shall be stainless steel.

16.21.6.2 Exterior Junction Boxes

A. Exterior junction boxes shall meet the general requirements for junction boxes. In addition, they shall be minimum 14-gauge steel and weatherproof, equivalent to NEMA 250 Type 4.

B. The bottom of all exterior junction boxes shall be sloped to allow drainage. Drain holes shall be equipped with stainless steel cotter keys with the ends turned up or similar system as Approved.

16.21.7 Bonding and Grounding Metallic Raceway and Junction Boxes

A. Metallic raceway and junction box installations shall comply with the following:

1. Provide appropriate fittings such that raceways and connected junction boxes are mechanically and electrically continuous.

2. Provide additional bonding jumpers or internal grounding wires if necessary to provide electrical continuity.

3. Safety ground raceway and junction boxes to car structure in accordance with TS 16.23.8.

16.21.8 Covers

A. Covers shall be completely removable. All junction box covers that access equipment or terminals shall be dust proof retained by compressive spring type latches or captive screws as Approved on a location by location basis.

B. All fasteners used in junction boxes shall be stainless steel. Screws and other hardware shall be zinc plated or stainless steel. All covers shall be designed to accept or mate with a bulb type clamp on seal.

C. All pull boxes that facilitate pulling of cable shall be a neoprene sealed and bolted design.

16.22 Wire and Cable

16.22.1 General

A. Comply with the following general requirements for all wire and cable used on the car:

1. Limit the number of wire types and sizes used in the car to the extent possible.

2. Apply and install wire and cable as indicated in NFPA 70, Chapter 3, Wiring Methods and Materials, EN 50343, APTA PR-E-RP-002-98, NFPA 130, and IEEE

Std 16, and the AAR Manual of Standards, Section F S-538, "Wiring Practice and Rolling Stock Standard", except where otherwise specified, and except that wire shall be as specified.

3. Car wiring shall have circuit protection conforming to NFPA 70, Article 240, Overcurrent Protection, or the Specifications.

4. Wire and cable shall comply with the flammability, smoke emission, and toxicity requirements of this Section, AAR RP-585, and NFPA 130.

5. Only wire or cable shall be used for carrying electrical current. Exceptions are pantographs and other devices specifically designed to be electrical conductors.

6. All control and power cables shall be terminated within enclosures or junction boxes.

7. Where the Specifications use wire insulation trade names, the use of an Approved equal is acceptable.

8. Submit documentation. (**CDRL 16--31, Documentation for Wire and Cable**)

16.22.2 Wire and Cable Type Requirements

16.22.2.1 Conductors

A. Comply with the following:

1. Material: Conductors shall be soft, annealed copper, in accordance with ASTM B33.

2. Stranding and conductor construction for all wires and cables shall be in accordance with the Association of American Railroads Manual of Standards and Recommended Practices, Recommended Practice RP-585, Wiring and Cable Specification

3. Plating: Shall be as indicated in standards referenced for wire types in TS 16.21.2, or if not indicated, in accordance with temperatures below:

   a. 150°C or less: Tinned; ASTM B33.

   b. 250°C or less: Silver-plated; ASTM B298.

   c. 450°C or less: Nickel-plated; ASTM B355.

4. Stranding: Shall be suitable for the application. Extra-fine wire stranding shall be used on applications subject to repetitive motion, where superior flexibility is necessary for proper installation, or as specified elsewhere. The use of solid wire is not permitted.

5. In no case shall wire smaller than the following sizes be used:

a. Wire which is pulled through conduits or wireways – AWG No. 16

b. Wire on electronic units, cards, and card racks – AWG No. 22

c. Wire within control compartments – AWG No. 18

d. Multiconductor cables where current is not a factor in wire size selection – AWG No. 18.

e. All other wire including that which is not pulled through wireways and conduits – AWG No. 16

SEPTA may Approve smaller wire sizes for selected applications upon submission of appropriate applicable data for justification.

16.22.2.2 Insulation

A. Comply with the following:

1. Flexibility: For wire sizes No. 6 AWG and larger, the insulation material shall be formulated for extra flexibility.

2. Voltage Rating:

a. Nominal voltages 100 V or less: Insulation shall be rated 600 V, AC and DC.

b. Nominal voltages greater than 100 V: Insulation shall be rated 2000 V, AC and DC.

3. General Carbody Wiring:

a. Sizes No. 12 to No. 28 AWG: Teflon, mineral-filled, abrasion-resistant insulation; or

b. All sizes: Flame retardant, flexible, cross-linked polyolefin complying with ICEA S-95-658, having a continuous temperature rating of 110°C (230°F) or 125°C (257°F), as appropriate for the application.

c. Flammability, Smoke Emission, and Toxicity Standards as specified in Section 23, System Safety and Security.

4. High-Temperature Applications:

a. Sizes No. 16 AWG and Larger:

(1) Abrasion resistant Teflon polytetrafluoroethylene (PTFE) complying with SAE AS 22759/6 or tetrafluoroethylene (TFE) complying with SAE AS 22759/10, as appropriate for the voltage level; or

(2) Silicone rubber complying with AAR RP-587 and suitable for the application.

b. Sizes No. 18 AWG and Smaller:

(1) Abrasion resistant Teflon PTFE complying with SAE AS 22759/6 or TFE complying with SAE AS 22759/10, as appropriate for the voltage level.

c. When used for interconnecting pieces of apparatus, wire used in high-temperature applications shall be in bundles with a high-temperature rated, low-smoke generating, insulated protective covering.

5. In Equipment: Wiring within replacement modular units, electronic apparatus such as cards and card racks, and other equipment, as Approved, shall be one of the following:

a. Tefzel ethylene tetrafluoroethylene (ETFE) per ASTM D3159 (material standard) and insulation construction per SAE AS 22759/16.

b. Teflon PTFE type EE per NEMA HP 3.

c. Cross-linked polyolefin insulated wire, as described for general carbody wiring, above.

6. Crowded Locations (cab console or similar locations):

a. Tefzel ETFE per ASTM D3159 and insulation construction per SAE AS 22759/16.

b. When used for this application, bundle these type wires with a protective covering of cross-linked modified polyolefin or similar high-temperature rated, low-smoke generating insulation. The protective covering shall be arranged to protect the wire insulation along the complete length of the wire against abrasion. The final arrangement shall be as approved.

c. The thermal effects of protective covering and of wire bundling shall be considered for each wire when selecting wire gauge.

7. All test reports covering production and qualification tests for all wire insulation types shall be submitted prior to any shipment of materials. Four samples of each type of wire shall be submitted with each test report. Each sample shall be of sufficient length that one complete uninterrupted length of manufacturer's wire marking is clearly visible. Each sample shall have a length of no less than 18". **(CDRL 16-32, Electrical Insulation Test Reports)**

16.22.2.2.1 Insulation Flammability Requirements

A. Insulation shall meet the following flammability requirements:

1. Irradiated cross linked polyolefin shall be tested in accordance with test method ICEA S-66-524/NEMA WC7, Paragraph 6.12.5. After five applications of 15 seconds each with a 3 second rest period between applications, flame shall extinguish in 10 seconds or less.

2. Other insulation materials shall be tested in accordance with IEEE 383.

16.22.2.2.2 Irradiated Cross Linked Polyolefin Wire Insulation

A. The irradiated cross linked polyolefin wire insulation shall be constructed and tested in accordance with the following requirements:

1. Flexibility Tests for Cables – Flexibility tests for cable sizes up to AWG No. 2/0 shall be performed in accordance with AAR Standard RP-585.

2. Single Conductor Thermal Overload Test – Insulation shall meet the requirements of test method ICEA S-19-81, Paragraph 6.9.2, at 90 degrees F. Stability Factor shall be 1.0 minimum. Alternatively stability factor difference, 1-14 days maximum, shall be 0.5 with a SIC (one day) maximum of 6.0.

3. Ozone – Using test method ICEA S-19-81, Paragraph 6.8, there shall be no insulation cracks after 24 hours exposure to an ozone concentration of 0.03 percent by volume at 90 degrees C plus or minus 2 degrees C.

4. Tension Set – Insulation shall meet the requirements of test method ICEA S-66-524, Paragraph 6.4.11.4. As an alternative procedure, test method ICEA S-19-81, paragraph 6.4.13.4, may be used with the additional provision that the specimen shall be stretched until the gauge marks are 4 inches apart and that the average of three specimens not exceed a tension set of 30 percent.

5. Corrosivity – Using test method ASTM D267, there shall be no more than 5 percent copper film removal after a test period of 16 hours at 175 degrees C, plus or minus two degrees C.

6. Moisture Absorption – Wiring and cable shall be subjected to the gravimetric method at 70 degrees C plus or minus 20 degrees C for 168 hours per ICEA-S-66-524.

7. Single Conductor Thermal Overload Test – A continuous current of 115 amperes shall be applied to an 18 foot length of AWG No. 10 test wire in 25^{o}C still air. A 3,000 volt DC potential shall be maintained between the test wire and an AWG No. 18 bare copper wire wrapped snugly around the outer insulation surface of the test wire. Failure shall occur when a short circuit is established between the bare copper wire and the test wire. Minimum time to failure shall be three minutes.

8. Bundle Overload – A bundle overload using a seven wire bundle shall be performed in accordance with AAR Standard RP-585.

9. Temperature Cycling Tests – This test shall be performed on an eight foot length of AWG No. 10 wire with 2 kV insulation.

    a. Thermocouples shall be attached to the outer jacket surface and on the conductor under a small incision in the insulation approximately 12 inches from one end of the sample. Both ends of the sample shall be securely clamped using hose clamps.

    b. Prior to temperature cycling, the sample shall be conditioned for two hours at a temperature of 150^{o}C.

    c. The sample shall then be temperature cycled between an ambient of 125^{o}C and -30^{o}C by transferring the sample between an air circulating oven set at 125^{o}C and an air circulating cold box set at -30^{o}C. The time during which the sample stays in each chamber shall be sufficient to allow both thermocouples on the sample to read the same temperature as the environment.

    d. One cycle shall be defined as an Approved dwell time at both 125^{o}C and -30^{o}C. The sample shall be subjected to a total of 250 cycles with a visual observation at the end of each cycle for cracks and other damage. After 250 cycles, the sample shall be immersed in water for six hours with both ends out of the water, then subjected to a dielectric test of 5kVac for five minutes, and also examined by microscope to verify that no cracks exist.

    e. Flame retardant flexible irradiated cross linked polyolefin insulation rated at 125^{o}C may be used provided that it meets the requirements of all of the above tests and standards modified to reflect the temperature rating related characteristics. The revised values and the use of such wire must be Approved. Cross linked polyolefin insulation shall not be permitted for use on wires connected to heater elements or any other high temperature device.

16.22.2.2.3 Other Insulation Parameters

A. All insulation other than irradiated cross linked polyolefin shall meet the following test requirements based on MIL-W-22759 and using the following parameters:

    1. Dielectric – Test per MIL-W-22759/10B (for 1,000 V wire with tests at 9.5 KV impulse) or MIL-W-22759/6B (for 600 V wires with tests at 8 KV impulse)

    2. Insulation Resistance – The minimum acceptable resistance to a solidly grounded carbody for each class of car wiring shall be as stated below when tested at the listed voltages using an Approved megohmmeter. All wiring is assumed to be solidly grounded except the wire class under test:

Wire Class	Voltage	Minimum Result
600 volts	1000 volts	50 megohms

Wire Class	Voltage	Minimum Result
230 volts	1000 volts	25 megaohms
37.5 volts or below	500 volts	5 megaohms

a. All carbody wiring and cables shall be capable of withstanding a high potential test with a minimum duration of 60 seconds using an applied 60 Hertz voltage as listed below. The application and removal of the voltage shall not exceed a rate of 150 volts/second. During the test period, the current leakage shall not increase. All wiring is assumed to be solidly grounded along with the carbody except for the wire class under test:

Wire Class	Test Voltage
600 volts	2200 volts
230 volts	1400 volts
37.5 volts or below	500 volts

b. Inasmuch as the insulation resistance varies with the season and humidity, the Contractor shall ensure that these requirements can be met under the most severe climate conditions.

3. Spark Test – 100 percent of all single conductor cables and all single conductor cables being used in a multiconductor cable shall be inspected by impulse dielectric test or by chain electrode spark test. Spark test apparatus and procedure shall be in accordance with MIL-W-22759. Spark test voltages shall be equivalent to impulse test voltages by corresponding RMS value at 3 kilohertz.

Impulse Test Voltage KV Peak	3 KHz Test Voltage KV RMS
8	5.7
9.5	6.7
10	7.1

4. Air Aging – Test per ASTM D638. Age sample for seven days at 302^{o}F in air oven. Minimum tensile strength and elongation shall not be less than 85 percent of the unaged values. Also test per IEEE STD 383-1974 and ASTM D573 for extended life.

5. Cold Bend – Test per NEMA WC3 except test temperature shall be -58^{o}F.

6. Weight Loss – Weight loss of the insulation material shall not exceed one percent when subjected to an oven temperature of 266E F for 500 hours.

7. Chemical Resistance – An appropriate length sample shall be measured for insulation diameter and total weight to record initial values. The wire shall be immersed to within 3inches of each end in the test fluid for 24 hours at 149 degrees F. During the immersion stage, the minimum bend radius of the wire shall be ten times the diameter of the wire being tested. Upon removal from the test fluid, the specimen shall be cooled to room temperature for one hour, and the diameter gauged and reweighed for comparison with the original values. The maximum diameter and weight increase shall not exceed 30 percent. Typical fluids for this test include:

    a. Humble No. 2214 Railroad Diesel Lubricating Oil and lubricants (100 percent solution)

    b. Humble Diesel 260 or Railroad T fuel oil (100 percent solution)

    c. Mineral oil (100 percent solution)

    d. Hydrochloric acid, nitric acid, sodium hydroxide, sulfuric acid (0.1 percent solution)

    e. Potassium hydroxide (0.1 percent solution)

    f. Petroleum distillates and other graffiti removers and cleaning compounds

    g. Kerosene solvents (100 percent solution)

    h. Trisodium phosphate solution (50 percent solution)

    i. Skydrol 500 B hydraulic fluid (100 percent solution)

    j. Water

8. Temperature Cycling Testing – The test shall be performed on an eight foot length sample of AWG No. 12 wire.

    a. Thermocouples shall be attached to the outer jacket surface and on the conductor under a small incision in the insulation about (12) inches from one end of the sample. Both ends of the sample shall be securely clamped using hose clamps.

    b. The sample shall be conditioned for two hours at a temperature of 150^{o}C. The sample shall then be temperature cycled between ambients of 125^{o}C and -30^{o}C by transferring the sample between an air circulating oven set at 125E C and an air circulating cold box set at -30^{o}C. The time during which the sample stays in each chamber shall be sufficient to allow both thermocouples on the sample to read the same temperature as the environment.

c. One cycle shall be defined as an Approved dwell time at both 125°C and -30°C. The sample shall be subjected to a total of 250 cycles with visual observation at the end of each cycle for cracks and other damage. After 250 cycles, the sample shall be immersed in water for six hours with both ends out of the water and then subjected to a dielectric test of five 5 kVAC for five minutes and also examined by microscope to verify that no cracks exist.

9. Single Conductor Thermal Overload Test – A continuous current of 115 amperes shall be applied to an 18 inch length of AWG No. 12 test wire in 25°C still air. A 1,000 volt dc potential shall be maintained between the test wire and an AWG No. 18 bare copper wire wrapped snugly around the outer insulating surface of the test wire. Failure shall occur when a short circuit is established between the copper wire and the test wire. Minimum time to failure shall be three minutes.

10. Seven Wire Bundle Thermal Overload Test – A seven wire cable bundle shall be formed by twisting six insulated AWG No. 12 conductors around a center insulated AWG No. 12 conductor.

    a. A 120 ampere current shall be passed through the center conductor for seven minutes. After a test period, the cable bundle shall be examined for visible damage to the outer six conductors. Failure shall occur if any of the outer conductors split, rupture, or melt and adhere to the center conductor insulation.

11. Production and Qualification Tests – The tests required for this Specification concerning qualification and production shall be in accordance with tests in MIL-W-22759 for all lots produced.

    a. All test reports covering production and qualification tests shall be submitted with samplings prior to any shipment of materials. **(CDRL 16-32, Electrical Insulation Test Reports)**

16.22.2.3 Multiconductor Cables

A. Multiconductor cables, where Approved, shall be constructed using conductors and insulation as described above or in NEMA WC 27500. Where a conflict exists, the most restrictive condition shall apply.

1. Fillers: Where required to obtain a circular cross-section, fillers shall be made of non-hygroscopic materials compatible with the wire insulation and jacket, and shall be of the same or of a higher temperature rating than the wire insulation.

2. Binder tape: Material shall be non-hygroscopic, of the same (or better) temperature class as the wire insulation, and of a compatible material. Binder tape shall be employed over the assembly of conductors if needed to assist in cable manufacture, or as required to permit the cable to function as intended in its application.

3. Shield (if required): Shall consist of either copper braid conforming to ASTM B33, concentrically-served copper, or aluminum/polyester tape with a drain wire, as appropriate for the application. The shields shall have the following minimum properties:

    a. Copper braid strands shall be either tinned, conforming to ASTM B33, or silver-coated conforming to ASTM B298, as appropriate for the wire insulation. Strand size and application shall be as recommended by the cable manufacturer for the application but shall be minimum No. 38 AWG. Shield coverage shall be minimum 85%.

    b. Aluminum/polyester tape shields shall consist of a helical wrap of aluminum/ polyester tape with a nominal thickness of 0.0004 in (0.01 mm) aluminum on a backing of 0.001-in (0.0254 mm) polyester. In contact with the aluminum side of the shielding tape shall be a No. 22 AWG 7/30 tinned copper drain wire conforming to ASTM B33 and ASTM B174. The tape shall have a minimum overlap of 10% of the tape width to ensure complete coverage.

4. Jackets:

    a. The overall jacket of multiconductor cables shall be of flame retardant, cross-linked, modified polyolefin; ETFE Tefzel or PTFE Teflon to match the wire insulation and application as Approved.

    b. The jacket shall be extruded and vulcanized over the cabled conductors, and shall be well centered, with a smooth appearance without objectionable roughness or irregularities, consistent with good industry practice.

5. Coupler cable jacket (sheath): Shall be of low-temperature polychloroprene (neoprene) per MIL-DTL-13777, with a wall thickness suitable for 600 volts.

6. Identification:

    a. Individual conductors in multiconductor cables shall be color coded or otherwise permanently identified as Approved.

    b. Overall jacket shall be permanently marked at maximum 3 ft (1 m) intervals with the following information, as a minimum:

        (1) Conductor size

        (2) Number of conductors

        (3) Voltage rating

        (4) Jacket type

16.22.2.4 Ethernet Cable

A. For network cabling, provide industrial-grade Ethernet cable (Category 6A or better, 300-volt rated) designed for reliable performance in a transit environment:

1. Conductors: Shall be tinned copper, solid or stranded as required for the application and specified performance.

2. Shielding: Shall be provided if required to obtain specified performance.

3. Jacket: Shall be abrasion-resistant.

4. Construction:

a. Shall be suitable for the intended installation method.

b. Shall comply with flammability, smoke emission, and toxicity requirements of this Section.

c. Shall be minimum IP65 rated in accordance with ANSI/IEC 60529 when mated with specified connectors.

5. Identification: Cable shall be permanently marked at maximum 3-ft (1-m) intervals with the following information, as a minimum:

a. Electrical performance rating (e.g. Cat 6)

b. Number of pairs and size (AWG)

16.22.3 Insulation Smoke Test

16.22.3.1 Scope

A. This test method describes the equipment and the procedure for preparing insulated wire samples from which the specific optical density (D_s) of smoke generated can be determined in the Aminco-NBS Smoke Chamber. This method is used for wire sizes up to and including AWG No. 12. For wire sizes above AWG No. 12, the standard procedure outlined in ASTM E662 shall be used. Equipment calibration, standardization, and operation shall be in accordance with ASTM E662, Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials. The performance criteria shall be D_s (4.0) </= 200 (flaming) and D_s </= 75 (non-flaming).

16.22.3.2 Apparatus

A. Aminco-NBS Smoke Chamber and Recorder

B. Aminco six tube 90 degree burner assembly for flaming mode testing. All burners shall be directed at the sample in one plane.

C. Notchless wire frame (Aminco AWG No. 20 wire frame with notches machined off)

D. Aminco troughless wire specimen holder assembly

E. Air oven

F. Humidification chamber

G. Heavy duty aluminum foil 0.001 +/− 0.0005 inch

H. Razor blade

I. Tape measure

16.22.3.3 Procedure

A. Determine the length of insulated wire required for testing. The individual sample length shall be calculated to produce a sample area of 35 square inches.

1. Calculate the sample length as follows:

$$\ell = \frac{35}{3.1416\, x\, d}$$

Where:

ℓ = sample length

d = diameter of insulated wire (inches)

2. Cut and identify a minimum of three samples of the required length.

3. Condition samples prior to testing by pre-drying in an air oven for 24 hours at 140^{o}F +/- 5^{o}F followed by humidification at 73^{o}F +/- 5^{o}F and a relative humidity of 50 percent for a minimum of 24 hours.

4. After conditioning, wind a sample uniformly around the wire frame so that the frame opening is uniformly covered.

5. Cover the wire wrapped frame with aluminum foil across the back, along the edges, and over the front surface periphery with a single sheet of aluminum foil with the dull side in contact with the wire.

6. Place the foil wrapped wire in a troughless sample holder such that the wire is vertically oriented. Insert millboard backing, spring, and retaining clip.

7. Carefully trim the aluminum foil from the front opening of the sample holder.

8. Adjust wire turns, if necessary, to assure that the sample holder opening is uniformly covered.

9. Perform smoke testing in accordance with ASTM E662 noting any unusual behavior that occurs during the test; for example, self-ignition of the sample in the non-flaming test mode or any extinguishment of a burner triplet during the test.

10. Report the sample orientation, test conditions, results, and observations made during the test. **(CDRL 16-33, Insulation Smoke Test Report)**

16.22.4 Wire and Cable Application Requirements

16.22.4.1 General

A. Selection of wire sizes and insulations shall be based on the current carrying capacity, voltage drop, mechanical strength, temperature, and flexibility requirements in accordance with applicable AAR, ICEA, ASTM, NFPA, and MIL specifications. However, in no case shall the properties of the wire and cable be less than those properties specified in the Specifications.

16.22.4.2 Wire Sizes

A. Comply with the following:

1. Wiring shall be sized for the intended load, voltage drop, application, and installation method.

2. Wire and cable ampacity shall comply with NFPA 70, Section 310.15, Ampacities for Conductors Rated 0-2000 Volts, or with EN 50343. Where the temperature rating of the Approved wire or cable is not included in Section 310.15 or EN 50343 tables, manufacturer's ratings may be used, provided that the rating method is consistent with NFPA 70 Section 310.15 or EN 50343.

3. Regardless of load, minimum wire sizes shall be as follows:

   a. Wire that is pulled through conduits or wireways: No. 16 AWG.

   b. Wire on electronic units, cards, and card racks: No. 22 AWG.

   c. Wire within control compartments: No. 18 AWG.

d. All other wire, including that which is laid in, rather than pulled through, wireways: No. 16 AWG.

e. Multiconductor cables where current is not a factor in wire size selection, such as LED indicator lights or status displays: No. 16 AWG.

f. Multiconductor cables within control compartments: No. 20 AWG.

4. Trainline wiring, and all associated connections, shall be sized for operation of trains with the maximum number of cars as allowed by Section 2, Design and Performance Criteria.

a. The maximum voltage drop permitted between the battery or low-voltage power supply (LVPS) and any supplied load shall not be greater than specified in Section 9, Auxiliary Power.

b. Voltage drop measurements shall include both the supply and return leads.

16.22.4.3 Insulation Level

A. Comply with the following:

1. All wiring within an enclosure shall be insulated for the highest voltage in the enclosure, unless Approved otherwise.

2. All wiring connected to a piece of apparatus shall be insulated for the highest voltage connected.

3. Insulation shall be in accordance with the Association of American Railroads Manual of Standards and Recommended Practices, Recommended Practice RP-585, Wiring and Cable Specification, and the following special requirements.

16.22.4.4 High Temperature Wire

A. Comply with the following:

1. If used for interconnecting pieces of apparatus, high-temperature wire shall be in bundles with a high-temperature rated protective covering.

2. High-temperature insulated wire shall not be used in conduit or raceways without Approval.

16.22.4.5 Circuit Shielding

A. Comply with the following:

1. All applications of shielded cable shall be Approved.

2. Trainline circuits:

    a. Wire shields shall be continuous up to the car's electrical coupler contacts, including contacts of the jumper cable connector at the intermediate couplers.

    b. The wire shields shall be connected through all applicable connectors and junction boxes.

    c. Circuits shall be categorized. Shields contained in one circuit category shall not be interconnected with shields contained in another category. Shields used to protect against interference shall not carry signal current.

3. Low-level signal wires shall not be interconnected with shields on high-level signal wires in the same category.

    a. Each group of shields (other than at the electric couplers) shall be carried through on a connector pin or pins, or on terminal strips which shall be in the immediate proximity of the categorized group of circuits.

    b. Loops due to interconnections of shields shall not be permitted.

4. Coaxial cables used as constant impedance transmission lines shall be terminated as dictated by the circuit termination design and shall not be considered shielded conductors. Triaxial cables may be used as coaxial impedance transmission lines with the outer conductor employed as an RF shield.

5. The following three items shall be considered as guidelines and are not absolute requirements:

    a. Shields used to suppress electromagnetic interference (EMI) at all frequencies shall be terminated only at the low potential side of the interference circuit, at the termination which exhibits maximum susceptibility.

    b. Shields used to protect against the effect of, or to exclude, EMI at frequencies below 150 kHz, shall be terminated either to the low potential side or at the balance point of the protected circuit at the termination which exhibits maximum susceptibility.

    c. Cables requiring both audio frequency (AF) and radio frequency (RF) shields shall be electrically isolated from each other.

        (1) The resistance between these circuits shall be at least 500 megohms when 500 Vdc is applied.

        (2) Double shielding shall be required on circuits that are both AF-susceptible and RF-susceptible.

16.22.5 Wiring Methods

A. The layout of wiring, for both car and equipment, shall be designed in advance of its installation and in cooperation with the suppliers of the related equipment.

1. All undercar wiring smaller than No. 6 AWG shall be run in closed wireways, conduits, or open wire mesh wireways in an Approved manner.

2. Lead wires to resiliently-mounted electrical apparatus shall be carried in conduit to a point as close to the apparatus as possible. The length of the leads between the end of the conduit and each piece of apparatus shall be as Approved.

3. Short runs of cables or harnesses entering or leaving conduit and apparatus shall have an Approved guard mounted to the carbody to protect the wires from mechanical damage.

4. Lead wires to solidly-mounted, electrical apparatus and equipment enclosures shall run in conduit connected to the apparatus or enclosure.

5. Wiring run through the floor shall be run in ducts or conduit. Wiring, even if enclosed in loom, shall not be run through partitions without suitable bushings being provided at such points of passage.

6. Harnessed wires shall not be installed in conduit.

16.22.6 Wiring Installation

16.22.6.1 General

A. Comply with the following:

1. Class 3 requirements of IPC/WHMA-A-620, unless otherwise Approved.

2. Wire runs shall be continuous and unbroken between connection points. Splices are prohibited.

3. Wiring shall be secured and protected against movement, chafing, and contact with conductive, sharp, hot, or abrasive objects.

4. Wiring shall not be secured directly to the car structure, equipment enclosures, or metallic surfaces.

5. Wire and cable shall be fully protected against contact with any surface other than that designed specifically to support or protect it. This applies to all current carrying wires, cables, and buses on the car.

6. Wire installation shall not be subject to accumulations of water, oil, or other foreign matter.

7. Wiring run in loom shall not be carried over a potential chafing hazard.

8. Wiring securing devices shall be either completely non-metallic or metallic with a resilient, insulating member between the wiring and the metallic portion of the device.

9. Wiring shall not be pinched or compressed exceeding manufacturer's recommendations.

10. No exposed wiring within the interior of the car shall be permitted.

11. Only totally environment proof electrical connectors shall be used underneath the car.

12. All jumpers, jumper heads, and jumper receptacles shall be sealed in an Approved manner to prevent the entry of water at any operating speed of the car.

16.22.6.2 Circuit Separation

A. Comply with the following:

1. Circuits shall be physically separated to reduce the possibility of unsafe conditions, interference, or equipment damage.

2. The following major circuit groups shall not be harnessed or bundled together, shall not run in the same conduit, and shall be physically separated and secured in enclosures, wire ducts, junction boxes, or other wire routing devices:

a. ATC circuits

b. High-voltage circuits

c. AC circuits

d. Communication circuits

e. Battery voltage level circuits

f. Semiconductor gating voltage level circuits

g. Network circuits

h. Catenary supply circuits

i. Conductors carrying in excess of 100 Amperes.

3. Wiring operating at potentials differing by 50 Volts or more shall be separated by a physical barrier as follows:

    a. Wires shall not be cabled together and shall not be placed in the same conduit.

    b. Where possible, wires shall not be placed in the same junction box or enclosure. Where a raceway, duct, junction box or enclosure is divided into two or more distinct areas by metallic partitions, each area may be considered separately in the application of this rule.

    c. Where it is impossible to avoid having wires at different voltages, the wires shall be physically separated, bundled, and secured separately such that contact between wiring is not possible even after securement failure.

4. Wiring connected to transient-generating apparatus, such as unsuppressed contactor coils, shall not be run adjacent to wiring carrying signals to, from, or between semiconductor circuits, logic circuits, vital zero-speed circuits, or communication circuits. In cases in which adequate physical separation is impossible, shielded wire shall be used for all conductors involved.

16.22.6.3 Clearance

A. Comply with the following:

1. Cable and wire shall be installed such that clearance is provided between any part of the carbody or support brackets.

2. At no time shall the clearance between the cable or wire and carbody or brackets or wire trays be less than 0.25 in (6.35 mm).

3. Cables shall not be closer than 2 in (51 mm) to a wheel or other moving surface.

4. Ensure that wires in electrical lockers are managed/routed to avoid restricting access to wire connectors or circuit board ports (e.g. USB ports).

16.22.6.4 Maintainability

A. Comply with the following:

1. Wire and cable shall be readily accessible for inspection and maintenance. Extensive wiring and cabling in the car interior is contrary to accessibility, even though access panels, false floors, and other portals may be provided. Submit a wiring plan that demonstrates conformance to this requirement. **(CDRL 16--34, Wiring Plan)**

2. Concealed wires, such as within conduits and wire ducts, shall be such that wires may be replaced or added to without the removal of other than an access

panel at each end of the wire. It shall not be necessary to disconnect or disassemble conduit to accomplish this task.

3. All circuits and branches shall be separable by means of terminal boards to isolate portions from others for troubleshooting and searching for undesired grounds.

4. Circuits subject to periodic high potential tests shall be so arranged that they can be conveniently set up for the tests.

5. Wires entering a removable box or enclosure shall be harnessed and secured to facilitate removal of the box or enclosure.

6. Wiring needed to calibrate and test car functions shall be a part of the permanent car wiring to enable SEPTA to conveniently maintain the equipment. This wiring shall terminate in Approved connectors in the respective control groups and cabinets.

16.22.6.5 Wire Handling

A. Comply with the following:

1. Wiring shall be installed by qualified and experienced wiring personnel:

   a. Installers shall use appropriate tools for stripping insulation, cutting, tinning, soldering, harness making, attaching terminals, and other wire fabrication tasks.

   b. Wiring tools and equipment shall be used as recommended by the tool and equipment manufacturer.

2. Wires shall be protected from damage during all phases of equipment manufacture.

   a. Wire shall not be walked on, dragged across sharp or abrasive objects, kinked or twisted, or otherwise mishandled.

   b. The ends of wire shall not be permitted to lay on wet floors or other damp areas where moisture may be absorbed into the conductors.

   c. Wire subjected to the above or similar damage shall be discarded or otherwise dispositioned subject to Approval.

3. When removing insulation, wire strands shall not be nicked or broken.

4. Contractor and suppliers shall ensure that all wiring and harnessing practices are well documented and controlled. Wiring and harnessing practices shall be based on standards such as IPC/WHMA-A-620 or equivalent.

16.22.6.6 Wiring Location Requirements

A. Comply with the following:

1. Wiring shall be located and secured such that normal equipment motion, heat sources, maintenance access, and the operational environment do not damage or reduce the life of the wiring.

2. Wiring shall not pass through or over the battery compartment, or over heat-generating equipment such as braking resistors, even if the wire or cable is in conduit.

16.22.6.7 Wire and Cable Entrance and Exit Points

A. Comply with the following:

1. Use permanently retained watertight strain relief bushings, with insulated throat liners, of an Approved design, at locations where wires, cables, or harnesses enter or exit conduit, ducts, apparatus, and equipment enclosures.

2. Strain relief bushings on equipment enclosures shall include a permanently retained O-ring type seal.

3. Harnesses exposed, short cable runs or harnesses entering or leaving exposed raceways shall have Approved, fire-resistant flexible dielectric sleeving over the raceway edges and grommet-type insulation of any penetration holes. Wiring shall be retained to the sleeving with tie-wraps.

4. Provide a watertight bushing and drip loop on all exposed wire and cable entries to prevent fluid runoff into connected equipment.

16.22.6.8 Wire and Cable Installation in Conduit

A. Wire and cable shall be installed in conduit without using power equipment and without exceeding the manufacturer's allowed wire or cable pulling tension or sidewall tension:

1. Clean the conduit just before installation of wire or cable by pulling a brush or swab through.

2. Install all cables to be placed in one duct simultaneously.

3. Use extreme care in installing wire and cables so as to avoid twisting, kinking, scraping, or injuring outer sheath.

4. Use continuous lengths of wire and cable between power source and equipment.

5. Wiring within conduit shall not be bundled or secured.

6. Pulling compound, if used, shall be non-conductive, non-hygroscopic, non-odorous and shall not attract vermin. It shall be compatible with wiring insulation used.

16.22.6.9 Conduit Fill

A. Conduit fill shall not exceed the maximum fill permitted by NFPA 70, Chapter 9, Tables, Table 1, Percent of Cross Section of Conduit and Tubing for Conductors and Cables.

16.22.6.10 Wire and Cable Installation in Wireway

A. The installation of wire and cable in wireway shall comply with the requirements of NFPA 70 Article 376, Metal Wireways, or Article 378, Nonmetallic Wireways, including but not limited to the size of conductors, number of conductors, and ampacity of conductors based on wireway fill.

B. Comply with the following:

1. Wire and cable shall be laid into wireway. If pulling is required, a pulling plan shall be prepared documenting the wire or cable manufacturer's minimum acceptable bend radius and maximum tension during pulling.

2. To the extent possible, all wire and cable shall be installed in a wireway at the same time, unless physical separation barriers are provided.

3. Wire and cable shall be installed neatly and fastened securely at not greater than 24-in (600-mm) intervals to eliminate movement and chafing, including each entrance and exit point. Fastening shall not damage wire or cable or exceed manufacturer’s recommendations.

4. When wire and cable is in its final position, inspect to ensure that it has sufficient bend radius, and that there is no sagging, pinching, or possibility of chafing that could cause damage over time.

16.22.6.11 Wire Installed in Harnesses

A. Wiring may be prefabricated into standard harnesses, wrapped, and tied with nylon wire ties.

1. Harnesses shall be installed with identical arrangement and location in each car having similar equipment.

2. Separate harnesses shall be provided for major circuit groups or types, or as required for specified circuit separation.

3. Harnessed wires shall not be installed in conduit.

16.22.6.12 Wire and Cable Installation by Cleating

A. No. 6 AWG or larger insulated wire may be cleated in place without conduit, duct or open wireway. Cable and wiring exiting wireways/wire ducts shall be cleated.

B. Cleating shall be as follows:

1. Cleat Type:

a. Cleats shall be molded neoprene rubber split-block cleats with clamp stops to prevent over-compression of the wire insulation. Minimize the quantity of different configuration cable cleats.

b. The cushioning material shall be fire retardant insulating material with a durometer of 50 to 60 meeting the requirements of TS 16.7.

c. If neoprene rubber split-block cleats are used each cleat shall have a stiffener of at least 10 gauge material on the side away from the mounting bracket which shall act to spread the bolt clamping force over the entire length of the cleat. Bolts shall have lock nuts.

d. Cleats shall be designed to grip each cable individually and firmly, but without causing any damage to cable insulation, including cold flow of the insulation. Each cable in the cleat shall have its own cutout sized to the correct wire diameter.

2. Installation:

a. Wire and cable runs shall be continuous and unbroken between terminations.

b. Cleated cables shall be routed and supported such that they cannot, under any combination of forces and car movement, touch each other or any other part of the car, except the cleat cushioning material.

c. In areas over the truck, in the wheel wash and not protected by underfloor mounted equipment, wire and cable shall be mechanically protected by an open mesh, expanded metal or other type of Approved guard. The guard may be attached to the bottom of each cleat with the cleat clamping bolts or other Approved arrangement.

d. Wire and cable shall be supported at not greater than 24-in (600-mm) intervals. The wire shall be protected at each support point against mechanical crushing and abrasion.

16.22.6.13 Wiring Within Enclosures

A. Wiring within enclosures shall be attached to wire supports rigidly fastened to the enclosure structure. Comply with the following:

1. Wiring shall be clear from edges, bolt heads, and similar areas, and shall not interfere with or contact enclosure covers, regardless of the insulation properties of covers.

2. Wiring shall be located on the top or sides of the enclosure. Wiring shall be a minimum of 1 in (25 mm) above the bottom of the enclosure, including wiring that must connect to the bottom of apparatus.

3. Wires entering an enclosure from different raceways shall not be harnessed together or with internal wiring.

4. Wiring shall be secured such that there is no strain on wire terminals, multi-pin connector pins, or other wire termination hardware.

5. Wire dress shall allow for sufficient slack at terminals to provide for shock and vibration induced movements, equipment shifting, alignment, cover removal, and component replacement.

6. Provide additional wire length for re-termination of wires without excess tension or splicing as follows:

a. No. 10 AWG and smaller: Four re-terminations

b. No. 8 AWG and larger: Three re-terminations

16.22.6.14 Spare Wires

A. Comply with the following:

1. Provide a minimum of 10% spare wires in each harness or group of wires between equipment enclosures, but no fewer than two spares for each wire size, unless otherwise Approved.

2. Provide at least one nonterminated spare Ethernet cable, as specified in TS 16.22.2.4, to each subsystem and intelligent device connected to the Train Control Network (E-TCN) and the Train Communication and Diagnostic Network (E-TCDN).

3. Unless Approved, no spare wiring shall be used by the Contractor.

4. Install spares in connectors on terminal boards or other means as Approved.

16.22.6.15 Identification

A. Comply with the following:

1. Submit a basic wire and terminal identification system that coordinates each electrical circuit in the car into a unified system and is in conformance with ASME Y14.44. (**CDRL 16--35, Wire and Cable Identification System**)

    a. Identify wiring, including circuit return wiring, and terminals according to their respective circuit function(s), and accurately correlate with the car schematic diagrams.

    b. Individually designate each circuit from point to point. Common designations for return circuits are not permitted.

    c. Alternative designations may be used with Approval in small standard assemblies, such as PA amplifiers.

2. Identify each terminal and identify each wire with its circuit designation, segment identifier, and, if attached to a terminal, its terminal designation. Circuit designation shall correspond with the circuit designation used in the schematics. Each wire segment shall have a unique segment identifier.

    a. Wires shall be marked every 6 in (150 mm) within 12 in (300 mm) of the end of the wire and every 12 in (300 mm) along the entire length of the wire. For premanufactured multiconductor cables, wires shall be marked 6 in (150 mm) from the end of the wire, every 12 in (300 mm) within 10 ft (3 m) of the end of the wire, and every 24 in (600 mm) over the remainder of the wire.

    b. Wire markers shall be stamped in two places, approximately 180 degrees apart, around the cylindrical portion, and shall be consistently oriented for viewing throughout the car and equipment to facilitate readability of the marking.

    c. Provide heat-shrink machine-printed sleeve labels that fit snugly around wire or cable after heat is applied, or continuous wire marking printed on the wire. Hand printing is prohibited.

        (1) Material: Heat shrinkable, fire retardant, zero halogen, oil and grease resistant. Shall comply with SAE AS 5942 and withstand the worst-case combinations of ambient and equipment temperatures.

        (2) Printing: By machine with permanent ink that is chemical and abrasion resistant.

        (3) Color: White or yellow with black printing.

    d. Wires in multiple-conductor cables shall be color-coded.

e. Color coded wires are permitted as an alternative in small standard assemblies such as PA amplifiers.

16.22.6.16 Wire Ties, Clamps, and Anchors

A. Wire ties shall be nylon formulated for resistance to ozone and ultraviolet light, rated for outdoor service.

1. Wire ties:

a. Width shall be selected for intended wiring load and minimum insulation indentation.

b. Shall be installed with tools with automatic tensioning devices, as supplied by the wire tie manufacturer.

c. Shall be installed with sufficient tension to restrain the wiring but without indenting the wire insulation.

d. Shall be installed with cut ends flush with the locking mechanism.

e. Shall have a controlled installation method to prevent overtightening, if used on network wiring.

2. Wire clamps:

a. Wire clamps shall be either nylon as specified above for wire ties or stainless steel covered with neoprene or silicon rubber, such as Adel clamps as manufactured by Adel Wiggins.

b. Shall be sized for each harness such that minimum 90% of the harness circumference is securely clamped.

c. Clamps shall be fastened with bolts and elastic stop nuts.

3. Wire tie anchors (if used):

a. Material: Shall be nylon, as specified above for wire ties.

b. Installation: Shall be fastened to a rigid structure using rivets or screws; adhesive-based wire tie anchors are not permitted.

Where mechanical fastening of wire tie anchors is not feasible, wire tie anchors that are attached using a structural adhesive may be proposed for approval.

16.22.6.17 Insulation Resistance

A. Insulation resistance to ground at 500 or 1,000 Vdc, as applicable for each nominal voltage circuit group when measured with an insulation resistance tester (megger), shall give no less than the resistances shown in Table 16-9, on a car with all circuit breakers closed, and all circuits complete.

Table 16-12, Insulation Resistance	
Nominal Circuit Voltage (dc or ac rms)	**Minimum Insulation Resistance**
Below 90 volts	2 megohms at 500 Vdc
90 volts to 300 volts	4 megohms at 1,000 Vdc
Above 300 volts	5 megohms at 1,000 Vdc

B. Ensure that these requirements will be met under the most severe conditions of temperature and humidity.

16.23 Wire and Cable Connections

16.23.1 General

A. All equipment enclosures and junction boxes, except primary power circuits, shall be fitted with terminal boards or connectors. Primary power circuits shall be fitted with compression terminals and knuckle joint connectors as specified.

B. Submit the proposed design and product line for all connections. Terminal boards with M4 or Number 6 or smaller screws and quick-disconnect terminals, other than those specified, will only be permitted with Approval.

16.23.2 Terminal Boards and Terminal Points

A. Comply with the following:

1. Electrical terminal points and terminal boards shall be one of the following types:

   a. Stud type in accordance with A-A-59125.

   b. Binding head screw type in accordance with A-A-59125, only where Approved

   c. An Approved constant tension spring clamp type, for wire sizes not to exceed No. 12 AWG.

2. Stud-type terminal points:

   a. Shall have brass studs and connections, each of which shall be locked using a single brass nut with flat brass washer and a plated spring-type lock washer. Studs, nuts, and washers may also be made of corrosion-resistant, plated steel, where Approved.

   b. Threaded studs shall have a minimum of 2.5 threads exposed beyond the final nuts and shall not project more than 2.5 threads plus 0.25 in (6.35 mm) beyond the final nuts, unless otherwise Approved.

   c. Adequate space shall be provided to permit connecting wire terminals with standard tools.

d. All terminals shall be properly torqued and marked to ensure sound connections. Spacers shall not be used.

3. Jumpers between terminal board points shall be brass or plated steel. Wire jumpers between adjacent terminals of terminal boards will not be permitted.

4. A maximum of two terminals shall be connected to any one binding screw. A maximum of four terminals shall be connected to any one threaded stud, provided that there is no interference between terminal barrels. On terminal boards, the wiring shall be arranged so that no more than two terminals are connected to a stud, from each side of the terminal boards.

5. Each board or connector shall have the necessary number of terminations plus a minimum of 10% spares, but not fewer than one spare unless Approved.

6. An Approved permanent marking strip on each terminal board shall be provided and attached adjacent to the wire junction point to identify the attached wires or the wires connected to terminal boards shall have the terminal point location printed on the wire.

16.23.3 Wire Terminations

A. Comply with the following:

1. Type:

a. Terminals and connections used throughout the car shall be the mechanical, solderless, crimp type, AMP brand as manufactured by TE Connectivity, or Approved equal.

b. The terminals used on conductors of size No. 10 AWG or smaller shall be of a type that securely grips and holds the insulation of the conductor, unless otherwise Approved.

c. Terminals shall be ring lugs in accordance with SAE AS 25036; spade and hook-type terminals shall not be used. Corrosive protection shall be provided for all base materials.

d. The use of cage-clamp type compression connections will be permitted on No. 12 AWG or smaller wire. Ferrules shall be used.

2. Installation:

a. Terminals and connections shall be attached to the wiring with proper crimping tools and dies as recommended by the manufacturer.

(1) Minimize the total number of crimping tool types needed for all crimp connections.

(2) Terminals fitting wire sizes No. 10-22 AWG shall require no more than three tool models to provide certified crimp connections.

(3) All terminals for the same wire size shall be crimped with the same model tool.

b. Conductors subject to motion relative to the terminal shall be protected by suitable means to prevent breakage of the conductor at or near the terminal.

c. Sufficient slack shall be provided in all wires and cables to prevent breaking or pulling out of bushings and terminals.

d. A maximum of one wire shall be crimped in any one terminal.

e. Where several wires are connected to a terminal strip on a device that is removable for maintenance, the wires shall be terminated with double ring terminations screwed to an insulating fanning strip that keeps the terminations in the correct relative locations while removed from the device, unless otherwise Approved.

3. Submit documentation. **(CDRL 16-36, Wire Termination Documentation)**

16.23.4 Power Cable Terminations

A. Comply with the following:

1. Type: Power cables shall be terminated with an Approved compression terminal.

2. Installation:

a. Sufficient cable slack shall be provided to preclude breaking or pull-out from bushings or terminals and to allow two terminal changes.

b. Cable conductors shall be clean prior to installation of terminals.

c. Compression terminals shall be applied using tools and procedures recommended by the terminal manufacturer for that purpose. Swaging tools shall be of a type that ensures complete swaging in every case.

16.23.5 Motor Lead Terminals

A. Comply with the following:

1. Type:

a. The motor lead terminals shall accommodate a three-phase connector designed for this application, such as a HARTING connector or Approved equal.

2. Installation:

    a. The motor lead terminals on the motor shall be in the junction box integral to the motor.

16.23.6 Cable Connectors

A. Comply with the following:

1. Type:

    a. Cable connectors shall be HARTING HAN series, or Approved equal, and shall conform to SAE AS 50151, or an equivalent standard as Approved.

    b. Unused connector pin positions shall be plugged in accordance with IPC/WHMA-A-620.

    c. Male contacts shall be mounted on the equipment side with female contacts mounted on the power side. Adjacent connectors shall be identified and keyed.

    d. They shall employ removable crimp contacts of the correct size for the wire being terminated.

    e. The connector contact area shall be plated with a minimum of 0.000030 in (0.0008 mm) of gold over a minimum of 0.000050 in (0.001 mm) of low-stress nickel, except in high current applications, plating shall be a minimum of 0.00010 in (0.0025 mm) of silver.

    f. Where quarter-turn, bayonet-lock connectors are specified they shall conform to all provisions in SAE AS 50151, or an Approved standard, except for the screw coupling requirement.

    g. The cable jacket shall be held by a clamp within the connector body.

    h. Bolts within the connector shall be long enough to ensure that there is sufficient room to terminate the cable wires within the connector body.

    i. Connectors in the electrical locker shall be of a type that provides visual and tactile indication that connectors are fully tightened/locked.

2. All cable connector applications shall be Approved.

3. Exterior locations:

    a. Cable connectors used in exterior locations shall be of the environmental watertight variety. Cable connectors shall be equipped with sealing gaskets on the front mating surface and on the back where the cable enters.

    b. Plastic bodied connectors shall not be used in exterior locations.

c. Except as provided above, all cable connectors in exterior locations, shall be quarter-turn, bayonet-lock, quick disconnect ITT VEAM, type CIR connectors, Harting connectors, or Approved equal. All cable connectors shall be from the same manufacturer.

4. In waterproof interior locations, the use of non-weatherproof connectors will be allowed as Approved. All other connector requirements specified in this section which do not directly apply to weatherproofing shall be met.

5. In high vibration or high motion areas such as speed sensors and trainline jumpers, connectors shall have the wire connections soldered and potted. A watertight jacket shall be molded over the cables and connectors to form a unitized assembly. Conduct an Approved vibration test on these unitized assemblies.

6. Installation:

a. Adjacent connectors shall either use different inserts or different insert orientations to prevent erroneous connections.

b. The receptacle half of all cable connectors shall be rigidly mounted.

c. Unused connector pin/socket positions shall be sealed with either connector contacts or plastic sealing plugs designed for that purpose.

d. In all locations where plug/socket contact degradation could potentially occur due to micro-movement of contacts because of wire movement, wires shall be cleated or supported close to the mating connector(s) to avoid such degradation.

16.23.7 Quick-Disconnect Terminals

A. Comply with the following:

1. Approved quick-disconnect terminals shall be used to facilitate maintenance and inspection.

2. They shall provide positive terminal engagement and be shock and vibration proof.

3. No "push-to-fit" (FASTON) type terminals will be permitted. If "push-to-fit" type terminals are allowed they shall be the locking tab type. Application of these type terminals will be on a case-by-case basis and shall be limited to low-voltage, excluding undercar application, and non-heat generating resistors (above 10 watts).

4. Terminals shall be provided with insulation equal to that of the wire.

5. Ethernet communication cables shall use M12 push-pull connectors.

16.23.8 Grounding Return Connections

16.23.8.1 Grounding

A. Comply with the following:

1. Grounding connections to the carbody and equipment shall be made in accordance with IEEE Std 16, Section 4.12, Grounding and Bonding.

2. Ground pads shall be visible and accessible for inspection and troubleshooting.

3. The ground connections shall be attached by a bolt, washer, and nut designed for the purpose.

   a. Equipment enclosures and shock-mounted equipment shall be grounded with flexible, strap-type, grounding leads bolted between a carbody grounding pad and the equipment's grounding pad.

   b. Where there is relative motion between the two items being connected, braided, strap-type leads shall be used.

   c. The ground strap termination method shall apply uniform pressure to the conductive surface.

   d. The current density shall not exceed the bonding requirements of TS 16.23.8.2.

4. The Contractor may propose alternate grounding connection methods with proven service history in similar environments.

5. See Section 9, Auxiliary Power, for ground brush, trainline ground, and related requirements.

6. Low-voltage and high-voltage circuits shall not be grounded to the same ground.

7. Submit a complete grounding scheme, which shall indicate the means by which it is proposed to prevent currents from passing through journal, motor, and truck-center bearings.

16.23.8.2 Bonding

A. Comply with the following:

1. All grounding and bonding jumpers and straps shall be sized to handle fault current and lightning discharge current, for which the voltage drop shall not exceed 25 volts.

2. The bonding method employed shall not produce a dc resistance in excess of 0.0025 ohms, or more than 0.025 ohms at 150 kHz for any applied ac voltage.

3. Grounding and bonding jumpers, and brazed shunt straps shall be "extra-flexible."

4. Bonding requirements shall conform to NFPA 70.

16.23.9 Wire Splicing

A. Comply with the following:

1. Splicing of conductors is prohibited except with Approval, on a case-by-case basis. Splicing of conductors in conduit is prohibited.

2. If a splice is Approved, it shall comply with the following:

a. The splice shall be in a junction box.

b. The spliced joint shall be mechanically as strong and have the same conductivity as the other parts of the conductor.

c. The splice shall be an insulated, permanent crimp splice in accordance with SAE AS 7928, Type II, Class I, and shall be insulated with self-sealing, weathertight, seamless shrink tubing.

d. It shall be installed with the crimping tool and die of the splice manufacturer.

e. The outside diameter of the spliced portion of the cable after the insulation is applied shall not exceed the outside diameter of the unspliced portion by more than 40%.

f. Splices shall be identified in the integrated schematic.

16.24 Electrical Devices and Hardware

16.24.1 General

A. Electrical devices shall be service proven. Where applicable, electrical devices shall conform to IEEE Std 16. (SEPTA is willing to consider for Approval enclosed devices compliant with EN 50124, provided that their high reliability and service-proven nature are demonstrated.)

16.24.2 Contactors and Relays

16.24.2.1 General

A. Comply with the following general requirements for both contactors and relays:

1. Unless otherwise Approved, contactors and relays shall meet or exceed the requirements of MIL-PRF-6106, MIL-DTL-5757 or IEC 60947-4 as applicable, with the following two qualifications:

    a. Devices shall be tested for proper functioning in orientations up to 30 degrees from the orientation in which they are mounted in the car, in each of the three possible rotations: pitch, yaw, and roll.

    b. If adequate documentation exists demonstrating that during functional and operational testing of the car the contactors underwent normal duty cycle tests, it shall be considered as an acceptable alternative to a burn-in.

    c. Contactors shall be NEMA unless otherwise Approved.

2. Devices shall be of heavy-duty construction suitable for use in the transit industry.

3. Devices shall be constructed and used in a fail-safe manner; to be confirmed by FMECA.

4. Devices shall be installed so that they are fully accessible for inspection, repair-in-place, or removal and replacement.

5. Contactors and relays shall incorporate means of visually determining whether they are picked up or dropped out. Relays on printed circuit boards or within electronic assemblies may be exempted from the requirement for a visual indication.

6. Unless Approved on a case-by-case basis, there shall be a maximum of no more than two wire terminations on any one contact of the device.

7. Under no circumstances shall either the main or auxiliary contact tips of the devices be placed in parallel for the purpose of carrying a current load at or above the manufacturer's contact tip rating.

8. Contact tip ratings shall be stated for the worst condition of reduced surface contact which may result from tip misalignment during normal operation of the device.

9. The coils of all devices shall be suppressed to protect the low-voltage network from generated transients.

10. Equipment boxes that contain relays or contactors shall be ventilated to prevent ozone corrosion.

11. Identification:

    a. All devices shall be readily identifiable by means of a permanent, durable marking strip giving the device circuit designation.

    b. No identifications shall be obscured, or partially obscured, by wire routing.

    c. The identification strip shall be mounted adjacent to the mounting of the device and readable when installed.

16.24.2.2 Contactors

A. Comply with the following:

1. Contactors shall be constructed so that the main contact tips make and break with a motion (wipe) that prevents deposits and pitting.

2. Contactors shall be built with series-fed blowout coils, unless otherwise Approved. Demonstrate the ability of each contactor type to reliably interrupt current over the full design operating range. In cases where there is unidirectional current flow, a permanent magnet blow-out device shall be considered.

3. Bifurcated contacts shall be used in low-voltage applications, whenever necessary due to dry contacts or low current switching requirements.

4. Adequate gap and creepage distances shall be maintained from high-voltage contactor tips and low-voltage coil and auxiliary contacts to prevent entry of high-voltage arcs or transients into the low-voltage circuits. The same applies to grounded mounting surfaces.

5. Contactor installation shall be such that the arc spray is directed by an arc chute away from ground and any other electrical devices proximate to the Contactor.

6. Contactor terminals shall be fully accessible for trouble shooting purposes.

7. Contactor tip replacement shall not exceed 10% of the total number of tips at 90-day intervals.

16.24.2.3 Relays

A. Comply with the following:

1. Time delay relays shall be of the solid state type. R-C delay relays shall be used as Approved. Mechanical and pneumatic time delay devices are prohibited.

2. Where plug-in relays are Approved, the relay shall be positively retained by means of a retaining clip or bar.

    a. This device shall be captive, of rugged construction and shall be easily positioned for relay installation and removal without the need for special tools.

    b. When the relay is removed, the retainer shall itself be retained so that it cannot come in contact with devices which may have exposed energized electrical circuits, and it shall not interfere with the operation of any other device when in this position.

3. Relays shall not be affected by the accumulation of airborne dust. Equipment boxes that contain relays or contactors shall be ventilated to prevent ozone corrosion.

4. Solid State Relays shall be rated to meet the worst-case environmental requirements of their installed location, meet the creepage and clearance requirements of the Specifications, and have output stages that conform to the semiconductor requirements of TS 16.26.

    a. Control of solid state relays shall limit switching frequency within the relay's rated duty cycle and the duty cycle shall be appropriate for the application for the service life of the vehicle.

16.24.2.4 Vital Relays

A. Comply with the following:

1. Vital biased neutral relays shall meet the requirements established by AAR C&S Manual, Part 6.2.1, Recommended Design Criteria for Tractive-Armature, Direct-Current Neutral Relay (Plug-In Type), where the requirements of the AAR Specification do not conflict with any requirements specified below.

2. Vital dc relays, except as specified below, shall comply with the vital relay definition in Section 1, General Topics and Definitions, and shall be plug-in, biased neutral relays with a nominal operating voltage based on the nominal battery voltage specified in Section 2, Design and Performance Criteria.

    a. They shall be rack mounted and shall be furnished with transparent covers which will not support combustion.

    b. The design of the relay covers and of the cabinet in which several relays are mounted shall permit viewing the relays without disassembly or other mechanical manipulation to determine whether each relay is picked up or dropped out.

    c. These relays shall be capable of operating continuously and successfully without resultant damage within the expected battery voltage range.

3. Biased neutral relays used for the ATC equipment shall comply with the following requirements:

    a. They shall be identical and interchangeable.

    b. All front contacts of each relay shall be silver-to-metalized-carbon which meet the requirements of AAR C&S Manual, Part 6.5.1, "Identical Items 'Boilerplate' for All Relay Manual Parts in Section 6," Paragraph F, "Contacts," Items 1-10.

    c. Each relay shall have a minimum of two silver-to-metalized-carbon back contacts unless otherwise Approved.

        (1) In reviewing any proposed alternate back contact composition, SEPTA will evaluate the composition, the overall relay characteristics, and the circuit applications of the contacts.

        (2) It shall be the Contractor's responsibility to perform any tests required by SEPTA and to provide all data requested by SEPTA.

        (3) In evaluating proposed alternates, if an alternate back contact composition is Approved and later found to be unacceptable due to relay characteristics or circuit application, provide relays as specified at no additional cost to SEPTA.

4. Biased neutral vital relays shall be designed so that their armatures will not pick up with the permanent magnet de-magnetized.

    a. These relays shall also be designed so that their armatures will not pick up when no current is applied to coils due to an interruption of the normal magnetic circuit.

5. Arc suppression for vital relay coil(s) shall be built into the relay or into its plugboard.

6. Decoder output relays shall be identical to other biased neutral relays except they may have a different coil resistance, different operating values, and six dependent front-back contacts. The front contacts shall be silver-to-metalized-carbon.

7. When three dc vital or non-vital relays, suppressed as specified, are connected in parallel, a vital relay front or back contact that breaks this load shall be capable of at least 5 million operations at this load without the contact resistance, measured with a 10 mA current, exceeding 5 ohms.

16.24.3 Switches

A. Comply with the following:

1. Switches provided shall be of the highest quality procurable and shall be fully suitable for the rigors of SEPTA's service environment. The design and selection of all switches shall be subject to review and Approval.

2. Safety sensitive switches that need to be sealed shall be a guarded toggle switch, sealed in the cut-in position. The seal on the guard shall need no tools to install or remove.

3. There shall be a maximum of two (2) wires connected to any terminal of a device and shall include sufficient wire slack to permit the replacement of an individual switch.

4. Switches and pushbuttons shall meet the following requirements:

   a. Contact resistance shall be less than 0.1 ohm at 3 Vdc and a 10 mA load.

   b. Open circuit resistance shall be 50 meg-ohms minimum.

   c. Resistance to case shall be 1000 meg-ohms minimum at 500 Vdc.

   d. They shall be rated for inductive loads and have a contact material of silver, silver with a gold flash, or gold plate and be normally a break before make type.

   e. They shall have all exposed energized wire connections insulated in an Approved manner to prevent false activation if bridged by foreign material.

5. Control switches subject to water splash shall be designed to meet IP54. This includes switches mounted near windows or doors, or mounted on the Operator’s control console.

6. Toggle and pushbutton switches shall be per MIL-DTL-3950, MIL-PRF-8805, MIL-DTL-83731, or equal, as Approved.

7. Safety-critical switches, such as those that can cause door openings, shall be designed to withstand a high potential test of 1,500 volts for 1 second, in a clean, dry condition, without false conduction.

8. Switches shall be provided with a "keying" feature so that after installation, the body of the switch is constrained from mechanical rotation.

9. Installation:

   a. Under no circumstances shall poles of switches be placed in parallel in order to carry currents in excess of the contact pole rating given by the manufacturer.

b. More than two wires connected to each terminal of the device shall be subject to Approval.

c. Switches shall be individually replaceable without disconnecting or removing anything other than the mounting fasteners and electrical connections of the switch to be replaced.

16.24.4 Circuit Breakers

16.24.4.1 General

A. Comply with the following general requirements for all circuit breakers:

1. Circuit breakers shall be rugged, fully suitable for the service intended, and of the highest quality procurable. Design and selection of all circuit breakers shall be subject to Approval.

2. Thermal-magnetic trip circuit breakers shall be low-voltage power circuit breakers (LVPCB) conforming to the requirements of IEEE C37.13 and IEEE C37.14.

3. The On, Off, and Tripped positions shall be permanently marked on the handle or the case of the circuit breaker.

   a. When the circuit breaker is tripped by either its overcurrent or shunt trip elements, the handle shall assume a distinct position between the On and Off positions to indicate that it has been tripped.

4. Circuit breaker terminals shall either be threaded to accept machine screws or use a threaded stud.

5. Each circuit breaker pole shall be equipped with adequate means of arc extinction to prevent flashover.

6. Circuit breaker current rating shall be clearly and permanently marked and shall be completely visible after installation.

7. All circuit breakers of the same rating shall be of the same manufacture and model throughout each car.

8. Application:

   a. Each and every input power circuit shall be protected by an individual circuit breaker.

   b. Separate circuit breakers shall be provided for major assemblies or functions.

   c. No circuit breaker shall protect more than one circuit, nor shall any one circuit be protected by more than one circuit breaker.

d. Circuit breaker terminals shall not be used as junction points.

e. Circuit breakers shall be sized by current rating and tripping time to protect both the associated equipment and the minimum size wire used for power distribution within the protected circuit without causing nuisance tripping.

f. The continuous current rating of thermal-magnetic trip circuit breakers shall be selected in accordance with IEEE C37.13 for the load and type of service specified.

9. Installation:

a. Circuit breakers shall be mounted in the vertical direction with the ON position up.

b. Circuit breakers shall be individually replaceable without disconnecting or removing anything other than a faceplate, the mounting fasteners, and electrical connections of the breaker to be replaced.

c. Wires to circuit breakers shall use ring terminals.

d. Circuit breaker terminals shall not be used as junction points.

e. Electrically operated circuit breakers shall be arranged for operation from the low-voltage dc supply.

f. Circuit breaker current rating shall be clearly and permanently visible after installation.

16.24.4.2 High-Voltage Circuit Breakers

A. Comply with the following, where high voltage is defined as primary power DC voltage and three-phase 230 Vac voltage:

1. Distribution-type, high-voltage circuit breakers shall be Eaton's replacement of Westinghouse Series C, FDB frame, or Heinemann type GH, or Approved equal.

2. The trip elements shall be thermal-magnetic, or magnetic, connected in series.

3. The circuit breaker handle shall protrude from the circuit breaker panel cover sufficiently to be operable in all positions.

4. DC primary power circuit breakers shall be three-phase ac devices with not less than three poles connected in series.

16.24.4.3 Low-Voltage Circuit Breakers

A. Comply with the following, where low voltage is defined as 120 Volts or lower:

1. Low-voltage circuit breakers shall be either one-pole or two-pole devices depending on the intended function.

2. Trip elements shall be thermal-magnetic, or magnetic, as appropriate for the application.

3. Low-voltage circuit breakers shall be provided as follows:

a. General Use: Eaton Series C, Quicklag C frame (formerly Westinghouse), or Approved equal, front connection or Approved access arrangement, and Approved labeling.

b. Fast Operation: Airpax brand as manufactured by Sensata Technologies, Airpax type UP, hermetically sealed, magnetic breaker.

16.24.5 Fuses

A. Comply with the following:

1. Application:

a. Fuses may be used only where specified or where the use of circuit breakers is not technically feasible, and only with Approval.

b. Fuses may be considered in applications as follows:

(1) To protect solid state equipment from catastrophic damage

(2) Where current or voltage levels prohibit circuit breakers

c. Fuses shall be used in car heater circuits only with Approval.

2. Air gap and creepage distances shall be as Approved. Fuses used in primary power voltage circuits shall be rated for no less than 1,000 Volts.

3. Fuses shall be readily accessible. Fuses mounted in exterior equipment boxes shall be accessible without going under the car.

4. High-voltage fuses shall be mounted in totally enclosed, dead front, fuse holders, with no exposed high-voltage connections.

a. The fuse shall be extracted from the circuit when the fuse holder is opened and the exposed fuse shall be safely isolated from any circuit connection.

b. Fuse holders shall contain fuse retention devices at both ends.

5. Fuses shall be permanently identified adjacent to the fuse. The rating of each fuse shall be permanently and clearly marked directly on each fuse.

6. Blown fuse indication shall be provided.

7. Unless explicitly specified otherwise in the Specifications, all fuse compartments shall have a spare fuse of identical size and rating for each "in-circuit" fuse, and shall be mounted next to the respective "in-circuit" fuse with the fuse holder clearly marked SPARE FUSE. The spare fuse holder shall not be enclosed and shall not consist of any loose parts.

8. All live portions of the protected circuitry shall be completely concealed so that no danger of electrocution exists from the accidental touching of any appurtenances or devices mounted thereto.

16.24.6 Bus Bars

A. Comply with the following:

1. Bus bars shall be fabricated from OFE (Oxygen Free Electronic CDA 10100) or ETP (Electrolytic Tough Pitch CDA 10100) copper. The bus bar conductivity shall be 100% IACS. All bus bar joints shall be silver or tin plated.

2. Current densities, other than at joints, shall not exceed 1,575 A/in² (244 A/cm²), and in any case shall not exceed a value which would cause a bus bar temperature rise greater than 30°C. Current densities in joints shall not exceed 600 A/in² (93 A/cm²).

3. Bus bars shall be properly brazed together at joints unless bolted connections are found to be absolutely necessary for maintenance purposes and are Approved.

    a. The overlap at busbar joints shall be no less than 10 times the thickness of the bus material.

    b. Bus bar connection bolts shall be torqued to obtain a uniform bus bar connection pressure of 200 psi (1.38 MPa).

    c. Bolting hardware shall be plated steel with Belleville washers to maintain connection pressure.

4. Except for connection areas, bus bars shall be safety-insulated, using a high-dielectric, powder coating or other Approved means. Tape is not acceptable. Bus bars that are behind insulating panels, and those cases where there are suitable warning labels and maintenance procedures that prohibit opening the equipment case when energized, are exempt from this requirement.

16.24.7 Capacitors

A. Comply with the following:

1. Type:

a. Hermetically sealed, dry polypropylene (tantalum) capacitors, in metal cases, shall be used in place of aluminum electrolytics, except for very high values which are not commercially practical or available, in which case long life grade aluminum electrolytics shall be used. When using electrolytic capacitors, the electrolyte shall be non-flammable.

b. Commutating capacitors shall be a paper or plastic film type, shall incorporate a non-toxic impregnant, and shall be chosen to give a service life of at least 20 years. Filter capacitors shall have high ripple current rating for long life.

c. Capacitor design and application shall incorporate mitigation against catastrophic thermal runaway failures, including those initiated from internal manufacturing defects.

2. Application:

a. Capacitors shall be derated 20% for voltage based on the nominal supply voltage and maximum case temperature.

b. If filter capacitors are exposed to low ripple voltages, lesser values of derating may be accepted if it can be shown that reduced operating temperatures can be achieved due to lower dissipation; however, the sum of the dc and ac ripple voltages shall always be less than the capacitor's voltage rating at a maximum case temperature of 85°C.

16.24.8 Resistors

A. Except for braking power resistors, all resistors shall be derated 50% for power dissipation. Other power resistor applications may be submitted for Approval of lower derating.

16.24.9 Transformers and Inductors

A. Comply with the following:

1. Type:

a. Transformers and inductors shall have vacuum impregnated windings.

b. Transformers shall be designed to minimize radiated and induced EMI.

c. They shall have minimum core losses and be of high efficiency design.

2. Application

    a. Transformers shall be rated to withstand at least twice the maximum peak-to-peak voltage that they shall be subjected to in operation.

    b. Transformers and inductors shall be derated 10% for current.

    c. Transformer and inductor temperature ratings shall be based on ambient temperature range as defined in Section 2, Design and Performance Criteria, and the device insulation design.

3. Installation:

    a. The location, orientation, mounting, cable connections and cable routing shall be in accordance with the overall EMI/EMC control plan for the car.

    b. Transformers and inductors shall be electrically insulated. If this is not possible or practical, insulating sleeving may be used. The sleeving shall provide adequate voltage protection and be rated for the temperature rating.

    c. All equipment and connecting cables shall be totally enclosed and shielded from flying ballast and debris and from snow, rain, dust, and dirt.

    d. Audible noise for power frequency devices shall not exceed 65 dB referred to 20 micropascals at a distance of two feet when operating at rated voltage and load.

16.24.10 Switch, Circuit Breaker and Fuse Panels

A. Comply with the following:

1. Switch, circuit breaker and fuse panels shall be rail industry proven.

2. Panelboards shall conform to NFPA 70 Article 408, Switchboards, Switchgear, and Panelboards, except as specified otherwise or as Approved.

3. Switch, circuit breaker and fuse panels shall be dead front types mounted in the specified equipment enclosures.

    a. The dead front panel shall be made of moisture-proof, electrically insulating, laminated phenolic or fiberglass, of Approved quality suitable for switchboards; or grounded metal.

    b. Each switch and circuit breaker panel shall be designed to prevent operating or maintenance personnel from coming in contact with live parts when operating the switches or circuit breakers.

c. Each switch, breaker, fuse, and indicating light shall be provided with a nameplate of raised or recessed lettering on the dead front clearly identifying the circuit to which each applies and its circuit designation.

d. Live portions of the protected circuitry shall be completely concealed so that no danger of electrocution or shock exists from touching the panel or any appurtenances or devices.

4. Power distribution to circuit breakers and switches shall be from a bus bar or bus circuit. Distributing power by successive or "daisy-chained" connections between device terminals will not be permitted.

5. A wiring gutter shall be provided along the top, sides, and bottom for the routing of high voltage leads to their designated circuit breakers.

6. The panel shall be secured by Approved, captive fasteners and shall be configured for easy removal so that maintenance and repair action is not impeded.

7. Provide all panel components with a nameplate of raised or recessed lettering on the dead front, clearly identifying the circuit which each control and its circuit designation.

16.24.11 Battery Backup Circuits

A. Where individual electronic circuits require their own battery, the following conditions apply:

1. Batteries shall be rechargeable nickel-cadmium or nickel metal hydride with a built-in charger or non-rechargeable lithium, unless otherwise Approved.

2. Batteries shall be easily replaceable, and shall not be soldered in place.

3. If a nickel-cadmium or nickel metal hydride battery is used, the charge time vs. discharge time shall be Approved for the specific application. In no case shall the battery life-span be less than seven years.

4. If a lithium battery is used, the calculated life-span and the assumptions for that calculation shall be Approved for the specific application. In no case shall the life span be less than seven years.

5. In order to properly assess the impact of distributed battery backup subsystems, provide a complete list of battery locations, battery type, estimated lifespan, discharge time, and the impact of battery discharge failure. Approval is required for all battery backup applications and will be made based on this total car evaluation.

6. Battery failure (loss of capacity shall be indicated as part of the relevant subsystem diagnostics.

16.24.12 Blower and Other Motors

A. Comply with the following:

1. Type:

a. Motors shall be direct driven.

b. Motors shall have permanently-lubricated insulated bearings. The selection of the bearing and the bearing's lubricant shall provide minimum of 14 years of continuous service before scheduled replacement.

c. Motor insulation shall be totally enclosed transportation-grade Class H rated.

2. Testing: Motor testing requirements are specified in Section 15, Test Program.

3. Application: Motors shall be sized so that the running current is 80% or less than the nameplate FLA.

4. Installation:

a. Motors shall be powered from a three-phase ac power supply and rated for inverter duty.

b. A flexible, braided, tinned copper ground strap shall provide electrical grounding of the motor to the structure of the unit.

c. Each motor assembly shall be balanced in two correction planes, in-situ, as defined in NEMA MG 1 or ANSI/AMCA 204, whichever is more stringent for the application. The residual unbalance shall limit the motor-blower assembly vibration to not more than 0.001 in (1 mil) peak-to-peak displacement in any direction at the motor end bells when mounted in the unit.

d. All motor-fan assemblies shall be isolated such that motor and fan vibration and noise transmitted to the car structure shall be below the limits specified in Section 2, Design and Performance Criteria.

16.24.13 DC-DC Converters

A. Stand-alone and board-mounted DC-DC converters shall comply with the following:

1. IEC 60571

2. Electromagnetic compatibility requirements as specified in Section 2, Design and Performance Criteria.

3. Flame, smoke, and toxicity requirements as specified in Section 23, System Safety and Security.

16.25 Electrical and Electronic Devices

16.25.1 Reliability Standards

A. The reliability standards for reliability prediction, Failure Reporting Analysis and Corrective Action System (FRACAS) for subsystems and equipment are specified within Section 21, Reliability, Availability, and Maintainability.

16.25.2 Ability to Repair

A. All electrical devices including such items as PC boards, relays, contactors, and filters shall be capable of being repaired by SEPTA in its electronics laboratory.

1. Electronic devices shall not be sealed, potted, or constructed to prohibit repair by SEPTA, unless Approved.

16.25.3 Optical Fibers

A. Each application of optical fibers shall be Approved prior to implementation in order to verify reliability and maintainability of the proposed application.

1. The connections between optical fibers and LRUs shall be via Approved "quick disconnects."

2. All fiber optic cables shall be installed in accordance with the cable manufacturer's instructions, shall be adequately protected from damage of any kind, and shall be readily accessible for maintenance and inspection.

3. Fiber optic cables shall be provided with a minimum of ten percent spares on a location to location basis.

16.25.4 Ingress Protection

A. The devices shall be located inside a locker, box or enclosure that is IP 66 rated and is dust and watertight under all operating conditions and the most extreme weather conditions, including operation through the car wash.

16.25.5 Electrostatic Discharge

A. Protection shall be provided against electrostatic discharges (ESDs) in compliance with IEC61349.

16.26 Semiconductor Standards

16.26.1 General

A. Comply with the following:

1. All low voltage apparatus shall function satisfactorily for any duration at any continuous voltage between 55 and 80 volts measured at the battery, shall not be damaged or operate in an unsafe manner by the continuous application of voltages between 0 and 74 volts, and shall withstand the application of 74 volts for one second.

2. Semiconductors shall be selected to withstand all continuous and transient voltage and power demands present in the circuit application without damage or reduction in life.

3. Circuit designs shall provide protection for the presence of high current switching equipment on the car and the resultant induced voltages and currents in electrical equipment.

4. Semiconductor devices shall be derated to operate within the acceptable region for electrical and temperature stress as specified in "Reliability Toolkit: Commercial Practices Edition."

5. All circuits on the car shall be designed to impose sufficient current load to positively eliminate any problems from "dry circuit" conditions to the satisfaction of SEPTA.

6. The need for adjustments shall be avoided wherever possible by the use of appropriate circuitry, stable components, and high tolerance drift compensation and temperature compensation circuits. Where adjustments on printed circuit boards are necessary, they shall be accomplished without the use of specialized (i.e., non-catalog U.S. supplier) test equipment unless this equipment is furnished by the Contractor.

7. Equipment containing devices that are sensitive to electrostatic discharge (ESD) shall have provisions for hookups properly identified for attaching grounding devices.

8. The circuit design shall employ protective techniques such that failures in power semiconductors shall fail safe or fail open and not cause consequent failure of components or major devices following them in the circuit.

16.26.2 Ratings

A. Comply with the following:

1. Discrete semiconductors shall have the following minimum voltage breakdown ratings:

   a. Semiconductors, except diodes (see below), operated from the battery supply, or those connected to trainlines, shall have minimum breakdown ratings of four times the maximum achievable circuit voltage. Suppression devices shall be provided as necessary to protect the devices and limit the circuit voltage.

   b. Diodes operated from the battery supply, used as suppression devices, or connected to trainlines shall have a minimum breakdown rating (PIV) of 1,000 volts.

   c. Discrete semiconductors operated from inverters or other isolating devices shall have a minimum breakdown rating of two times the maximum circuit voltage, except where specified otherwise.

2. Semiconductor junction temperatures shall be limited to maximum 150°C (or to the maximum rated temperature for the device, whichever is less) at maximum ambient temperature and at maximum rated output power.

3. Semiconductors shall be operated at less than 50% of the maximum continuous current rating or 50% of the maximum continuous power rating, whichever is more restrictive.

   a. High power/current devices may be exempt from this requirement with prior Approval, on a case-by-case basis.

   b. Submit complete device information, including all manufacturer's application recommendations, and calculated current and power demands with all waiver requests. If Approved, such waivers do not reduce other requirements, including reliability.

4. Integrated circuits operated from the battery supply through inverters or other isolating devices shall be operated within the voltage and current ratings specified by the manufacturer, derated to less than 50% of the maximum stress level at the maximum operating temperature of the device as specified by the manufacturer.

5. Where the supplies to integrated circuits are regulated and surge protected, the voltage rating shall be 15% below the manufacturer’s recommended maximum. In addition, the maximum power shall be limited to 50% of the manufacturer's specified maximum at the maximum operating temperature.

6. Silicon semiconductors shall be hermetically sealed and rated for operation over the temperature range of -40°C to +85°C. Non-hermetic devices may be acceptable to SEPTA on a case-by-case basis provided comparable reliability documentation is submitted for Approval.

7. Gallium Arsenide and similar optical semi-conductors shall be rated for operation over the temperature range of -40°C to +85°C.

16.26.3 Availability

A. All semiconductors shall be available from at least two manufacturers and available from U.S. distributors.

1. Single source devices, such as high-voltage power devices, microprocessors, application-specific integrated circuits (ASIC)s, and related support chips may be used only if Approved.

2. Single-source devices must be essential to the proposed equipment, shall meet the proven service requirements, and shall be supplied by experienced manufacturers likely to support the device.

16.26.4 Other Prohibitions

A. Comply with the following:

1. Electronic equipment shall use stock components and shall function properly with the component manufacture's full range of tolerances such that after-purchase screening or testing of components shall not be required.

2. Matching of components is permitted only if the components are normally available from the manufacturer in matched sets.

3. Germanium semiconductors shall not be used.

16.26.5 Burn In

A. Comply with the following:

1. All semiconductors in plastic packaging shall be burned in and screened for defects to a level equivalent to MIL-STD-883, Method 5004, Reliability Class B, or Approved equivalent. The method used must be submitted. **(CDRL 16-37, Plastic Packaged Semiconductor Burn In Method)**

2. As a minimum, the supplier shall have had a proven effective component screening and burn in program in effect for five or more years. Alternative methods based on a minimum 100 hour burn in for the completed device which uses the semiconductors will be considered.

3. The burn in must be performed with the equipment operational (power on) and with the necessary input signals and loads to simulate the maximum power dissipating condition in the device at the maximum ambient temperature.

4. Hermetic semiconductors shall receive screening and burn in, following procedures that can be documented to have produced assembled product reliability in accordance with the overall system requirements in this Specification.

16.27 Printed Circuit Board Standards

16.27.1 General

A. Comply with the following:

1. Printed circuit boards (PCBs) shall be designed and constructed to the IPC 2220 Series and inspected to the IPC 2220 Series and IPC-A-610, unless more stringent requirements are noted here. Traces shall be made as wide as practical, with the minimum width being based on a 10°C temperature rise.

2. PCBs used in electronic control units shall be of the "plug-in" type, with positive support against vibration, except where Approved otherwise. PCBs used in a stand-alone manner shall have positive support against vibration, and be replaceable without soldering.

3. Circuit board material shall be as follows:

   a. Per NEMA LI 1, using Type FR-4 or FR-4 high Tg base material as required by solder type, for boards having no components with power dissipation greater than 2 watts, and not mounted adjacent to components dissipating greater than 2 watts. Otherwise, circuit board material shall be Type FR-5.

   b. Minimum thickness of 0.0625-in (1.5875 mm).

   c. The copper laminate shall be firmly attached to the board and shall be resistant to blistering and peeling when repaired.

4. Circuit boards shall be inherently stiff to prevent damage due to vibration or handling. Circuit boards larger than 100 in^2 (645 cm^2) shall be centrally reinforced. Alternate methods for reinforcing larger circuit boards shall be Approved.

5. Provisions shall be made on all plug in printed circuit boards for "keying" to prevent insertion into the wrong socket.

6. Components with pins shall be mounted only on one side. Connections shall be made to the other side or internal layers via plated through holes. SMT devices may be mounted on both sides if part of an Approved existing design.

7. PCBs shall be mounted in the vertical plane with positive retention by keeper bars unless otherwise Approved. These retaining mechanisms shall be simple, easily applied/removed without tools and shall remain attached to the card rack.

8. All PCBs with the same function shall be interchangeable between equipment groups without additional adjustment. PCBs shall be fully inter-changeable without adjustment using digital circuits, stable components, and tight tolerance components as applicable.

9. Non-repairable or "throw-away" circuit boards may be supplied only by approval of SEPTA. In making this request for approval. Where use of non-repairable circuit boards is granted, the Contractor shall supply to SEPTA spare circuit boards of each type in number Approved.

10. Potentiometers shall not be permitted, unless Approved otherwise.

16.27.2 Marking

A. Comply with the following:

1. Circuit boards shall be labeled with a part number, serial number, and descriptive nomenclature.

2. All components on the board shall be labeled with component drawing references and such other information as may be required to repair and troubleshoot the board.

3. The component and wiring sides of the board shall each be marked to indicate capacitor and diode polarity, and at least two leads or one lead and a graphic symbol indicating orientation of all transistors and thyristors.

4. Integrated circuits and other multi-terminal devices shall have an index mark on the component side of the board, visible with the component inserted, to indicate proper keying and insertion; the first pin on all IC packages shall be identified on the wiring side of the board.

5. For boards whose component density is greater than 2.25 components per square inch (0.35 components per square centimeter), the Contractor may submit an alternate marking plan for Approval. Such a plan shall include board marking, augmented by layout drawings.

16.27.3 Component Mounting

A. Comply with the following:

1. All components shall be secured to and supported at the board in such a manner as to meet the shock and vibration requirements of Section 2, Design and Performance Criteria.

2. Power resistors shall be mounted on standoffs to prevent board damage and discoloration under the worst-case operating conditions.

16.27.4 IC and Device Sockets

A. Comply with the following:

1. IC and device sockets are prohibited except for components that must be removed for reprogramming or initial calibration procedures or devices that are available only in mounting in sockets.

a. All socket applications are subject to Approval.

b. All other components shall be soldered in place.

2. Where Approved, IC sockets shall comply with MIL-DTL-83502 and MIL-DTL-83734, as is applicable for the device, and shall be made of the following materials:

a. The bodies shall be molded from diallyl phthalate, PTFE Teflon, or Approved equal.

b. The contacts shall be fabricated from beryllium copper and shall be plated with a minimum of 0.000030 in (0.0008 mm) of gold over a minimum of 0.000050 in (0.001 mm) of low-stress nickel in the area of contact with IC pins.

16.27.5 Conformal Coating

A. Both sides of the assembled printed circuit boards shall be coated with a clear insulating and protective coating material conforming to IPC-CC-830, or Approved equal.

1. The coating shall be easily removed with a brush-applied solvent or penetrated by a hot soldering iron when a component must be unsoldered. The coating solvent shall not adversely affect board mounted components.

2. IC sockets, connectors, and test points shall be masked when the coating is applied.

16.27.6 Keying and Interlocks

A. Printed-circuit boards shall be "keyed" to prevent insertion into the wrong socket.

1. Boards that may be used on other SEPTA fleets shall be keyed differently to prevent interchange.

2. Circuit boards that can cause damage or unsafe train operation when removed from the subsystem shall be interlocked through a safety circuit to disable the car if a circuit board is removed. This safety circuit shall be implemented by hardware unless otherwise Approved. The Contractor shall address this application in the FMECA.

16.27.7 Circuit Board Connectors

A. Comply with the following:

1. Printed circuit board connectors shall be service-proven heavy duty, high reliability, two-part type and shall be Approved prior to commencing design.

2. Connectors that comply with MIL-DTL-55302 or DIN 41612 (IEC 60603-2/EN 60603-2), Class 1, and that have plated contacts as described below, are considered to comply with the requirements of this Section.

3. The connector contact area shall be plated with a minimum of 0.000030 in (0.0008 mm) of gold over a minimum of 0.000050 in (0.001 mm) of low stress nickel.

16.27.8 Testing

A. Comply with the following:

1. Sufficient clearance shall be provided between components to allow testing, removal, and replacement without difficulty due to lack of space.

2. Test points shall be provided in appropriate locations on modules and printed circuit boards.

a. A negative return test point shall also be provided.

b. The test points shall either accept and hold a standard 0.080-in (2-mm) diameter tip plug, or shall be a turret lug similar to Cambion Part number 160-1026-01-05-00, or Approved equal, with sufficient clearance to permit it to accept a standard oscilloscope probe clip, and shall be identified by appropriate markings.

16.27.9 Plated-Through Holes

A. In addition to the general guidelines of the IPC–Association Connecting Electronics Industries®, the following requirements shall be met:

1. Plating Holes:

a. Copper plate shall be a minimum of 0.001 in (0.025 mm) minimum average thickness, and 0.003-in (0.076 mm) maximum average thickness.

b. Solder plates shall be 0.0003 in (0.08 mm) minimum average thickness and 0.0015 in (0.038 mm) maximum average thickness.

2. Plated Hole Defects:

a. No more that than three voids per hole will be acceptable.

b. Total area of the voids shall not exceed 10% of the total wall area.

c. The largest void dimension shall not exceed 25% of the core diameter or the board thickness, whichever is smaller.

d. There shall be no pits, voids, or cracks at the junction of the hole wall and terminal area to a depth of 1.5 times the total copper thickness on the surface.

16.27.10 Multilayer Boards

A. Multilayer PC boards and high-density surface mount components are permitted. To ensure repairability by SEPTA, submit the following minimum documentation:

1. Assembly and detailed layout drawings.

2. Complete parts listing

3. Schematics and interconnection diagrams

4. Source control for any parts on the parts list that cannot be directly ordered from an electronics catalog.

5. Theory of operation.

B. The Contractor may propose, for Approval, alternate methods to ensure long term maintainability of equipment.

16.27.11 Enclosures and Racks

A. Comply with the following:

1. Enclosures and racks shall provide environmental and EMI shielding as required to comply with the Specifications.

2. Circuit board racks shall mount in an enclosure complying with the Specifications.

3. The rack, circuit board, and circuit board hardware shall be designed as an integrated subsystem.

4. Circuit boards that are rack mounted shall plug into racks containing the mating half of the circuit board connector.

5. Printed circuit boards shall be positively retained by means of keeper bars or other Approved method. The enclosure or rack cover shall not be used to retain the circuit boards.

6. Each circuit board shall be fitted with an ejector or hand grip to assist in board removal.

7. The rack and the edge of each board, or the card ejector, shall be labeled with corresponding numbers to identify board location within the enclosure.

8. Enclosure features shall be presented for Approval during preliminary design and prior to commencing final design.

16.27.12 Extenders

A. Provide printed circuit board extenders for all rack-mounted circuit boards. **(CDRL 16-38, PCB Extenders)**. Maintenance and troubleshooting procedures shall be provided as specified in Section 26, Manuals and Training

16.28 Microprocessor-Based Subsystem Hardware

16.28.1 Hardware Platform

A. Carborne and custom computer hardware shall be designed and constructed in accordance with the general electronic design principles of this Section and the following requirements:

1. The microprocessor based control systems shall be based on an established family of microprocessors in wide use in the control system industry.

2. They shall be supported by a full range of software development languages and diagnostic programs.

3. Commercially available hardware shall be readily available in the US through retail and wholesale sources and shall be subject to documentation and training requirements of the Specifications. Any use of commercially available computer boards shall be Approved. Such Approval will be based upon a technical review of the product, product documentation, and a commercial assessment of product availability.

4. Computers, whether portable or not, and microprocessor hardware shall be readily available through retail or wholesale outlets in the US for 15 years. They shall be from Approved domestic manufacturers. If they are not available for 15 years, they shall be supported with replacement parts or be capable of being replaced with form/fit/function-compatible direct replacements.

5. A special algorithm shall be provided to ensure that computer shutdown and restart occur in a safe and predictable manner; that spurious faults are not generated during shutdown or restart; that stored diagnostic data is not lost during shutdown or restart; and that time-stamp integrity is maintained on all diagnostic data through any shutdown and restart process, including immediately after restart.

6. Hardware shall be capable of handling dates in the range from 2000 to 2099. The date data processing shall not experience abnormal ending or invalid or incorrect results from the hardware in operation at SEPTA. Each hardware date data interface shall support a four-digit year format.

16.28.2 Electrical Isolation and Preprocessing

A. Comply with the following:

1. The control subsystem shall be powered by dedicated transformer-isolated power supplies driven from the LVPS.

2. Control subsystem input and output signals shall be through isolation buffers.

   a. High-voltage inputs and outputs shall be isolated external to the microcomputer card rack.

   b. Low-voltage (battery and logic voltage level) inputs and outputs shall be isolated via buffer cards in or external to the microcomputer card rack.

3. Isolation buffers shall consist of optical isolators, transformer isolators, and other circuits appropriate to the application. Voltage divider circuits will not be allowed. They shall:

   a. Protect and isolate the control subsystem from damage due to overvoltage, undervoltage, transients, shorts, and opens

   b. Perform necessary voltage translations

   c. Remove noise and undesired signals

   d. Limit, preprocess, discriminate and format those signals that would otherwise require excessive processor time.

16.28.3 Program and Data Storage

A. Comply with the following:

1. Program code and fixed data shall be stored in non-volatile memory.

16.28.4 Expansion Capacity

A. Comply with the following:

1. Hardware shall be designed to allow program expansion without hardware modification.

2. The hardware shall include spare input and output channels, of each type used within the subsystem, except for major output drivers, the quantity of which is fixed by the overall subsystem design (e.g., traction motor power semiconductors and sign character drivers). The architecture and assembly construction shall allow for the installation of additional I/O hardware.

3. Memory devices or hard drives shall be removable to allow easy replacement and upgrade as older technologies become obsolete. Interfaces to such devices shall not be proprietary.

4. The memory for each device shall be sized so the needs of the installed software shall not use more than 50% of the installed memory. This requirement applies individually to each type of ROM and each type of RAM that is used. Baselining of memory usage shall be performed as specified in Section 19, Software Engineering.

5. Processor speeds shall be twice what is needed for the provided software. The Contractor may ask for deviation from the requirement, based on product maturity and the lack of potential for expansion or modification. In no case may more than 75% of the processor time be used. Baselining of processor time shall be performed as specified in Section 19, Software Engineering.

6. Simple singular functions performed by dedicated embedded processors may use up to 75% of the available processor time and do not have to provide spare I/O capability.

16.29 Contract Deliverable Requirements List (CDRL)

The following contract deliverables have been identified in this section; however, the Contractor is responsible for providing and submitting anything necessary to fulfill the requirements of this contract, including those not identified by CDRL number.

CDRL 16-01, Recommended Cleaning Agents 16-2
CDRL 16-02, Certification of No Prohibited Materials 16-3
CDRL 16-03, Corrosion Control of Materials 16-4
CDRL 16-04, Proposed Materials Not Covered by Specification or Standard 16-4
CDRL 16-05, Safety Data Sheets 16-4
CDRL 16-06, Fasteners Design Package 16-8
CDRL 16-07, Carshell Mill Certification Reports 16-18
CDRL 16-08, Stainless Steel Test and Inspection Plan 16-20
CDRL 16-09, HSLA Steel Test and Inspection Plan 16-21
CDRL 16-10, Steel Casting Qualification Test Report 16-22
CDRL 16-11, Steel Castings Radiographic Inspection Sampling Frequency 16-23
CDRL 16-12, Structural Forgings Design Qualification Test Report 16-27
CDRL 16-13, Aluminum Test and Inspection Plan 16-31
CDRL 16-14, Welding Procedure Qualification 16-33
CDRL 16-15, Production Weld Inspection Plan 16-35
CDRL 16-16, Production PJP and Fillet Weld Sampling Plan 16-36
CDRL 16-17, Ring Weld Sampling Plan 16-36
CDRL 16-18, Welding Machine Qualification Records and Welding Procedure Schedule Certifications 16-37
CDRL 16-19, Phenolic Composite Floor Panel Test Results 16-47
CDRL 16-20, FRP Repair Procedure 16-54
CDRL 16-21, FRP Performance Test Certificates 16-54
CDRL 16-22, Pneumatic System Design Analysis 16-58
CDRL 16-23, Air Brake Supplier's Written Approval 16-60
CDRL 16-24, Pressure Vessel Test Reports 16-64
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16.30 CDRL Details

This section lists the expected content for each CDRL required above. The lists provided for each CDRL are an outline only and should not be considered exhaustive, all CDRLs are subject to SEPTA review and Approval.

CDRL 16-01 Recommended Cleaning Agents:

1. Include manufacturer's recommended cleaning agents for each material exposed to normal cleaning.
2. Where applicable, include recommended dilutions and frequencies of application.
3. Include a Safety Data Sheet (SDS) for each cleaning agent.

CDRL 16-02 Certification of No Prohibited Materials

1. List of prohibited materials, and certification that none are present on vehicles.

CDRL 16-03 Corrosion Control of Materials:

1. Update and resubmit this document whenever materials or treatments change.
2. Submit drawing(s) showing the locations of all materials that require treatment to prevent corrosion due to atmospheric exposure.
3. Submit details of the treatment of faying metallic surfaces, and areas of dissimilar metal or other material joining that could result in galvanic action and material deterioration.
4. Include protection plan for the truck frame that at a minimum addresses the following:
    a. An overall description of how the truck design will minimize corrosion during the life of the truck

b. Venting and drainage (Section 11, Trucks)

c. Painting (this Section and Section 11, Trucks)

d. Dissimilar material connections (this Section)

e. Truck frame and bolster base materials (ASTM G101 corrosion index of 6.0 minimum if alternate materials are proposed) (this Section and Section 11, Trucks)

f. Fastener coatings (this Section)

CDRL 16-04 Proposed Materials not Covered by Specification or Standard:

1. Submit material, identified by commercial trademark, name, and address of Supplier for each type of material proposed for use that is not included in the Specifications.

2. Description and technical data specifications of material composition.

CDRL 16-05 Safety Data Sheets

1. Submit as one complete package including an SDS for each chemical material used in the manufacture of the vehicle.

CDRL 16-06 Fasteners Design Package:

1. Matrix listing each type of fastener used on the vehicle. Furnish the following information:

   a. Fastener type

   b. Manufacturer

   c. Base material and plating or finish

   d. Size(s)

   e. Property class, grade, strength

   f. Indication of application for structural and safety-related fasteners

   g. Indication of location for fasteners used where there are location-specific requirements

   h. Indication of application for fasteners used where there are application-specific requirements

2. Manufacturer's data for each type of fastener, with sufficient information to demonstrate compliance with the Specifications.

3. Plating type used for high strength fasteners.

4. Alternate plating or coating system (if proposed):

    a. Qualification data for each process used at each Supplier applying proposed coating, including the following:

        i. Coating manufacturer's product data including required thickness

        ii. ASTM B117 test results from an accredited third party laboratory

        iii. Documentation of torque/tension characteristics

        iv. A statement from the coating manufacturer regarding the propensity for the coating process to cause hydrogen embrittlement of the fastener during coating

5. Structural threaded fasteners: Sufficient information to demonstrate compliance with the requirement for coordination of nut strength with bolt strength to prevent undetected internal thread stripping, including calculations if required.

6. Safety-related fasteners: Proposed sample quantities to be used for production lot testing.

CDRL 16-07 Carshell Mill Certification Report

1. Submit mill certification reports for all materials used in the constriction of the carshell

2. Include mill certification reports for all suppliers and sub-suppliers material used construction of the carshell

CDRL 16-08 Stainless Steel Test and Inspection Plan:

1. Submit and obtain Approval before purchasing stainless steel material to be used in welded applications.

2. Austenitic stainless steel: Include frequency of submittal of certifications in accordance with Certification Provision of ASTM A666 and frequency of submittal of checks for susceptibility to intergranular corrosion in accordance with ASTM A262.

3. Ferritic stainless steel: Include frequency of submittal of checks for susceptibility to intergranular corrosion in accordance with ASTM A763.

CDRL 16-09 HSLA Steel Test and Inspection Plan:

1. Include provisions for submission of reports and certification to SEPTA for each shipment in accordance with the applicable requirements of purchase specification and specified CGHAZ impact tests.

CDRL 16-10 Steel Casting Qualification Test Report:

1. Obtain Approval before production of castings.

2. If the casting selected for qualification fails to qualify, include a plan of action with details of how failed material will be handled.

CDRL 16-11 Steel Castings Radiographic Inspection Sampling Frequency

1. Submit Proposed Radiographic Inspection Sampling Frequency.

CDRL 16-12 Structural Forgings Design Qualification Test Report:

1. In case the forging selected for qualification fails to qualify, include a plan of action including details of how failed material will be handled.

CDRL 16-13 Aluminum Test and Inspection Plan:

1. Include Inspection Plan for acceptance of structural aluminum
2. Include qualification tests of aluminum castings, forgings, and extrusions.
3. Include Quality Assurance testing

CDRL 16-14 Welding Procedure Qualification:

1. Include welding procedure qualification for all welding procedures
2. Include procedure qualification records (PQRs) containing welding test results.
3. Submit WPSs along with PQRs

CDRL 16-15 Production Weld Inspection Plan:

1. CJP welds: The minimum acceptable inspection plan shall require inspection of 1 foot of a full penetration weld for every 200 feet of production welds made.
2. PJP & Fillet Welds: The minimum acceptable inspection plan shall require inspection of 1 foot of a PJP/fillet weld for every five carshells or subassemblies made.
3. Ring Welds: The minimum acceptable inspection plan shall require inspection of one sample ring weld for every 300 production welds made.

CDRL 16-16 Production PJP and Fillet Weld Sampling Plan:

1. Submit a sampling plan for production PJP and fillet welds.

CDRL 16-17 Ring Weld Sampling Plan:

1. Submit a random sampling plan for additional nondestructive examinations of ring welds

CDRL 16-18 Welding Machine Qualification Records and Welding Procedure Schedule Certifications:

1. Include welding machine qualification records on all welding machines.

2. Include welding procedure schedule certifications

CDRL 16-19 Phenolic Composite Floor Panel Test Results:

1. Include the test results of the required testing of TS 16.10.8.

CDRL 16-20 FRP Repair Procedure:

1. Submit all FRP repair procedures.

CDRL 16-21 FRP Performance Test Certificates:

1. For each FRP item, furnish an independent laboratory test certificate stating that the production FRP material complies with the specified strength requirements when tested in accordance with the specified standards.

2. Submit repair procedures for all FRP material.

CDRL 16-22 Pneumatic System Design Analysis

1. Submit the details of the pneumatic system design analysis and of any special preventative measures proposed to incorporate in the design.

CDRL 16-23 Air Brake Supplier's Written Approval:

1. Include the air brake supplier's written approval for the entire air brake system, its application to the vehicle, and equipment.

CDRL 16-24 Pressure Vessel Test Reports:

1. Include all pressure vessel test reports.

CDRL 16-25 Paint Manufacturer's Data:

1. Submit manufacturer's data for each type of painting material used on the car to show color, gloss, adhesion, finish, and orange peel characteristics.

2. Submit for each primer, topcoat, and base coat clear coat paint for exterior, undercar, truck frames, and paint or powder coat used for the interior of the car or equipment.

3. Manufacturer's data shall include the following information:

    a. Composition.

    b. Curing characteristics.

    c. Recommended minimum and maximum dry film thickness.

    d. Performance characteristics.

    e. Manufacturer's data on powder coating material.

CDRL 16-26 Paint Preparation and Application:

1. Include procedures for surface cleaning and preparation, priming, surfacing, and painting for the carbody and all equipment that is painted or powder coated.
2. Include documented approval by the paint component manufacturer(s).
3. Include a detailed paint schedule showing the following:
    a. Equipment painted.
    b. Paint type and manufacturers.
    c. Recommended thickness.
    d. Other pertinent information.

CDRL 16-27 Paint Testing on First Car:

1. Submit a test procedure that includes the specified test criteria and that generally complies with the requirements of Section 15, Test Program, for Test Procedures.
2. Submit a test report that documents the results of the test and generally complies with the requirements of Section 15, for Test Reports.

CDRL 16-28 Floor Fire Test Report:

1. Submit the complete floor fire test report.

CDRL 16-29 Floor Fire Test Drawings:

1. Include all drawings created for the floor fire testing.

CDRL 16-30 Electrical Fitting and Junction Box Product Line:

1. Submit the proposed product line(s) for all fittings and junction boxes for car wiring. Details shall include (but not be limited to):
    a. A product line overview
    b. Data sheets for all parts to be used on the car.

CDRL 16-31 Documentation for Wire and Cable:

1. Submit for each proposed size and type of wire and cable before using.
2. Documentation:
    a. Manufacturer's specifications.
    b. Manufacturer's qualification test documentation.

c. Three copies of test reports, certified by the manufacturer or testing agency and notarized.

CDRL 16-32 Electrical Insulation Test Reports:

1. All test reports covering production and qualification tests for all wire insulation types shall be submitted for approval prior to any shipment of materials.

2. Four samples of each type of wire shall be submitted with each test report. Each sample shall be of sufficient length that one complete uninterrupted length of manufacturer's wire marking is clearly visible. Each sample shall have a length of no less than 18 inches.

CDRL 16-33 Insulation Smoke Test Report:

1. Perform smoke testing in accordance with ASTM E662 noting any unusual behavior that occurs during the test; for example, self-ignition of the sample in the non-flaming test mode or any extinguishment of a burner triplet during the test.

2. Prepare and submit an insulation smoke test report.

3. The report shall detail the sample orientation, test conditions, results, and observations made during the test.

CDRL 16-34 Wiring Plan:

1. Include all wiring proposed for installation on the car.

2. Clearly indicate how wire and cable is routed and the type of raceway or concealment used.

CDRL 16-35 Wire and Cable Identification System:

1. Submit a basic wire and terminal identification system that coordinates each electrical circuit in the car into a unified system and is in conformance with ASME Y14.44

CDRL 16-36 Wire Termination Documentation:

1. Include manufacturer's data on the proposed product lines

2. Include Contractor’s standard training, certification, and testing procedures for crimping.

3. Include MIL-T-16366 test results for temperature rise, voltage drop, vibration, current overload, and corrosion for each proposed termination by part number.

CDRL 16-37 Plastic Packaged Semiconductor Burn In Method:

1. All semiconductors in plastic packaging shall be burned in and screened for defects to a level equivalent to MIL-STD-883, Method 5004, Reliability Class B, or Approved equivalent.

2. Submit for Approval details of the burn-in method to be used.

CDRL 16-38 PCB Extenders:

1. Provide 50 sets of each type.

16.31 Referenced Standards

29 CFR 1910.119	Process safety management of highly hazardous chemicals
29 CFR 1910.1200	Hazard Communication
49 CFR 223	Safety Glazing Standards – Locomotives, Passenger Cars and Cabooses
49 CFR 229.85	High Voltage Markings: Doors, Cover Plates, or Barriers
49 CFR 231	Railroad Safety Appliance Standards
49 CFR 238	Passenger Equipment Safety Standards
A-A-59125	Commercial Item Description: Terminal Boards, Molded, Barrier Screw and Stud Types and Associated Accessories (supersedes MIL-T-55164)
AAR C&S Manual	AAR Communications & Signals Manual
AAR MSRP, Sect E	Standard M-601, Hose, Wrapped, Air-Brake, “End Hose”
AAR MSRP, Sect E	Standard M-618, Hose, Air, Wire-Reinforced
AAR MSRP, Sect E	Standard M-620, Hose Air, Fabric-Reinforced
AAR MSRP, Sect E	Standard M-927, Hose Fittings and Hose Assemblies, Air, Wire Reinforced
AAR MSRP, Sect E	Standard S-400, Brake Equipment—Installation Specifications
AAR MSRP, Sect F	Standard S-538, Wiring Practice and Rolling Stock Standard
AAR MSRP, Sect G	Standard M-101, Axles, Carbon Steel, Heat Treated
AAR MSRP, Sect G	Standard M-107/208, Wheels, Carbon Steel

AAR MSRP, Sect S	Standard M-201, Castings, Steel
AAR MSRP, Sect S	Standard M-202, Truck Bolsters, Cast or Structural—Design and Testing
AAR MSRP, Sect S	Standard M-203, Truck Side Frames, Cast Steel—Design and Testing
AAR MSRP, Sect S	Standard M-211, Foundry and Product Approval Requirements for the Manufacture of Couplers, Coupler Yokes, Knuckles, Follower Blocks, and Coupler Parts
AAR RP-585	Wire and Cable Specification
AAR RP-587	Wire and Cable Insulating Material—Silicone Rubber Insulated
AATCC 8	Colorfastness to Crocking: Crockmeter
AATCC 16.2	Colorfasteness to Light: Carbon-Arc
AIA/NAS NASM20995	Wire, Safety or Lock
Aluminum Association	Aluminum Design Manual
Aluminum Association	Aluminum Standards and Data
Aluminum Corporation of America	Technical Report No. 524, “Specification Covering Use of Aluminum in Passenger Carrying Railway Vehicles”
ANSI/AMCA 204	Balance Quality and Vibration Levels for Fans
ANSI B18.1.2	Large Rivets 1/2 Inch Nominal Diameter and Larger
ANSI C80.1	Electrical Rigid Steel Conduit
ANSI Z26.1	Safety Glazing Materials for Glazing Motor Vehicles and Motor Vehicle Equipment Operating on Land Highways – Safety Standard
ANSI/IEC 60529	Degrees of Protection Provided by Enclosures (IP Codes)
APTA PR-CS-S-004-98	Standard for Austenitic Stainless Steel for Railroad Passenger Equipment
APTA PR-C-S-015-99, Rev. 2	Standard for Aluminum and Aluminum Alloys for Passenger Equipment Carbody Construction
APTA PR-E-RP-002-98	Recommended Practice for Wiring of Passenger Equipment

APTA PR-M-S-012-99	Standard for the Manufacture for Wrought Steel Wheels for Passenger Cars and Locomotives
ASHRAE 41.3	Methods For Pressure Measurement
ASME B4.1	Preferred Limits and Fits for Cylindrical Parts
ASME B18.2.6	Fasteners for Use in Structural Applications
ASME B18.8.1	Clevis Pins and Cotter Pins (Inch Series)
ASME B18.16.6	Prevailing Torque Locknuts (Inch Series)
ASME B31.1	Power Piping
ASME B31.5	Refrigeration Piping and Heat Transfer Components
ASME BPVC, Section VIII-1	Boiler and Pressure Vessel Code, Rules for Construction of Pressure Vessels Division 1
ASME BPVC, Section IX	Boiler and Pressure Vessel Code, Welding Brazing, and Fusing Qualifications
ASME Y14.44	Reference Designations for Electrical and Electronics Parts and Equipment
ASTM A6/A6M	Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling
ASTM A27/A27M	Standard Specification for Steel Castings, Carbon, for General Application
ASTM A36/A36M	Standard Specification for Carbon Structural Steel
ASTM A53	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A240/A240M	Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A262	Standard Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels
ASTM A449	Standard Specification for Hex Cap Screws, Bolts and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use

ASTM A480/A480M	Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
ASTM A488/488M	Standard Practice for Steel Castings, Welding, Qualifications of Procedures and Personnel
ASTM A502	Standard Specification for Rivets, Steel, Structural
ASTM A504/A504M	Standard Specification for Wrought Carbon Steel Wheels
ASTM A568/A568M	Standard Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for
ASTM A588/A588M	Standard Specification for High-Strength Low-Alloy Structural Steel, up to 50 ksi [345 MPa] Minimum Yield Point, with Atmospheric Corrosion Resistance
ASTM A606/A606M	Standard Specification for Steel, Sheet and Strip, High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, with Improved Atmospheric Corrosion Resistance
ASTM A666	Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar
ASTM A668/A668M	Standard Specification for Steel Forgings, Carbon and Alloy, for General Industrial Use
ASTM A710/A710M	Standard Specification for Precipitation–Strengthened Low-Carbon Nickel-Copper-Chromium-Molybdenum-Columbium Alloy Structural Steel Plates
ASTM A729/A729M	Standard Specification for Carbon and Alloy Steel Axles, Heat-Treated, for Mass Transit and Electric Railway Service
ASTM A763	Standard Practices for Detecting Susceptibility to Intergranular Attack in Ferritic Stainless Steels
ASTM A923	Standard Test Methods for Detecting Detrimental Intermetallic Phase in Duplex Austenitic/Ferritic Stainless Steels
ASTM B26	Standard Specification for Aluminum-Alloy Sand Castings
ASTM B33	Standard Specification of Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes
ASTM B85	Standard Specification for Aluminum-Alloy Die Castings

ASTM B88	Standard Specification for Seamless Copper Water Tube
ASTM B108	Standard Specification for Aluminum-Alloy Permanent Mold Castings
ASTM B117	Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B174	Standard Specification for Bunch-Stranded Copper Conductors for Electrical Conductors
ASTM B221	Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
ASTM B280	Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
ASTM B298	Standard Specification for Silver-Coated Soft or Annealed Copper Wire
ASTM B355	Standard Specification for Nickel-Coated Soft or Annealed Copper Wire
ASTM B633	Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel
ASTM C273/C273M	Standard Test Method for Shear Properties of Sandwich Core Materials
ASTM C297	Standard Test Method for Flatwise Tensile Strength of Sandwich Constructions
ASTM C365	Standard Test Method for Flatwise Compressive Properties of Sandwich Cores
ASTM C393/ C393M	Standard Test Method for Core Shear Properties of Sandwich Constructions by Beam Flexure
ASTM C542	Standard Specification for Lock-Strip Gaskets
ASTM D256	Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics
ASTM D267	Standard Specification for Gold Bronze Powder
ASTM D573	Standard Test Method for Rubber-Deterioration in an Air Oven
ASTM D618	Standard Practice for Conditioning Plastics for Testing

ASTM D638	Standard Test Method for Tensile Properties of Plastics
ASTM D648	Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position
ASTM D695	Standard Test Method for Compressive Properties of Rigid Plastics
ASTM D751	Standard Test Methods for Coated Fabrics
ASTM D785	Standard Test Method for Rockwell Hardness of Plastics and Electrical Insulating Materials
ASTM D790	Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
ASTM D792	Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
ASTM D952	Standard Test Method for Bond or Cohesive Strength of Sheet Plastics and Electrical Insulating Materials
ASTM D1055	Standard Specifications for Flexible Cellular Materials-Latex Foam
ASTM D1117	Standard Guide for Evaluating Nonwoven Fabrics
ASTM D1630	Standard Test Method for Rubber Property-Abrasion Resistance (Footwear Abrader)
ASTM D2047	Standard Test Method for Static Coefficient of Friction of Polish-Coated Flooring Surfaces as Measured by the James Machine
ASTM D2261	Standard Test Method for Tearing Strength of Fabrics by the Tongue (Single Rip) Procedure (Constant-Rate-of-Extension Tensile Testing Machine)
ASTM D2584	Standard Test Method for Ignition Loss of Cured Reinforced Resins
ASTM D3159	Standard Specification for Modified ETFE Fluoropolymer Molding and Extrusion Materials
ASTM D3363	Standard Test Method for Film Hardness by Pencil Test
ASTM D3574	Standard Test Methods for Flexible Cellular Materials —Slab, Bonded, and Molded Urethane Foams

ASTM D3597	Standard Performance Specification for Woven Upholstery Fabrics—Plain, Tufted, or Flocked
ASTM D3775	Standard Test Method for Warp (End) and Filling (Pick) Count of Woven Fabrics
ASTM D3776/D3776M	Standard Test Methods for Mass Per Unit Area (Weight) of Fabric
ASTM D3884	Standard Guide for Abrasion Resistance of Textile Fabrics (Rotary Platform Abrader Method)
ASTM D4034	Test Method for Resistance to Yarn Slippage at the Sewn Seam in Woven Upholstery Fabrics
ASTM D4157	Standard Test Method for Abrasion Resistance of Textile Fabrics (Oscillatory Cylinder Method)
ASTM D4541	Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers
ASTM D4705	Standard Test Method for Stitch Tear Strength of Leather, Double Hole
ASTM D4966	Standard Test Method for Abrasion Resistance of Textile Fabrics (Martindale Abrasion Tester Method)
ASTM D5034	Standard Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test)
ASTM D5402	Standard Practice for Assessing the Solvent Resistance of Organic Coatings Using Solvent Rubs
ASTM D5420	Standard Test Method for Impact Resistance of Flat, Rigid Plastic Specimen by Means of a Striker Impacted by a Falling Weight
ASTM D5628	Standard Test Method for Impact Resistance of Flat, Rigid Plastic Specimens by Means of a Falling Dart (Tup or Falling Mass)
ASTM E94/E94M	Standard Guide for Radiographic Examination
ASTM E119	Standard Test Methods for Fire Tests of Building Construction and Materials
ASTM E155	Standard Reference Radiographs for Inspection of Aluminum and Magnesium Castings

ASTM E162	Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source
ASTM E165	Standard Practice for Liquid Penetrant Testing for General Industry
ASTM E340	Standard Practice for Macroetching Metals and Alloys
ASTM E390	Standard Reference Radiographs for Steel Fusion Welds
ASTM E446	Standard Reference Radiographs for Steel Castings Up to 2 in. (50.8 mm) in Thickness
ASTM E662	Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials
ASTM E709	Standard Guide for Magnetic Particle Testing
ASTM E1030/E1030M	Standard Practice for Radiographic Examination of Metallic Castings
ASTM E1742	Standard Practice for Radiographic Examination
ASTM F436	Standard Specification for Hardened Steel Washers Inch and Metric Dimensions
ASTM F519	Standard Test Method for Mechanical Hydrogen Embrittlement Evaluation of Plating/Coating Processes and Service Environments
ASTM F606/F606M	Standard Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, Direct Tension Indicators, and Rivets
ASTM F593	Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs
ASTM F1344	Standard Specification for Rubber Floor Tile
ASTM G101	Standard Guide for Estimating the Atmospheric Corrosion Resistance of Low-Alloy Steels
AWS	Welding Handbook
AWS A2.4	Standard Symbols for Welding, Brazing, and Nondestructive Examination

AWS A3.0M/A3.0	Standard Welding Terms and Definitions Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying
AWS B2.2/B2.2M	Specification for Brazing Procedure and Performance Qualification
AWS C3.4M/C3.4	Specification for Torch Brazing
AWS C7.4/C7.4M	Process Specification and Operator Qualification for Laser Beam Welding
AWS D1.1/D1.1M	Structural Welding Code - Steel
AWS D1.2/D1.2M	Structural Welding Code - Aluminum
AWS D1.3/D1.3M	Structural Welding Code - Sheet Steel
AWS D1.6/D1.6M	Structural Welding Code - Stainless Steel
AWS D15.1/D15.1M	Railroad Welding Specification for Cars and Locomotives
AWS D17.2/D17.2M	Specification for Resistance Welding for Aerospace Applications
BSS 7239	Generation of Toxic Gases Standard
DIN 25570	Pipes for rail vehicles – Summary, selection, application, bending radius
DIN 41612	Two-Part Connectors For Printed Boards
DIN/EN/ISO 8434-1	Metallic tube connections for fluid power and general use – Part 1: 24° cone connectors
EN 10305-1	Steel tubes for precision applications – Technical delivery conditions – Part 1: Seamless cold drawn tubes
EN 15085	Railway applications -Welding of railway vehicles and components
EN 50124	Railway Applications - Insulation Coordination
EN 50343	Railway applications - Rolling stock - Rules for installation of cabling
Fed Spec KK-L-165C	Leather, Cattlehide, Vegetable Tanned and Chrome Retanned; Impregnated, and Soles

Fed Spec MMM-A-181	Adhesives, Phenol, Resorcinol or Melamine Base
FTMS 191A Method 5122	Federal Standard for Textile Test Methods – Method 5122: Strength of Cloth' Diaphragm Bursting Method
ICEA S-19-81	Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
ICEA S-66-524/NEMA WC7	Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
ICEA S-95-658	Power Cables Rated 2000 V or Less for the Distribution of Electrical Energy
IEC 60571	Railway applications – Electronic equipment used on rolling stock
IEC 60947-4	Low-Voltage Switchgear and Control Gear, Part 4: Contactors and Motor-Starters
IEC 60603-2/EN 60603-2	Connectors for frequencies below 3 MHz for use with printed boards - Part 2: Detail specification for two-part connectors with assessed quality, for printed boards, for basic grid of 2,54 mm (0,1 in) with common mounting features
IEC 61349	Low-voltage switchgear and control gear assemblies
IEEE Std 16	Standard for Electrical and Electronic Control Apparatus on Rail Vehicles
IEEE C37.13	Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures
IEEE C37.14	Standard for DC (3200 V and below) Power Circuit Breakers Used in Enclosures
IEEE 383	Standard for Qualifying Electric Cables and Splices for Nuclear Facilities
IFI-108	Grade and Source Identification Marking of Grades B and C Prevailing-Torque Type Hex Locknuts
IFI-114	Break Mandrel Blind Rivets
IFI-543	Test for Evaluating the Torque-Tension Relationship on Both External and Internal Metric Threaded Fasteners

IPC-2220 Series:

IPC-2221	Generic Standard on Printed Board Design
IPC-2222	Sectional Design Standard for Rigid Organic Printed Boards
IPC-2223	Sectional Design Standard for Flexible Printed Boards
IPC-2224	Sectional Standard for Design of PWBs for PC Cards;
IPC-2225	Sectional Design Standard for Organic Multichip Modules (MCM-L) and MCM-L Assemblies
IPC-2226	Sectional Design Standard for High Density Interconnect (HDI) Printed Boards
IPC-A-610	Acceptability of Electronic Assemblies
IPC-CC-830	Qualification and Performance of Electrical Insulating Compound for Printed Wiring Assemblies
IPC/WHMA-A-620	Requirements and Acceptance for Cable and Wire Harness Assemblies
ISO 273	Fasteners -- Clearance holes for bolts and screws
ISO 898-1	Mechanical properties of fasteners made of carbon steel and alloy steel -- Part 1: Bolts, screws and studs with specified property classes -- Coarse thread and fine pitch thread
ISO 898-2	Mechanical properties of fasteners made of carbon steel and alloy steel -- Part 2: Nuts with specified property classes -- Coarse thread and fine pitch thread
ISO 2230	Rubber products -- Guidelines for storage
ISO 2553	Welding and allied processes – Symbolic representation on drawings – Welded joints
ISO 9223	Corrosion of metals and alloys — Corrosivity of atmospheres — Classification, determination and estimation
MIL-DTL-3950	Detail Specification: Switches, Toggle, Environmentally Sealed, General Specification for
MIL-DTL-5757	Detail Specification: Relays, Electromagnetic, General Specification for

MIL-DTL-13777	Detail Specification: Cable, Special Purpose, Electrical
MIL-DTL-55302	Detail Specification: Connectors, Printed Circuit Subassembly and Accessories
MIL-DTL-83502	Detail Specification: Sockets, Plug-In Electronic Components, Round Style, General Specification for
MIL-DTL-83731	Detail Specification: Switches, Toggle, Unsealed and Sealed, General Specification For
MIL-DTL-83734	Detail Specification: Sockets, Plug-In Electronic Components, Dual-In-Line Packages (DIPS) and Single-in-Line Packages (SIPS), General Specification for
MIL-HDBK-132	Protective Finishes for Metal and Wood Surfaces
MIL-P-23469	Pin-Rivet, Grooved and Collar, Grooved Pin-Rivet, Swage-Locked (Lockpin)
MIL-PRF-6106	Relays, Electromagnetic
MIL-PRF-8805	Performance Specification: Switches and Switch Assemblies, Sensitive, Snap Action (Basic, Limit, Push Button and Toggle Switches), General Specification for
MIL-STD-883	Microcircuits, Test Standards
MIL-T-16366	Terminals, Electrical Lug and Conductor Splices, Crimp Style
MIL-W-22759	Wire, Electrical, Fluoropolymer-Insulated, Copper or Copper Alloy
NAS 410	NAS Certification & Qualification Of Nondestructive Test Personnel
NASM21044	Nut, Self-Locking, Hexagon, Regular Height, 250 Degrees F, 125 KSI Ftu and 60 KSI Ftu
NEMA 250	Enclosures for Electrical Equipment (1000 Voltage Maximum)
NEMA HP 3	Electrical and Electronic Polytetrafluoroethylene (PTFE) Insulated High Temperature Hook -up Wire, Types ET (250 V), E (600 V) and EE (1000 V)
NEMA LD 3	High-Pressure Decorative Laminates (HPDL)
NEMA LI 1	Industrial Laminated Thermosetting Products

NEMA MG 1	Motors and Generators
NEMA WC 3	Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
NEMA WC 27500	Standard for Aerospace and Industrial Electrical Cable
NFPA 70	National Electrical Code
NFPA 130	Standard for Fixed Guideway Transit and Passenger Rail Systems
NIST PS 1	Structural Plywood
SAE AMS 5567	Steel, Corrosion Resistant, Seamless or Welded Hydraulic Tubing 19Cr - 10Ni (304) Solution Heat Treated
SAE AMSC 7438	Core Material, Aluminum, for Sandwich Construction
SAE AMST 6845	Tubing, Steel, Corrosion-Resistant (S30400), Aerospace Vehicle Hydraulic System 1/8 Hard Condition
SAE AS 5942	Marking of Electrical Insulating Materials
SAE AS 50151	Connectors, Electrical, Circular Threaded, AN Type, General Specification For
SAE AS 7928	Terminals, Lug: Splices, Conductor: Crimp Style, Copper, General Specification for
SAE AS 22759	Wire, Electrical, Fluoropolymer-Insulated, Copper or Copper Alloy
SAE AS 25036	Terminal, Lug, Crimp Style, Copper, Insulated, Ring Tongue, Bell-Mouthed, Type II, Class 1 (For 105°C Total Conductor Temperature)
SAE J343	Test and Test Procedures for SAE 100R Series Hydraulic Hose and Hose Assemblies
SAE J356	Welded Flash-Controlled Low-Carbon Steel Tubing Normalized for Bending, Double Flaring, and Beading
SAE J429	Mechanical and Material Requirements for Externally Threaded Fasteners
SAE J516	Hydraulic Hose Fittings
SAE J517	Hydraulic Hose

SAE J524	Seamless Low-Carbon Steel Tubing Annealed for Bending and Flaring
SAE J533	Flares for Tubing
SAE J673	Automotive Safety Glazing Materials
SAE J995	Mechanical and Material Requirements for Steel Nuts
SAE J1273	Recommended Practices for Hydraulic Hose Assemblies
SAE J1405	Optional Test Procedures for Hydraulic Hose Assemblies
SAE USCAR 7	De-embrittlement Verification Test
UL 900	Standard for Air Filter Units

SECTION 17
NETWORK AND TRAINLINE CONTROL

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17.1 Scope

A. This Section provides the requirements for network and trainline controls on the Silverliner VI cars.

17.2 Design Requirements

17.2.1 Architecture

A. Comply with the following:

1. The trainlines shall consist of discrete wires for safety, operational reliability, and resiliency, an Ethernet Train Backbone to provide monitoring and diagnostic, digitized audio and video, and other required communication, and battery trainlines to support operational requirements.

2. Select functions for electrical trainlines based on the premise that a hard-wired trainline has fewer failure modes than a network with subsystems and is thus inherently more reliable.

3. The identification of certain trainline signals and functions in these requirements are not exhaustive. As the design progresses, the signals and functions shall be amended as necessary, to meet the safety and performance requirements of the Specifications and to provide safe, reliable operation of the train. Determine the final discrete trainline configuration during the design and safety analysis process and establish by the Final Design Review.

4. The Contractor shall develop a trainline and network list that identifies trainline and vehicle signals and functions. The list shall indicate the transmission method used for each signal and define whether it is a discrete trainline or network transmission. An initial trainline and network list shall be submitted to SEPTA for review at the conceptual design review, and for further review and prior to the final design review. (**CDRL 17-01, Trainline and Network List)**

17.2.2 General Requirements

A. Comply with the following:

1. All trainline components, including networks, shall be designed to ensure proper operation of trainlined functions for train lengths of up to twelve cars, made up of any combination of car types, and coupled in any orientation. While expected normal train consists will not generally exceed 6 cars, the design shall permit one disabled train to couple to another train and facilitate regular shop movement of empty trains.

2. Trainline design shall permit operation from any cab in the train.

3. The Contractor shall ensure that all trainline signals function reliably across automatic coupler contacts without requiring additional coupler maintenance.

4. All networks shall be based on the 7-layer Open Systems Interconnection (OSI) model. Full documentation of each layer for each network shall be provided in a Network Interface Control Document to be submitted prior to Preliminary Design Review. The document shall be updated with all changes through testing and the end of the warranty period. (**CDRL 17-02, Network Interface Control Documents)**

5. Receptacle locations, jumper lengths, coupler electric portions, coupler cables, and all other aspects of inter-car connections shall be designed for reliable operation over curves, turnouts, interlockings and switches while minimizing risk of damage due to wayside debris.

6. Pay strict attention to balancing with respect to ground and noise sources, EMI, shielding, grounding, impedance and impedance matching, attenuation, and terminations when designing trainline circuits for data network, audio, RF, and low-level signal applications.

7. The network designs shall assume that the cars within a train are not at the same potential, and the shielding of the cable shall be terminated to prevent ground current from flowing between cars. The bonding and termination of cables shall minimize the effect of ground current by using typical engineering practices such as centralizing a common ground point.

8. Where redundant trainlines are employed, the redundancy scheme shall ensure that redundant circuits are routed in separate harness bundles, conduits, or raceways, and interconnected with the use of different connectors.

9. Special consideration shall be given to making and breaking of the automatic coupler contacts to avoid contact damage due to arcing and/or welding.

10. Networks shall use shielded Category 6A or better Ethernet cables, as specified in Section 16, Materials and Workmanship. Network cables shall meet all the tests for smoke and flammability specified in Section 23, System Safety and Security.

11. Coupler pins and trainline circuits shall be so arranged that, in the event of an inadvertent coupling of the Silverliner VI cars to the Silverliner IV or Silverliner V cars, no damage or hazardous mis-operation can occur on the Silverliner VI, the Silverliner IV, or the Silverliner V.

12. Submit a control specification and performance analysis. (**CDRL 17-03, Control Specification and Performance Analysis)**

B. Refer to Section 24, Cybersecurity, for additional cybersecurity-related requirements.

17.3 Network Communications

17.3.1 General

A. Comply with the following:

1. Physical redundancy in network switches and other subcomponents shall be employed, as specified in this section, to ensure high availability of all subsystems.

2. Where redundancy is employed, redundant components and associated circuitry shall be configured such that normal train operation may continue with loss of one of the redundant network components.

3. Wireless data transfer interfaces between subsystems on the cars are prohibited.

4. The design shall include interconnection of subsystems between multiple networks, as required.

5. The isolation of the network connections when coupling or uncoupling shall be done by solid state devices. Switching of the train networks through the drum switch or control relay contacts is prohibited.

6. The protocol used over the train networks shall provide a transparent data highway and shall not be tied to any specific subsystem protocol. The protocols shall be conceived such that changes or replacement of network subsystems with other compliant technologies will not cause obsolescence of interface protocols or equipment.

7. Network functionality and redundancy shall be at least equivalent to traditional direct-wired trainline and control cables, without reduction in safety, reliability, or control sensitivity.

8. The train networks shall be active whenever battery power is applied, regardless of whether a cab is active.

9. Provide Ethernet cable spares as specified in Section 16, Materials and Workmanship.

10. Submit a detailed network design description. **(CDRL 17-04, Network Design Document**)

17.3.2 Train Communication and Diagnostic Network (TCDN)

17.3.2.1 General Requirements

A. Provide an all-Ethernet/IP-based Train Communication and Diagnostic Network (TCDN) to support the transmission of commands and data such as diagnostic and monitoring and communication. The TCDN shall be composed of two physically

redundant Gigabit Ethernet Train Backbones (ETB) and of a ring-based redundant Gigabit Ethernet Consist Network (ECN).

1. The TCDN shall be composed of two physically redundant Ethernet Train Backbones (ETBs) and of a fully redundant Ethernet Consist Network, as further described in this section.

2. The TCDN shall be based on IEC 61375-2-5, IEC 61375-3-4 and IEEE Std 1473, for Type E protocol.

3. Where possible, the data format employed shall conform to the Train Real Time Data Protocol (TRDP), as specified in IEC 61375-2-3.

4. During normal conditions, the inauguration of the TCDN (Train IP Network Addressing, election of Master, Backup Ethernet Train Backbone Nodes (ETBN), etc.) shall be determined by attributes (such as control lock switch in Run position, Coupled) that shall be reported internally to the ETBN by the Master Logical Control Units (MLCUs) and the Logic Control Units (LCUs) of each car over the Ethernet Consist Network.

5. The TCDN shall automatically configure itself such that activation of any Operator's cab in a train will recognize that car as the controlling car in the train. Network controllers in the other cars in the train shall recognize the controlling car and respond appropriately.

6. The TCDN shall use network cable as specified in TS 17-2.

7. The IP address mapping and routing scheme used on the TCDN shall allow for unicast and multicast transmission. The general broadcast of messages shall be limited to the greatest extent possible, and its use shall necessitate SEPTA's Approval on a case-by-case basis.

8. Protocols used on the TCDN to support services over IP at the network layer, transport layer, and application layer of the ISO/OSI model (including IGMP, ICMP, ARP, UDP, TCP, TFTP, FTP, SFTP, SNMP, RTP, TELNET and HTTP) shall be subject to approval by SEPTA.

9. The TCDN shall use a pair of redundant 1000BASE-T fault-tolerant Ethernet networks (IEEE Std 802.3) to handle the communication between the consist switch(es) of the A-car and B-car using a ring topology.

10. The TCDN shall be configured as a group of independent virtual LANs. Virtual LANs shall be used to segregate and load shed services as appropriate but, as a minimum, to separate public address and passenger emergency intercom traffic from other subsystem functions. All voice and audio control shall be accomplished over IETF/RFC-recognized IP services, such as RTP and RTCP.

11. Provide an Ethernet Universal Service Port (USP) to access the TCDN.

a. The port shall be located in a convenient location in the cab area, and shall be used to support of PTU functions and configuration / troubleshooting tools simultaneous with operation of the TOD.

b. The ECN USP shall be located behind a panel secured by the maintenance key specified in Section 14, Interior and Exterior Appointments, and comply with physical security requirements in Section 24, Cybersecurity. (See also in Section 27, Special Tools and Test Equipment).

c. Connections between PTU and the USP shall be made via a 8P8C ("RJ45") connector.

17.3.2.2 Ethernet Train Backbone (ETB)

A. The two physically redundant ETBs shall be used to interconnect each car and each married pair.

1. The Ethernet trainlines shall be physically routed independently from end-to-end of each electrical coupler face, via two sets of fully redundant ETBNs.

2. The TCDN traffic to be exchanged between married pairs shall be carried in parallel by both ETBs for redundancy, so that the failure to communicate over one ETB shall not interrupt TCDN traffic from flowing between married pairs.

3. The design of the ETBs shall be based on IEC 61375-2-5, IEEE Std 802.3, and IEEE Std 1473, for Type E protocol.

4. The ETB architecture shall permit the execution of a function that shall be capable of identifying the number, sequence, and orientation of each car in a train composed of up to 12 cars. This function shall also have the ability to recognize and locate any number of dead cars within a 12-car train.

5. The two ETBs making up the TCDN shall implement Internet Protocols (IP) over redundant 1000BASE-T Ethernet networks based on IEEE Std 802.3. Fully redundant ETBN shall be used within each ETB to accomplish the following:

a. Manage electrical coupling and isolation of the ETB trunks.

b. Bypass the ETBN in case of its malfunction or when operating the TCDN through dead cars.

c. Report faulty network or hardware conditions to the Vehicle Monitoring and Diagnostic System (VMDS). Provide separate faults that identify whether one or both of the redundant network paths/devices has failed. Provide detailed fault information as part of the Fault Management Plan specified in Section 18, Monitoring and Diagnostics.

d. Perform an automated discovery of neighboring nodes and of LAN policies such as link aggregation (Train Topology Discovery Protocol

(TTDP)), Quality of Service (QoS), and Virtual Local Area Network (VLAN), as applicable.

e. If needed, manage an IP address translation scheme to support all possible train configurations polarity (A-car to A-car, B-car to B-car, and A-car to B-car), when coupled front-end to front-end, rear-end to rear-end, or front-end to rear-end.

f. Handle the switching of telegrams over the TCDN and manage the routing of IP protocol data units between the ETB and the consist switch.

6. The TCDN ETBs shall be fault-tolerant, and their topology shall be able to prevent a single point of failure from disabling communication between the consist switch(es) and the end devices connected to the TCDN Ethernet Consist Network, or from disabling communication of the end devices among themselves. Where possible, a point-to-point topology shall be employed (such as from end device to consist switch) to mitigate medium access control (MAC) issues (e.g., collisions), and to ease troubleshooting.

17.3.2.3 Ethernet Consist Network (ECN)

A. The TCDN Ethernet Consist Network (ECN) shall be used to interconnect, at the car level, all the end devices (subsystems and components).

1. Redundancy of the TCDN Ethernet Consist Network shall be implemented at the network level so that communication to/from a critical end device can be maintained in case of failure of a consist switch.

2. Redundancy of the TCDN Ethernet Consist Network shall also be implemented at the end-device level (dual homing) for devices whose network failure would result in a service interruption, so that the communication to/from the critical end device can be maintained in case of failure of one of its redundant links.

3. The design of the TCDN Ethernet Consist Network shall be based on IEC 61375-3-4, IEEE Std 802.3, and IEEE Std 1473, for Type E protocol.

4. The fault-tolerant TCDN Ethernet Consist Network shall be provided between cars of a married pair, as required to permit communications and control facilities provided on only one car of the married pair to be reached by the other cars without requiring use of the TCDN ETBs.

5. The end devices connected to the Ethernet Consist Network shall comply with TS 17.4.3.

6. The traffic-handling policies over the Ethernet Consist Network shall rely on known, available, and standard applications, such as VLAN and QoS, in order to avoid congestion, and to provide precedence to certain data packets according to configurable priorities.

17.3.3 Video Surveillance System Network

A. Provide a video surveillance system (VSS) network.

1. The VSS network shall connect the VSS equipment specified in Section 13, Communications.

2. The VSS network shall allow VSS subsystems on each car to communicate with each other.

3. The VSS equipment shall wirelessly transmit video on a per-car basis. Wireless offload shall be performed as specified in Section 13, Communications. The Train-to-Wayside Data Transfer (TWDT) subsystem shall be directly connected to each set of VSS equipment on a per-car basis. The VSS network may be connected to the TWDT subsystem if necessary, based on the design of the VSS subsystem.

4. The VSS network should otherwise be isolated and separate from other networks on the car.

5. The VSS network shall use network cable as specified in TS 17.2.

6. The protocol for the VSS network shall be Approved.

7. Install an Advantech EKI-9528 28 Port M12 managed PoE Switch or Approved equal for the Video Surveillance System's exclusive use.

8. A dedicated port for each Video Surveillance System camera is required.

17.3.4 Data Transmission Across Coupler

A. Choose appropriate technology for transporting data across the coupler, taking into consideration the worst-case conditions for using a conventional electrical coupler system.

1. Analyze the level of risk with the aid of the System Integrator.

2. Link aggregation using TTDP shall be employed for the aggregation of multiple Ethernet ports across the electrical coupler.

17.3.5 Test Points

A. The car design shall provide test points for all networks for the purpose of troubleshooting and maintenance.

1. Test points shall be accessible and shall not require dismantling vehicle components and cabling for access purposes.

2. Each ECN switch shall include one spare Gigabit port for the purposes of network mirroring of any other port on that switch.

3. Where the application of test points could result in weakening the integrity of networks, provide test harnesses that permit temporary branching off onto network legs that are normally encapsulated between connectors.

4. Test points or test harnesses shall permit simultaneous hook up of a scope/meter and a protocol analyzer in locations that are suitable (practical and safe) for the execution of dynamic tests.

17.4 Network Design

17.4.1 General

17.4.1.1 Protocols

A. Comply with the following:

1. Communication protocols shall be organized and documented in terms of the ISO/OSI communication model.

2. Data network protocols and transmission methodology shall be as Approved.

   a. Data network protocols shall implement industry best practices to provide for robust, secure, and reliable communications between subsystems, and between subsystem devices.

   b. Protocols shall be designed to support anticipated future needs of the vehicle, such as the addition or replacement of a component or device.

   c. All network protocols and transmissions shall be defined and submitted to SEPTA as per the requirements of Section 25,Program Management and Commissioning.

3. Any network protocol used to support the management of non-IEEE Std 802.3 compliant topologies, or to execute network tasks residing at the application layer of the OSI model, shall be designed and programmed in separate software configuration items to allow full disclosure of associated documentation to SEPTA, and to permit the integration of similar solutions as obtained from multiple source vendors.

4. The communication protocols shall provide for interconnecting of networks, as applicable, and for the prioritization and filtering of network traffic.

17.4.1.2 Traffic Levels

A. The calculated peak and average traffic levels on each married pair shall not exceed 60% of the maximum peak and average traffic levels.

17.4.1.3 General Network Requirements

A. Comply with the following:

1. Network data formats shall be structured in a universal fashion, not intimately tied to the needs of a particular subsystem. These data formats shall be fully documented and submitted to SEPTA for Approval.

2. Subsystem designers, including the propulsion and braking subsystem designers, shall provide written approval of the network characteristics for those signals. During vehicle commissioning, actual peak and average data traffic levels shall be measured to demonstrate compliance with this requirement.

3. Protocols shall include error detection. All nodes on the network shall collect summary statistics regarding current and historical error rates and make that information available to the VMDS specified in Section 18, Monitoring and Diagnostics.

4. Physical designs shall presume that there are static and dynamic differences in the ground reference level of each car and equipment package within a car.

17.4.1.4 Signal Quality

A. The physical network design shall consider the effects of common-mode noise, such as that typically encountered on self-propelled electric multiple-unit vehicles.

1. Submit **CDRL 17-05, Signal Quality Plan**.

2. The thresholds specified in the Signal Quality Plan shall provide enough signal-to-noise (SNR) benchmarking to allow troubleshooting the networks for noisy conditions with the use of standard scopes/meters, and shall not require the hook-up of protocol analyzers for that purpose.

3. The SNR and bit-error-rate (BER) values provided in the final Signal Quality Plan shall also result from static tests conducted in a laboratory, and from dynamic tests conducted on the new cars (e.g., to provide historical data), and shall not rely on levels that are found in specifications or white papers that do not specifically apply to railway conditions.

4. Testing shall be performed as specified in Section 15, Test Program.

17.4.2 Ethernet Switches

A. Comply with the following:

1. All IP switches (whether integrated into subsystem controllers or stand-alone units) shall be managed and designed to support the following:

a. IPV4 and IPV6 in bi-mode in reference to RFC-3964

(1) This requirement shall not be interpreted to require all components on the car to be compatible with IPV6. Only Layer 3 (managed) switches must be able to handle IPV6 addresses.

b. MAC services and addressing as per IEEE Std 802.3

c. Management and Remote Management as per IEEE Std 802.1D

d. Ethernet Frame Relaying, Filtering and Queuing as per IEEE Std 802.1D

e. Virtual Local Area Network as per IEEE Std 802.1Q

f. Link Layer Discovery Protocol as per IEEE Std 802.1AB

g. QoS as per IEEE Std 802.1P

h. Link Redundancy Management

i. Host enough buffering and queuing capability to avoid the congestion on common network and/or internetwork bottlenecks.

2. The use of Ethernet hubs is prohibited.

3. The design specification of the component shall meet the following additional requirements:

   a. Specifically designed for use in a rail transit application.

   b. Meets the requirements in the Specifications for vibration, shock, electrostatic discharge, and EMC, as specified in Section 2, Design and Performance Criteria.

   c. Complies with the requirements in the Specifications for electronic equipment as specified in Section 16, Materials and Workmanship.

4. IP routers and IP switches shall employ Ethernet M12 connectors, utilizing D-coded 4-pin connectors for 100Mbps links, and X-coded 8-pin connectors for 1000Mbps links.

5. The connector shall be equipped with a positive locking mechanism, although an alternative solution may be proposed to SEPTA for Approval.

17.4.3 End Devices

A. All car network end devices shall implement a unique device ID scheme (such as realized with encoded plugs) to ensure that the replacement of end devices does not require manual reentry or reconfiguration for any purpose, including to associate an IP addresses or subsystem attributes that may define equipment type, location, orientation, or numbering sequence in the vehicle.

B. End devices which are availability-critical shall use two separate physical network interfaces (dual homing) to communicate on the ECN.

C. All protocols used for addressing car network end devices, as follows, shall be fully documented and disclosed to SEPTA, together with the escrowed source code as specified in Section 19, Software Engineering:

1. To support the administration of the network topologies

2. To coordinate the transmission of data

3. To ensure the security of the car network.

17.5 Discrete Trainlines

A. Electrical trainlines shall be provided to ensure vehicle functionality, safety, and reliability of the Silverliner VI railcars and trains.

1. Identify all ETB, ECN, and trainline functions in the Preliminary Hazard List specified in Section 23, System Safety and Security. Determine the placement of functions on either the ETB, trainlines, or both as part of the system integration effort required in Section 25, Program Management and Commissioning, and review during the Preliminary Hazard Analysis specified in Section 23, System Safety and Security.

2. Coordinate arrangement of trainline connections through the coupler as required by Section 4, Coupler and Draft Gear.

3. Propulsion and braking control shall be implemented through the use of discrete trainlines including separate power and braking current-based "P-wire" trainlines. Back-up trainlines, such as power request, full service brake request, and others necessary to provide traction and braking requests during degraded scenarios (including partial failure of master controller or brake handle, or trainline failure) shall be implemented. The Contractor shall coordinate the design and implementation of the traction request and brake request trainlines and submit an integrated trainline design package demonstrating compliance with the design requirements of the Technical Specification. **CDRL 17-06, Discrete Propulsion and Braking Trainline Design**.

Table 17-1, Trainlines

Trainline	Spec Ref	Basic Function
High Level Right Door Close	6, Passenger Doors	Closes high level right-side doors in response to a pushbutton operation at the conductors door controller.
High Level Left Door Close	6, Passenger Doors	Closes high level left-side doors in response to a pushbutton operation at the conductors door controller.
Low Level Right Door Close	6, Passenger Doors	Closes low level right-side doors in response to a pushbutton operation at the conductors door controller.

Trainline	Spec Ref	Basic Function
Low Level Left Door Close	6, Passenger Doors	Closes low level left-side doors in response to a pushbutton operation at the conductors door controller.
High Level Right Door Open	6, Passenger Doors	Opens high level right-side doors in response to a pushbutton operation at the conductors door controller.
High Level Left Door Open	6, Passenger Doors	Opens high level left-side doors in response to a pushbutton operation at the conductors door controller.
Low Level Right Door Open	6, Passenger Doors	Opens low level right-side doors in response to a pushbutton operation at the conductors door controller.
Low Level Left Door Open	6, Passenger Doors	Opens low level left-side doors in response to a pushbutton operation at the conductors door controller.
High Level Right Door Close Return	6, Passenger Doors	Return for high level right door close.
High Level Left Door Close Return	6, Passenger Doors	Return for high level left door close.
Low Level Right Door Close Return	6, Passenger Doors	Return for low level right door close.
Low Level Left Door Close Return	6, Passenger Doors	Return for low level left door close.
High Level Right Door Open Return	6, Passenger Doors	Return for high level right door open.
High Level Left Door Open Return	6, Passenger Doors	Return for high level left door open.
Low Level Right Door Open Return	6, Passenger Doors	Return for low level right door open.
Low Level Left Door Open Return	6, Passenger Doors	Return for low level left door open.
Propulsion P-wire +	5, Operator's Cab and 10, Propulsion and High Voltage System	P-wire loop for propulsion control
Propulsion P-wire -	5, Operator's Cab and 10, Propulsion and High Voltage System	P-wire loop for propulsion control
Propulsion A	5, Operator's Cab and 10, Propulsion and High Voltage System	Discrete propulsion trainline used for failover during P-wire impairment
Propulsion B	5, Operator's Cab and 10, Propulsion and High Voltage System	Discrete propulsion trainline used for failover during P-wire impairment
Propulsion C	5, Operator's Cab and 10, Propulsion and High Voltage System	Discrete propulsion trainline used for failover during P-wire impairment
Power Enable	5, Operator's Cab and 10, Propulsion	Used to indicate that powering is enabled

Trainline	Spec Ref	Basic Function
	and High Voltage System	
Yard Mode	5, Operator's Cab and 10, Propulsion and High Voltage System	Used to modify tractive effort demand and maximum speed for slow-speed yard moves.
Carwash Mode	5, Operator's Cab, 10, Propulsion and High Voltage System, and 7, Heating, Ventilation, and Air Conditioning	Used to modify tractive effort demand, maximum speed, and blower operation for carwash.
Braking Enable	12, Friction Brake	The leading cab Brake Controller Handle is in the Minimum brake position or beyond
Brake Demand P-wire +	12, Friction Brake	A DC current P-wire loop for braking effort command
Brake Demand P-wire -	12, Friction Brake	A DC current P-wire loop for braking effort command.
Emergency Brake	12, Friction Brake	Brake pipe is charged and no condition or command exists to initiate an emergency brake.
Additional redundant braking and propulsion trainlines	5, Operator's Cab 12, Friction Brake 10, Propulsion	To provide back-up control of propulsion and braking in instances of potential p-wire or handle failures.
Parking Applied Light	12, Friction Brake	Provides indication in cabs and via the diagnostic system that there is an application of a parking brake somewhere on the train.
Brakes Released Light	12, Friction Brake	Provides indication in the cabs that all brakes are released on the train.
Brakes Applied Light	12, Friction Brake	Provides indication in the cab of the activation status of friction brakes on the train.
Pantograph Up	10, Propulsion and High Voltage System	Requests raising of pantographs throughout the train.
Pantograph Down	10, Propulsion and High Voltage System	Requests the dropping of pantographs throughout the train
Car Activation	5, Operator's Cab	Provides indication that a cab is activated in the train, allowing for activation of any shutdown car in a train.
All Doors Closed and Locked Indication	6, Passenger Doors	Provides indication to activated door control panels that all doors are closed and locked.
All Doors Closed Summary	6, Passenger Doors	Loop summary circuit that indicates all side doors are closed and locked in the active cab, to allow traction power to be generated and to allow friction brakes to be released. Double break.

Trainline	Spec Ref	Basic Function
Cab Reset	10, Propulsion and High Voltage System	Commands propulsion system reset for certain failure conditions which require manual reset for safety reasons.
Cab Interlock	5, Operator's Cab	Provides indication that a cab is activated in the train, allowing for interlock to prevent multiple cab activations.
Doorway Interlock	6, Passenger Doors	Identifies that a door control panel is activated, allowing the prevention of activating multiple door control panels on a train.
T/M Bypass Switch	10, Propulsion and High Voltage System	Traction Master Bypass switch, used to bypass certain traction interlocks to allow limited speed movement of train in certain failure conditions.
Propulsion Fault	10, Propulsion and High Voltage System	Indicates in each cab the occurrence of at least one major propulsion fault somewhere in the train.
Interior Fire	7, Heating, Ventilation, and Air Conditioning	Indicates in each cab the activation of an interior smoke alarm somewhere in the train.
Snow Brake	12, Friction Brake	Provide light friction braking to prevent icing.
Door Emergency Release	6, Passenger Doors	Provides indication in the operator cabs that an emergency door release has been activated somewhere in the train.
Door Closed and Locked	6, Passenger Doors	Indicates that all doors on the train are fully closed and locked
Bypass in use	5, Operator's Cab	Informs the train operator as to the activation of a service-impacting bypass in the train, such as traction, door, brake, speed, penalty, or emergency valve bypass.
Train Shut Down	5, Operator's Cab	Commands a train-wide shutdown of car systems
Wheel Slide Enable in Emergency	12, Friction Brake	Enables wheel slide protection during emergency brake conditions when certain pre-requisites are met.
Buzzer	13, Communications	Controls the communication system buzzer system
Reverse/Forward	5, Operator's Cab	Used to command direction of motion through input from reverser in active operator’s cab
Forward/Reverse	5, Operator's Cab	Used to command direction of motion through input from reverser in active operator’s cab
Cab Makeup	5, Operator's Cab	Establishes and activates controlling console. Provides signal to other

Trainline	Spec Ref	Basic Function
		control stands that there is an active controlling car to prevent double-activation.
ETB Network Buses	17, Trainline and Network Control	Redundant Ethernet Train Backbone cables which support high-speed communication requirements throughout the train.
Battery (B+)	9, Auxiliary Power Systems	Multiple wires that allow sufficient combined current carrying capacity throughout a train.
Battery (B-)	9, Auxiliary Power Systems	Multiple wires that allow sufficient combined current carrying capacity throughout a train and keep each car in the train at a common potential so that potential sneak circuit paths/loops are mitigated.
Ground	9, Auxiliary Power Systems	Ensure common ground reference throughout a train
Ethernet Train Backbone	17, Network and Trainline Control	Sufficient contacts for a quantity for quantity of 6 Gigabit networks with future upgradeability to 10 Gigabit, each supported by 4-pair Category 6A cabling connections (potential of 3 redundant networks, one redundant network implemented as ETB, and two spare).

17.6 Faults and Diagnostics

17.6.1 Fault Tolerance

A. Comply with the following:

1. Network interfaces shall be designed to minimize the possibility that a transceiver component fault could disable the network.

2. Component faults shall not inhibit or severely degrade train control functions other than the failed component.

3. Fault recovery shall be automatic to the maximum extent possible. Systems shall be designed so that the failure of any subsystem to respond properly shall not inhibit or severely degrade network functions outside of the unresponsive subsystem. This includes periods during which a subsystem is being reset.

4. The subsystem design shall allow all faults to be simply isolated. Network component faults shall cause the offending equipment to be disabled or disconnected from the network.

5. All faults shall be reported to the VMDS.

6. When nodes on the network are replaced, the network system shall automatically identify the replacement equipment and its communication links without any requirement for reconfiguration by a maintainer.

17.6.2 Network Diagnostics

A. For the purposes of network maintainability and diagnostics, full per interface statistics of each network connected device shall be available. The interface statistics shall include, at a minimum, packets transmitted, received, transmitted errors (broken down by type), received errors (broken down by type), packet types (unicast, multicast, broadcast, etc.), as well as interface connection duration, speed, and resets.

B. The network statistics shall be stored centrally and reported when requested via the PTU, onboard VMDS, or via the wayside TWDT subsystem. The display of the network statistics shall provide a network device overview and indicate issues such as interfaces that have a high number of errors and resets. In addition to the interface statistics reported by each interface, a resettable local counter on each display type shall be provided to facilitate troubleshooting and identification of fixes.

17.6.3 Network Self-Test

A. The network subsystem shall include self-test features that automatically identify defective nodes.

1. The subsystem shall incorporate a self-test to verify that all system components are working normally within predefined limits, and to check and troubleshoot the integrity of the system.

a. The subsystem shall initiate a self-test upon startup.

b. The self-test shall be capable of being initiated by the PTU. The ETB and ECN self-test shall also be capable of being initiated by the VMDS and via the TWDT subsystem.

c. Onboard network hardware shall generate worst-case round-trip traffic and characterize the performance of the network (using and providing reports on latency, throughput, and interface errors) in an attempt to identify latent defects in network cables, connectors, and devices.

d. The network self-test shall be such that each physical link can be traversed, and the network self-test (including the TOD) shall allow maintainer selection of either a complete network characterization (testing all interfaces), or a per interface characterization. The completion of the self-test shall indicate test results, expected values, and highlight potential issues.

e. Test results, including failure conditions, from the self-tests shall be communicated to the VMDS and shall be downloadable as part of the fault log by the PTU.

f. Submit documentation detailing the proposed design. **(CDRL 17-07, Network Self-Test Capability Document)**

17.7 Obsolescence and Expansion

17.7.1 Replacements and Upgrade

A. Additions and changes to vehicle subsystems shall be easily incorporated into the existing architecture without modification to other portions of the networks. Interfaces shall be documented as part of the systems integration process deliverables specified in Section 25, Program Management and Commissioning.

17.7.2 System Expansion

1. The architecture shall allow for additional subsystems and for additional functions within initial subsystems. The architecture shall allow for additional trainline functions without degrading network operation.

2. Network components shall be designed with obsolescence of implemented hardware and software planned, so that future hardware and software can be implemented without redesign of the network or networked subsystems.

3. The ETB, ECN, and systems utilizing the ETB and ECN for communication shall be designed for interoperability with future fleets, and future subsystems, without requiring software changes. Reconfiguration to support additional subsystems shall be capable of being accomplished by tools supplied by the Contractor to SEPTA.

17.7.3 Interoperability

A. All hardware and software interfaces to the networks, and the network equipment itself (e.g., switches) shall be non-proprietary:

1. Hardware used as part of a subsystem's network interface, and the network equipment itself, shall be commercially available from multiple U.S.-based suppliers.

2. Software used as part of a subsystem's network interface, and software for the network equipment itself, shall be written in a commercially available language.

3. Configuration and parameter updates of network interface hardware and network equipment shall be nonproprietary and shall not require special equipment or tools to implement.

4. Replacement of network interface hardware and network equipment shall not require special equipment or tools.

5. Full disclosure of system interoperability is required as part of the Interface Control Documents (ICD), specified in Section 25, Program Management and Commissioning.

17.7.4 Network Development Lab

A. To facilitate future development and integration of current and future fleets, and to facilitate the replacement and development of existing and future subsystems into the Ethernet Train Backbone and Ethernet Consist Network, the contractor shall supply SEPTA with a comprehensive set of simulation utilities and network devices that provides SEPTA the complete capability to simulate the ETB and ECN communications between any devices on the network.

B. This shall include the capability to simulate the Monitoring and Diagnostic system and all end-devices on the ETB and ECN.

C. The simulation tools shall be graphical in nature, and allowing SEPTA to set and adjust signals, trigger common network processing faults, and other functions useful for the design and development of network software.

D. The system shall be demonstrated at the Network Integration Test, delivered to SEPTA with the pilot vehicles, and updated and maintained by the Contractor throughout the warranty period.

17.7.5 Network and Trainline Engineering Responsibilities

A. Perform the following tasks related to this Section:

1. Prepare the following submittals, as a minimum:

a. Submit **CDRL 17-08, Control-Level Specification**.

b. Submit **CDRL 17-09, Network Interface Card (NIC) Specification**.

c. Data Network Interface Control Documents as specified in Section 25, Program Management and Commissioning.

2. Perform network testing as specified in Section 15, Test Program.

17.8 PTU Protocol Analyzer

A. Provide a Portable Test Unit (PTU) with protocol analyzer capabilities as specified in Section 27, Special Tools and Test Equipment.

17.9 Network Testing Requirements

A. The Contractor shall test to ensure each Ethernet link satisfies the complete Cabling Transmission Performance and Test Requirements of TIA/EIA 568-B.1 for Category 6A

(CAT6A) cables and the 100BASE-TX link transmission performance requirements specified in IEEE Std 802.3-2012.

1. Tests shall be performed as per TIA/EIA 568-B.2, utilizing a device that meets the accuracy requirements of a Level III tester.

2. Tests shall be performed each time a cable is replaced or re-terminated through test and warranty.

B. Test results shall be recorded by the Contractor and provided to SEPTA in a spreadsheet format for each car.

17.10 Contract Deliverable Requirements List (CDRL)

The following contract deliverables have been identified in this section; however, the Contractor is responsible for providing and submitting anything necessary to fulfill the requirements of this contract, including those not identified by CDRL number.

CDRL 17-01, Trainline and Network List 17-1
CDRL 17-02, Network Interface Control Documents 17-2
CDRL 17-03, Control Specification and Performance Analysis 17-2
CDRL 17-04, Network Design Document 17-3
CDRL 17-05, Signal Quality Plan 17-9
CDRL 17-06, Discrete Propulsion and Braking Trainline Design 17-11
CDRL 17-07, Network Self-Test Capability 17-17
CDRL 17-08, Control-Level Specification 17-18
CDRL 17-09, Network Interface Card (NIC) Specification 17-18

17.11 CDRL Details

This section lists the expected content for each CDRL required above. The lists provided for each CDRL are an outline only and should not be considered exhaustive, all CDRLs are subject to SEPTA review and Approval.

CDRL 17-01 Trainline and Network List

1. The list shall include trainline and vehicle signals and functions, including trainlines which transverse the coupler, and trainline utilized between cars of the married pair.

2. The list shall include the transmission method use for each signal and be organized to clearly identify discrete trainlines from network transmissions.

3. The list shall be submitted prior to the CDR.

4. Updates shall be provided at each subsequent design review, with approval by the time of the FDR.

CDRL 17-02 Network Interface Control Documents

1. Demonstration that all networks – including networks between subsystem components – are included in the CDRL.
2. The CDRL should provide full documentation of each layer for each network.
3. Submit prior to the Preliminary Design Review.
4. Provide updates at each Design Review.
5. Provide updates with each Software Release which impacts Network Interface Control Document.
6. Provide a final update at the conclusion of the warranty period for the last car which provides the latest and accurate Network Interface Control Document for all vehicles.

CDRL 17-03 Control Specification and Performance Analysis:

1. Demonstrate that the medium and method of transmission for all trainlined signals allows for normal train operation from any cab with train lengths up to six cars, and for emergency operation with up to 12 cars.
2. The analysis shall consider voltage drop, signal loss, signal-to-noise ratios, burst noise, distortion, and other factors that can corrupt signal transmission.

CDRL 17-04 Network Design Document:

1. Submit prior to CDR and update for each Design Review.
2. Include architectures, trainlines, associated protocols, addresses, functionality, and interface with Vehicle Monitoring and Diagnostic System (VMDS).
3. Include network diagrams showing all interconnections within a car, to other cars in a train, and to wayside wireless connections.
4. Include a list of all IP devices and spare Ethernet cables provided to each subsystem and intelligent device connected to the ECN-, as required where adding future cable for expansion or replacing failed cable may be difficult.
5. Include detailed calculations of peak and average data traffic levels. Also submit peak and average traffic levels for the transmission media, as recommended by the protocol supplier.

CDRL 17-05 Signal Quality Plan:

1. Clearly identify the susceptibility limit of the network to noise (in frequency and intensity) and specify pass-fail criteria.

CDRL 17-06 Discrete Propulsion and Braking Trainline Control

1. Provide detailed design description of the proposed trainlines utilized for traction and braking commands.

2. Propose back-up methods for failures of the trainlines, master controller, and brake handle.

CDRL 17-07 Network Self-Test Capability:

1. Define the capabilities of all network self-test functions.

CDRL 17-08 Control-Level Specification:

1. This specification shall accomplish the following:

   a. Clearly define the motoring and braking concept.

   b. Identify the types of interface used to handle vehicle functions that are critical to safety, operation, and to the reliability of the cars, in relation to IEEE 1475 Type, I, II or III.

CDRL 17-09 Network Interface Card (NIC) Specification:

1. This specification shall define all design requirements needed by each subsystem vendor to accomplish the following:

   a. Implement adequate ESD/EMI protection to ensure protection of the subsystems and prevent interference from offending nodes.

   b. Establish physical layer performance and tolerance with pass/fail criteria.

   c. Identify the network policies/services that must be respected and used by each subsystem (e.g., packet priority, network redundancy arbitration, watchdog timing).

   d. Dictate the mechanisms (e.g., DPRAM sink time supervision watchdog, error detection and correction) that must be implemented to prevent latency and discard invalid messages.

17.12 Referenced Standards

The following standards are referenced in this Section:

IEC 61375-2-5	Electronic railway equipment - Train communication network (TCN) - Part 2-5: Ethernet Train Backbone
IEC 61375-2-3	Electronic railway equipment - Train communication network (TCN) - Part 2-3: TCN Communication Profile

IEC 61375-3-4	Electronic railway equipment - Train communication network (TCN) - Part 3-4: Ethernet Consist Network
IEEE Std 802.1D	Standard for Local and metropolitan area networks: Media Access Control (MAC) Bridges
IEEE Std 802.1Q	Standard for Local and metropolitan area networks -Bridges and Bridged Networks
IEEE Std 802.1AB	Standard for Local and metropolitan area networks - Station and Media Access Control Connectivity Discovery
IEEE Std 802.3	Standard for Ethernet
IEEE Std 1473	Standard for Communications Protocol Aboard Passenger Trains
IEEE Std 1475	Standard for the functioning of Interfaces Among Propulsion, Friction Brake, and Train-Borne Master Control on Rail Rapid Transit Vehicles
IEEE Std 1558	Standard for Software Documentation for Rail Equipment and Systems
RFC-3964	Security Considerations for 6to4
TIA/EIA 568-B.1	Commercial Building Telecommunications Cabling Standard – Part 1: General Requirements
TIA/EIA 568-B.2	Commercial Building Telecommunications Cabling Standard – Part 2: Balanced Twisted-Pair Cabling Components

SECTION 18
MONITORING AND DIAGNOSTICS

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18.1 General

18.1.1 Scope

A. This Section provides requirements for monitoring and diagnostics on the Silverliner VI cars. In addition, compliance with these requirements will require specific design elements on all other subsystems of the procurement.

B. Subsystems specified in this Section include the following:

1. Vehicle Monitoring and Diagnostics Subsystem (VMDS)

2. Train to/from wayside data transfer capability, including wayside components.

18.1.2 Duty Cycle

A. Monitoring and diagnostics equipment shall be rated for continuous duty at maximum sampling rates.

18.1.3 Power

A. The Monitoring Subsystem shall be powered from the battery voltage as specified in Section 2, Design and Performance Criteria, and shall have all required power conversion and/or power conditioning devices as integral components.

18.1.4 Environmental Conditions

A. All equipment shall perform reliably under the environmental conditions specified in Section 2, Design and Performance Criteria.

B. Equipment shall be subject to a storage temperature range as specified in Section 2, Design and Performance Criteria. Equipment operated within the storage temperature range shall not be damaged, but may operate in a degraded mode.

18.2 Vehicle Monitoring and Diagnostic Subsystem

18.2.1 General

A. Provide a fully integrated VMDS. The VMDS shall provide the following functions:

1. Collect, store, and analyze fault, event, and real-time data information obtained from monitored subsystems within the car, and where necessary to fulfill the requirements of this section, from additional VMDS subsystems in the train. Stored subsystem faults, combined with associated real-time data, shall be sufficient to identify failures to the line replaceable unit (LRU) level, and where feasible, to the lowest line replaceable unit (LLRU) level.

2. Real-time data shall be defined as streaming data from all subsystems and car signals, including car operational characteristics and car status information, that provide the complete operational state of the car and its subsystems.

3. All information presented to the following parties shall be appropriate for their needs; this includes, but is not limited to:

    a. All operation-relevant information for the Operator.

    b. Information to maintenance personnel to facilitate preventive and responsive maintenance of the train and all of its equipment.

    c. Information to engineering staff for general diagnostic and analysis purposes.

    d. Control Center and Operations staff.

4. Initiate automatic and user- initiated tests of each car subsystem on the Train Communication and Diagnostic Network (TCDN) and measure/record the results. This function can only be initiated from an active cab.

5. Provide for efficient transfer of all stored information to the wayside via the Train-to-Wayside Data Transfer (TWDT) subsystem and to maintenance equipment including PTUs via a dedicated service port.

6. The VMDS shall allow personnel to quickly identify faults within the car or train, to isolate the source (subsystem) of the fault(s), and to efficiently and thoroughly investigate train incidents. Fault details shall be sufficient to identify the car, subsystem, location, and type of fault without the need for additional tools or reference materials such as code books.

7. The Contractor shall be responsible for all integration and implementation activities associated with the VMDS. The Contractor shall compile and integrate all subsystem data seamlessly. Gaps, overlaps, or inconsistencies in information shall be reviewed and resolved by the Contractor.

8. Submit documentation. **(CDRL 18-01, VMDS Design Document, and CDRL 18-02, VMDS Subsystem Interface Documents)**

18.2.2 VMDS Self-Test

A. The subsystem shall incorporate self-tests to verify that all VMDS subsystem components are working normally within predefined limits, and to check and troubleshoot the integrity of the VMDS.

    1. The subsystem shall initiate a self-test upon startup.

    2. The self-test shall be capable of being initiated by maintenance personnel via the PTU or from the VMDS via the TOD screens.

    3. Failure conditions from the electronics self-tests shall be communicated and shall be downloadable as part of the fault log by the PTU and stored within the VMDS.

    4. Submit documentation. **(CDRL 18-03, VMDS Self-Test Capability)**

18.2.3 Global Positioning System (GPS)

A. Comply with the following:

1. Provide a Wide Area Augmentation System (WAAS)-enabled GPS antenna and receiver.

2. The GPS receiver shall be connected to the VMDS subsystem and GPS information shall be forwarded one-way to subsystems connected to the TCDN.

3. The Contractor shall determine a secure method, meeting the requirements of Section 24, Cybersecurity, of providing GPS data to the CCTV Network. A GPS splitter or separate GPS antenna and receiver may be proposed, subject to SEPTA Approval.

4. GPS information shall be used for time synchronization and location determination, as applicable. The GPS shall furnish the primary car time.

5. The GPS software shall account for Week Number Rollover (WNRO).

6. All data shall be date and time stamped to allow immediate synchronization between data sets.

   a. Time stamps shall be stored both in UTC time and in local time, where the local time is defined as either Eastern Standard Time (EST) or Eastern Daylight Time (EDT) as appropriate.

   b. Daylight saving time rules shall be adjustable or completely removable via the wayside Train-to-Wayside Data Transfer (TWDT) subsystem and by PTU. For update via TWDT, updated daylight saving time rules shall be uploaded from the wayside TWDT subsystem to the VMDS and distributed train-wide to non-safety critical subsystems. It shall be possible to upload non-safety critical subsystems by PTU. Upload to safety-critical subsystems shall be by PTU only.

7. Provide satellite prediction and recent ephemeris data features for quicker location determination when the GPS is powered on.

8. Mount the GPS antenna on the roof, or other location, optimized for satellite access. Coordinate the antenna location with other car antennas to avoid interference.

18.2.4 Virtual Cab

A. Provide a virtual cab system. Comply with the following:

1. Virtual Cab:

   a. A VMDS feature by means of which a supervisory or technical user on the wayside may remotely view the real-time information presented on the actual cab displays (TOD 1 and TOD 2) of an Silverliner VI car, for

purposes of remote troubleshooting, on-the-road troubleshooting, incident management, and the like.

b. The capability shall be implemented either as a console or web application; it shall be launchable from the VMDS. A cab whose displays are viewed via Virtual Cab is referred to as a target cab.

2. Real-Time Information:

a. Manner of Viewing:

(1) Real-time information includes every piece of information that is available to an on-board user, whether presented as a graphical display, in a data table (such as a fault list), as an indicator or status button, or in any other fashion.

(2) Real-time information includes train-wide information to the same extent visible in the cab.

(3) Real-time information shall be presented via Virtual Cab in exactly the same manner as it is presented in the cab itself, so that a user familiar with the cab displays on the Silverliner VI car will require no special training to use the Virtual Cab. This does not preclude the use of static screens.

(4) Each screen image presented via Virtual Cab shall be accompanied by the car number from which it originates.

3. Screens and Navigation:

a. The wayside user shall be able to view all screens that are available in the cab itself, including all maintenance-level screens, without the need to enter any password within the screens viewed.

b. To the extent possible, the wayside user shall be able to navigate among screens in the same manner as in the cab itself, with mouse clicks substituting for TOD and other inputs.

c. Only one screen view is required per wayside user; therefore, an additional navigation element, in the same style, shall be provided on the wayside to navigate between the TOD 1 and TOD 2 screens, with the screen selection of each display persisting while the other is being viewed.

d. The viewing and navigation by the wayside user shall be independent of the use of displays by the on-board user, shall be invisible to the on-board user, and shall not hinder use of the displays by the on-board user in any way.

e. The wayside user shall not be able to carry out any command on the train other than the viewing of information via the screens; for example, the wayside user shall not be able to turn interior lights on or off, initiate a system self-test, or take any other action of that nature.

4. Scope and Capacity:

   a. Any cab, including an active cab, shall be able to be a target cab.

   b. Any target cab shall be able to be viewed simultaneously by as many as 10 distinct wayside users, each with entirely independent navigation capability as described above.

   c. Each user may also view multiple screens simultaneously. These screens could be from the same cab or different cabs.

   d. This multi-user, multi-screen capability is critical because, in the event of an incident, the affected train or cab becomes the focus of attention, with multiple users exploring different aspects of the situation.

   e. Overall, the VMDS shall support a minimum of 30 distinct, simultaneous wayside users.

   f. For each user, the screen refresh interval shall not exceed two seconds.

   g. Means shall be provided for the user to select target cab(s) to view, and to be made aware of target cab(s) that are unavailable to view, whether due to a capacity limit having been reached or any other reason.

5. Efficiency:

   a. Presentation of screens on the wayside shall be bandwidth-efficient, with only required dynamic information being transmitted between the cab and the wayside.

   b. Static screen elements, such as pre-defined graphics and pre-defined text, shall be stored on the wayside. These shall be kept up-to-date with the on-board screens.

6. Non-Interference:

   a. Use of Virtual Cab with respect to a given target cab shall not preclude or interrupt other concurrent upload or downloaded processes with respect to the same married pair.

   b. In particular, concurrent TWDT downloads shall not be precluded or interrupted, because these are also critical for incident management.

7. Access Levels:

   a. Use of Virtual Cab shall be controlled by VMDS access levels.

b. There shall be one Virtual Cab access level allowing the user to view on-board screens other than maintenance-level screens, and another allowing the user to view all on-board screens.

18.2.5 Other VMDS Functionality

A. The VMDS shall also meet the following requirements.

1. It shall be accessible from within the car.

2. It shall not degrade the reliability and safety of other car subsystems. A failure in the VMDS or its wiring shall not cause a fault in another car subsystem.

3. It shall detect and annunciate failures within the VMDS including failures or faults detected during power-on self-tests, during diagnostic tests, or by faults or hardware failures that occur subsequent to startup.

   a. Detectable faults shall include all hardware and software of the VMDS.

   b. Faults shall be annunciated via the Train Operator's Display (TOD).

   c. The fault logging system shall also record a sufficient amount of trace data, sampling data at a rate no slower than 100 ms and recording relevant data for 3 seconds before and 2 seconds after the fault.

4. Each car subsystem shall perform its own diagnostics, log fault and real-time data, and provide this information to the VMDS. A subset of information shall be reported by way of the TOD located on the console of each cab.

5. The VMDS design shall provide complete galvanic isolation of all inputs and outputs. The isolation and input protection shall meet the electromagnetic compatibility requirements in Section 2, Design and Performance Criteria. The VMDS shall be protected from damage due to transient over- and under-voltage conditions.

6. The VMDS shall communicate with all cars in a train of up to eight cars, using the TCDN. The subsystem shall identify trains longer than eight cars, in the case of non-standard operating scenarios.

7. The VMDS shall store all collected data in a non-volatile, non crash-hardened memory module with capacity for storing a minimum of 90 days of data without loss of data or overwrites.

   a. Real-time data shall be stored on both memory modules at sampling rates appropriate for the rate of change and priority of the sampled signal. Recording of real-time data from a certain subsystem shall cease if there is no change in input signal to that subsystem or request for data from the VMDS to that subsystem during a defined interval. Data recording shall resume immediately whenever there is a change in signals or a query from the VMDS. Sampling rates, and defined intervals

for each subsystem, shall be established and Approved during design reviews.

b. Polling rates for fault and event data from monitored subsystems shall be equal to the sampling rate of real-time data unless otherwise Approved.

c. Both memory modules shall be non-volatile so that memory is not lost when power to the VMDS is cut off.

8. Provision shall be made within the VMDS and any other data storage device to take advantage of higher capacity media as it becomes available to prevent obsolescence constraints.

9. Fault data shall be recorded in a structured format so that statistical analysis may be conducted after download.

10. The VMDS software shall be designed so as to differentiate a failure of a subsystem from a failure to communicate with it.

11. The VMDS shall include capabilities to limit or interrupt fault data logging while the car is in the Shop. This capability shall allow the Shop to see and use fault data in response to tests, but shall not include such data in the normal data logs. Geo-fencing may be used to perform this function.

12. Provide log file validation and replacement within the control algorithm to ensure against file corruption during file creation.

13. The VMDS shall include capabilities for downloading stored data:

    a. Download shall be via a PTU. The PTU application for the VMDS shall comply with the requirements of this Section and the PTU requirements of Section 27, Special Tools and Test Equipment. The interface to the PTU shall be an IP addressable output that uses an RJ45 Ethernet connector. There shall be one PTU Universal Service Port supplied per car, as described in Section 17, Network and Trainline Control. The PTU Universal Service Port will allow authorized users to connect a PTU laptop using web browser based programs to the VMDS and all connected subsystems on the TCDN (ATC, PTC, Brakes, Event Recorder, CCTV, pantograph video monitoring, etc.).

    b. Download of all data on the VMDS shall not exceed 5 minutes.

    c. All data shall be downloaded in a common, spreadsheet-style format that can be directly loaded into Microsoft Excel®. No data conversion shall be required.

    d. The data shall be able to be exported in .csv data format.

    e. The VMDS shall also be capable of downloading data via the wireless data transfer subsystem as specified in TS 18-3.

f. Data downloads from PTU and from TWDT shall be selectable, so that a subset of time, signals, fault data, trace data and other parameters can be chosen and downloaded by the user.

g. Data downloads from either the PTU or TWDT shall not result in the deletion of any VMDS data.

14. It shall be possible to initiate a self-test via the VMDS for subsystems connected to the TCDN. VMDS shall be capable of initiating a self-test of smoke detectors and confirming their operational status.

18.2.6 Monitored Subsystems

A. Real-time data and fault data shall be available for all processor-based subsystems and other important subsystems, including from at least the following subsystems:

1. ATC
2. PTC
3. Doors, including individual door open/closed status
4. Friction brake
5. Propulsion, including master controller position
6. LVPS
7. Auxiliary power subsystem
8. HVAC
9. Communications subsystems, including CCTV
10. Monitoring subsystems, including ride quality monitoring and pantograph video monitoring systems
11. Interior and Exterior Lights, including Emergency Lights (basic fault status, as specified in Section 8, Lighting. Real-time data is not required.)
12. Control lock
13. Discrete trainline and train network states
14. Control and indication elements, including door control pushbuttons, couple/uncouple function and bypass and cut-out switches
15. Air compressor
16. Smoke Detectors

18.2.7 Faults, Data Classification, and Attributes

Data requirements and the organization and classification of data shall conform to the following.

A. Even though the word “fault” is used below, this functionality also applies to events that may not be faults.

B. Submit a plan **(CDRL 18-04, VMDS Fault Management Plan) .**

C. VMDS software:

1. Shall be designed so as to enable SEPTA to modify attributes (fault priorities, fault text, fault help text) via upload of an attribute table from the Wayside TWDT subsystem to each car. Updating the attribute file shall follow the software update process specified in Section 19, Software Engineering.

2. Fault logic and triggering conditions shall be customizable from the VMDS software; e.g., fault triggering conditions shall be customizable thresholds set by the user, and logic will be the combination of conditions, including duration of conditions, that are needed to generate a flag or fault. SEPTA shall be able to modify troubleshooting instructions.

D. Predictive Maintenance Data General Requirements:

1. The predictive maintenance data shall consist of, at a minimum, the following:

a. Condition Based Monitoring Data: This data shall include, at a minimum, the number of cycles for assets that are maintained based on the number of cycles of operation (e.g., primary circuit breaker, doors, compressors, HVAC, brakes, air compressors, etc.). Specific condition monitoring items for Propulsion, Brakes, Doors, and HVAC shall be identified for Approval.

b. Elapsed Time Meter: This function shall indicate the total time that the car is in an operational mode, either by that car's cab control key setting or via trainlines from any other car's cab control key setting in a train. Time shall be displayed as a 4-digit hour display as well as a 5^{th} digit displaying tenths of an hour.

c. Energy Consumption Data: This data shall be calculated by each applicable subsystem subject to significant characteristics of energy usage or generation (e.g., propulsion, dynamic brakes, and auxiliary subsystems). Energy usage shall be measured in kWh, and shall be reported to the VMDS at a frequency subject to Approval. SEPTA shall be able to select a date interval and determine the following:

(1) Energy consumed by the propulsion subsystem

(2) Total energy consumed by the auxiliary subsystems, noting item (e) below is a subset of this item

(3) Energy dissipated in the braking resistors

(4) Energy returned to the overhead wire via regenerative braking

(5) Energy returned to the auxiliary subsystems via regenerative braking

(6) Total energy consumed by the car (separate values for real and reactive power and for power factor), considering regeneration to the overhead wire (net consumption)

(7) Total energy consumed by the car, without any consideration for regeneration (gross consumption)

(8) Any other energy data as required by Section 2, Design and Performance Criteria. Data shall be presented in a format to permit a direct comparison with the requirements stated in Section 2, Design and Performance Criteria.

2. The predictive maintenance data values shall be recorded by each applicable subsystem in a preset time period subject to Approval.

3. The predictive maintenance data values shall be reported to the VMDS and saved by the VMDS in a file format that can be downloaded by PTU and can be transferred to the wayside by the TWDT subsystem.

4. An Approved subset of the predictive maintenance data values shall be flagged on the TOD when a preset threshold is exceeded. These thresholds shall be PTU-configurable.

E. Wherever possible, data, attribute tables, and configuration files shall be in non-proprietary, user-readable formats such as plaintext or comma-separated-values files, unless otherwise Approved.

18.2.8 Train Operator's Display 1 (TOD 1) and Train Operator's Display 2 (TOD 2) Screens

A. Provide a TOD 1 and TOD 2 screen in each cab for the Operator and the maintenance technicians. See Section 5, Operator's Cab, for TOD 1 and TOD 2 screen location requirements.

1. Both screens shall be microprocessor-based, self-contained, suitable for railroad applications, and shall require no external controls, adjustment, or routine maintenance.

2. The TOD 1 and TOD 2 screens shall be designed with control buttons on the perimeter of screen.

a. A touch screen shall not be used, unless otherwise Approved.

b. No touch screen controls shall be required for the operation of the vehicle while it is in motion.

3. The TOD 1 and TOD 2 screens shall have the same functionality and shall allow the user to select which of the three default screens will be displayed: Operating Screen, Monitoring Screen or Combined Mode screen. The system shall ensure that at least one of the TOD screens is displaying the Operating Screen or Combined Mode Screen at all times and shall not allow the Monitoring Screen to be displayed on both screens at the same time.

4. In the event of a screen failure, the system will automatically display the Combined Mode screen on the still-functioning screen. The content of the Combined Mode screen shall be approved by SEPTA during design review.

5. The screen displays shall be sufficiently large to present the information to the user without undue scrolling.

6. Each screen may use additional levels of subsidiary screens to present extensive information as well as additional subsidiary screen choices.

   a. If several screens are used to display levels of primary and subsidiary data, then the screens shall be arranged in a sequential hierarchy that shows the most important and general data first, and allows user to move to subsidiary data from there.

   b. If subsidiary screens are used, return to the primary screen shall be possible with one command.

7. Display information shall be divided among, and presented on, screens in a logical and orderly manner consistent with car operating and maintenance manuals.

   a. Data shall be organized and displayed in a time-based format, unless otherwise Approved.

   b. Information shall be displayed graphically, textually, or both.

   c. Data shall be displayed in the most efficient manner available, and shall be labeled in easily- understood plain English. Display of information in coded form is prohibited.

   d. Each screen shall be designed with the same layout and format, regardless of its place in the hierarchy of primary and subsidiary data.

   e. The interface for screen selection shall be the same type for all screens.

   f. Display screens shall be designed, physically and functionally, to allow for easy addition of display items.

8. Display screens shall be readable in direct sunlight or with the cab lighting at night. The displays shall also have auto-brightness control available to the operator.

9. The display screens shall be glare free.

10. The TOD 1 and TOD 2 screens shall provide capabilities for allowing remote access from the wayside to view screens via the TWDT subsystem.

11. The TOD screens shall enter into a sleep mode after 10 minutes of inactivity in a non-active cab. Touching any TOD button will wake up the TOD screen and reset the sleep mode timer.

12. It shall be possible to operate the TOD screens in a non-active cab.

13. All information and data available on the TOD screens shall be mirrored/accessible through PTU interface.

18.2.8.1 Train Operator's Display Operating Screen

A. Comply with the following:

1. The TOD Operating Screen shall present car data necessary for the following:

a. Prepare the train for operation.

b. Assist the Operator with fundamental train operation functions.

c. It shall be the responsibility of the Contractor to incorporate as many indicator lights and gauges as practical into the TOD Operating Screen. At a minimum, the following functions shall be included in the TOD Operating Screen:

(1) Brakes Applied indicator

(2) Brakes Released indicator

(3) Emergency Brake Applied indicator

(4) Parking Brake Applied indicator

(5) Parking Brake Released indicator

(6) Brake Pipe Pressure Gauge

(7) Brake Cylinder Pressure Gauge

(8) Main Reservoir Pressure Gauge

(9) Wheel Slip/Slide indicator

(10) Doors Closed indicator

(11) Doors Open indicator

(12) Tractive and Electric Brake indicator

(13) Train Speed

(14) Brake Assurance

18.2.8.2 Train Operator's Display Monitoring Screen

A. Comply with the following:

1. The TOD Monitoring Screen shall provide the necessary interfaces to assist with the following:

   a. Overall train status

   b. Maintenance activities on the train.

   c. Enhanced troubleshooting activities of the train.

   d. The selection and display of current route, current location, adjustments to route and broadcast of train information, per Section 13, Communications.

2. The TOD Monitoring Screen shall display the following information at a minimum:

   a. Overall train status displaying individual door open/close status, brake applied/release status and parking brake applied/released status for each car on the train.

   b. Pantograph status

   c. Line Voltage

   d. Line Current

   e. Car Orientation

   f. Active Cab

   g. Direction of Travel

   h. Primary Circuit Breaker Status

   i. Regenerative Braking Cut-in/Cut-Out

   j. Propulsion Cutout Switch Status

   k. Friction Brake Cut-out Switch Status

   l. Propulsion/Door Bypass Switch Status

m. Speed Interlock Bypass Switch Status

n. Friction Brake Interlock Bypass Switch Status

o. Traction Master Bypass Switch Status

3. The TOD Monitoring Screen shall provide access to the following, at a minimum:

a. Detailed status from all major subsystems.

b. Car mileage, cumulative cab active hour data, and cumulative operating hour data for subsystems.

c. Subsystems software versions screen

d. Subsystems maintenance tests screen

e. Self-test initiation screen

f. Detailed VMDS fault data

g. Subsystems fault data

h. Detailed troubleshooting instructions

i. The TOD Monitoring Screen shall display train status and failure information useful to the train crew and maintenance personnel and shall serve as the display and controls for the VMDS.

j. The TOD Monitoring Screen shall inform the Operator of fault conditions affecting the operation of the train, and shall display major failures from all cars in the train.

k. The fault data displayed on the TOD Monitoring Screen shall include the time, date, car number, and a subsystem description of the fault.

l. Where more than one of the same type of equipment is installed on a car, the fault data displayed on the TOD Monitoring Screen shall identify the specific equipment exhibiting the fault.

m. If necessary, provisions shall be made to allow the user to scroll fault data for all subsystems and to drill down to lower-level screens that provide more detailed data on each subsystem and shall clearly identify faults preventing or interrupting train operation.

n. Provisions shall be made to allow the user to sort and/or filter the faults by date/time, car number, fault severity, and subsystem.

o. Fault information shall include troubleshooting instructions that can reasonably be performed by the Operator.

p. Train status and failure information on the TOD Monitoring Screen shall be organized logically based on the needs of personnel who will use the information and shall be organized into different screens, as described below.

q. Activation and de-activation of all subsystem bypass and cut-out switches shall be recorded in the fault log.

r. Car Wash Mode and Yard Mode activation/deactivation function as described in Section 10, Propulsion and High Voltage System shall be recorded in the fault log.

s. Maintenance Screens: These screens will provide maintenance personnel with in-depth diagnostic information of the TCDN connected subsystems on the train. Access to the Maintenance screens shall be password-protected per the requirements in Section 24, Cybersecurity. The Maintenance screens shall include the following screens as a minimum:

(1) Fault Log Screen: This screen shall display all of the faults logged by the VMDS on the train, color-coded to indicate severity. The user can scroll through the list of faults, and also sort and filter the faults by date/time, car number, fault severity, and subsystem. The user can also select a specific fault from the list in order to display detailed information on the fault, including possible corrective actions by maintenance personnel.

(2) Subsystem Status Screens: These screens shall display detailed status for each TCDN connected subsystems. The information displayed on this screen would be the same information available with the PTU, without requiring the use of a PTU.

(3) Trainline Status Screen

(4) Circuit Breaker Screen: This screen shall display the status of each circuit breaker.

(5) Software Version Screen: This screen shall display all software versions and all firmware versions residing on the train, and shall include information on expected software checksums, actual software checksums, and any pending software updates. This screen shall be used as part of the software update process specified in Section 19, Software Engineering. Any software or firmware version that is different than on the rest of the train or any checksum that is different than the expected version shall be highlighted.

(6) Test Screen: This screen shall be used by maintenance personnel to initiate a self-test on any TCDN connected subsystem on the train, including the VMDS.

(7) Operational Data Screen: This screen shall display cumulative operational data such as odometer data, Active Cab Hours (Cumulative hours the control lock is in the Run position), etc.

4. Submit a functional description of the TOD screens and a depiction of its layouts. **(CDRL 18-01)**

18.2.9 Ride Quality Monitor

A. All cars shall include provisions for the installation of ride quality monitoring equipment that meets the requirements of 49 CFR 213.333(k), with ten pantograph cars to be supplied with ride quality monitoring equipment. At least one pilot vehicle shall be equipped with the ride quality monitoring equipment and the remaining nine equipped cars shall be proposed by the contractor. This shall include at least one tri-axle accelerometer mounted to a truck and one on the carbody. All diagnostics shall be reported out to the propulsion system controller and VMDS.

B. Submit a functional description of the Ride Quality Monitoring System **(CDRL 18-05, Ride Quality Monitoring System Design Document)** .

18.3 Train-to-Wayside Data Transfer (TWDT)

18.3.1 General

A. Develop an integrated design for onboard and wayside equipment to fully support a TWDT subsystem as specified in this Section.

1. The subsystem shall be wireless and provide reliable and secure transfer of data to and from the cars.

2. Design and supply the carborne equipment as part of the Contract, and provide a wayside database, a shared file subsystem, and user-interface software, as specified in TS 18.3.5.

3. The TWDT system vendor shall host the wayside portion of the TWDT VMDS subsystem application through the end of warranty, at which time, SEPTA will decide if the vendor will continue to host these services through a separate yearly service agreement, or if the TWDT VMDS wayside application will be transferred to SEPTA's network. The TWDT system shall be designed to meet the network requirements in TS 18.4 for this possible transfer of hosting duties.

4. The TWDT subsystem shall include provisions to have CCTV video data and Cybersecurity events to be sent to separate existing devices on SEPTA's computer network, as this security sensitive non-VMDS data is used by different user groups within SEPTA.

B. Submit a design package**. (CDRL 18-06, TWDT Design Package)**

1. The TWDT sub-system shall be capable of performing all functions on cellular and WiFi data networks. For the cellular and WiFi connectivity, provide a Digi

TX64 Rail router including all ancillary equipment, on every vehicle to provide the communications connection of the TWDT subsystem.

a. Provide the following at a minimum for the cellular and WiFi system:

(1) External roof mounted dual-band MIMO antenna with RX and TX capability (MobileMark LTMG944-A3CB3CW3JG2C-wht-180, or approved equal) for Cellular 5G and GPS reception

(2) DIGI TX64 Rail Router and power supplies

(3) Connecting cables with M12 connectors (cable length per Approved design)

(4) Security requirements shall be per Section 24, Cybersecurity.

2. The connectivity and transition between cellular and WiFi networks shall be robust with no loss of data.

3. Provide an Advantech EKI-9508G-MPW-B network switch port extender with power cable OPT1-M12C-5FA-100, or Approved equal, connected to the Digi TX64 to allow for all TWDT connections required by the specifications, plus spare connections for future use.

4. An alternate DIGI rail router model may be proposed for Approval.

18.3.2 TWDT Faults and Diagnostics

A. Comply with the following:

1. The subsystem shall incorporate a self-test to verify that all subsystem components are working normally within predefined limits, and to check and troubleshoot the integrity of the subsystem.

a. The subsystem shall initiate a self-test upon startup.

b. The self-test shall be capable of being initiated by the VMDS or by PTU.

c. Failure conditions from the electronics self-tests shall be communicated to the VMDS and shall be downloadable as part of the fault log by the PTU.

d. Submit documentation. **(CDRL 18-07, TWDT Self-Test Capability)**

2. All data shall be downloaded to the wayside in a common, spreadsheet-style format that can be directly loaded into Microsoft Excel. No data conversion shall be required.

3. The data shall be able to be exported in .csv data format.

4. Submit a functional block diagram of the subsystem and its equipment together, showing all signals that will be transmitted via TWDT, as part of the design review process. Include the details in the Interface Control Documents (ICD) required by TS 25, Program Management and Commissioning.

5. Submit documentation. **(CDRL 18-08, TWDT Diagnostic Subsystem)**

6. The PTU application for the TWDT subsystem shall comply with the requirements of this Section and the PTU requirements of Section 27, Special Tools and Test Equipment. The interface to the PTU shall be through the PTU Universal Service Port.

18.3.3 Data Transfer

A. Data transfer shall be configurable to be either scheduled for automatic operation or by request of a wayside user, or both.

B. Data to be transferred from the car to the wayside shall include the following (in order of priority, first in first out):

1. All fault data logged by the VMDS. This shall include, but is not limited to:

   a. Fault detected by, generated by, and logged by the VMDS.

   b. Fault detected by subsystems, reported to the VMDS, and logged by the VMDS.

2. Real-time data from the VMDS

   a. Real-time data generated by, and logged by the VMDS.

   b. Real-time data generated by subsystems, transmitted to the VMDS, and logged by the VMDS.

3. Predictive maintenance data from the VMDS

4. Video data recorded by the CCTV subsystem

5. Live video data from the CCTV subsystem

6. Pantograph video data

7. Onboard software and firmware version and parameter file information

8. Security log files, as specified in Section 24, Cybersecurity

9. Intrusion Detection System events, as specified in Section 24, Cybersecurity

10. Provision for vehicle management system data, as specified in the Interface Control Document requirements in Section 25, Program Management and Commissioning

C. Data to be transferred from the wayside to the cars shall be done in a first-in-first-out process and include the following:

D. PIS data, including audio and video service and other special announcements. Data transfer status for PIS data shall have error handling so as to point out if a transfer fails or user input is invalid, and to allow for the execution of a subsequent transfer.

1. Commercial data for broadcast on the PIS

2. Daylight saving time rules, as required by TS 18.2.3.

3. Onboard software and firmware version and parameter file information

4. Software, and files associated with the software upload process, as specified in Section 19, Software Engineering

5. Parameter files as specified in the software subsystem adjustability requirements of Section 19, Software Engineering

6. Additional data types as proposed by the Contractor and subject to Approval

E. The TWDT subsystem shall allow for multiple data transfer requests to the same car to be queued and managed by a priority mechanism subject to Approval.

F. SEPTA shall have the ability to set the priority assigned to individual types of data from a wayside control station, using a password protected access mode.

G. The TWDT subsystem shall allow for data to be transferred between the car and the wayside (in both directions) when the train is either keyed up or keyed down.

H. The TWDT subsystem shall allow for data to be transferred between the car and the wayside (in both directions) when the train is either stationary or in motion.

I. The TWDT subsystem shall be designed so that any transfer interrupted as a result of a loss of communication between the wayside and the car shall automatically resume as soon as the communication re-establishes.

J. The TWDT subsystem shall include email and texting capabilities:

1. The TWDT subsystem shall allow for automatic notification of the data transferred from the car to the wayside.

2. The TWDT data subject to the notification feature, the frequency of the notification (instantaneous, daily, weekly, etc.), and the definition of SEPTA's email and text distribution groups shall all be made user-configurable by the subsystem.

3. The TWDT wayside application shall allow SEPTA to create customizable fault and car status information reports to be distributed to SEPTA email and text distribution groups.

K. The TWDT subsystem shall save the data transferred from the car to a shared memory space on the wayside, allowing simultaneous access to the transferred data by multiple programs. See TS 18.3.5 for details.

L. Implement the latest techniques of authentication and data encryption when designing the TWDT subsystem, as specified in Section 24, Cybersecurity.

18.3.4 Carborne TWDT Equipment

A. The TWDT subsystem shall be active on every car.

B. The interface point shall be implemented through the use of multiple antennas connected to a carborne TWDT controller. The onboard TWDT antennas shall use MIMO (Multiple Input Multiple Output) technology to provide the best characteristics of speed, bandwidth, and reliability. The TWDT controller shall be interfaced to the VMDS, the CCTV subsystem, the PIS subsystem via a connection between the TCDN and the TWDT controller, and other subsystems as required to provide the data transfer specified in TS 18.3.3.

C. Communication between each TWDT controller and the wayside shall be at the car level, meaning equipment within each car shall use the TWDT local to the car.

D. Mechanisms preventing any unintended traffic from being exchanged between the wayside and the TWDT controller shall be implemented on the car as specified in Section 17, Network and Trainline Control, and Section 24, Cybersecurity.

E. Power to the carborne TWDT subsystem shall be from a dedicated circuit breaker on each car.

F. Although multiple networks will be connected to the TWDT controller, the Contractor shall propose for Approval network isolation methods to ensure that the networks remain isolated from each other.

18.3.5 Wayside TWDT Components

A. Provide the wayside components necessary to fully implement the TWDT subsystem.

B. The wayside components shall include a web-based user interface, Fleet Management Wayside Application Software, a database, and a shared file subsystem. The central control unit shall be equipped with at least one operator terminal and one technician terminal.

C. The web-based user interface shall provide the following functionality:

1. Select a subset of data to be downloaded, as specified in TS 18.2.4, if data has not already been automatically downloaded to the wayside TWDT, on a per-car basis.

2. Create graphs and dashboards from VMDS real-time data.

3. Allow users to create and combine predefined filters for VMDS real-time data.

D. The subsystem architecture shall be expandable to support network connectivity with other SEPTA systems.

E. The user interface of the Fleet Management Wayside Application Software shall be efficient and easy to use, and shall provide the following discrete functions:

1. Maintain the history of all Software Configuration Items (SCIs) and status changes, making it possible to determine which versions currently reside in which equipment, on which cars, and which versions were used in the past.

2. Automatically read the current software configuration of the entire fleet on a scheduled basis and when a car is powered up.

3. Maintain the nominal configuration for each SCI on a car-by-car and an item-by-item basis.

4. Provide a software update capability for the fleet, as specified in Section 19, Software Engineering.

5. Provide read-only remote access to the TOD.

F. The TWDT database shall be hosted on the central data server and shall provide, at a minimum, the following discrete functions:

1. Store the real-time information transferred from the car and any applicable metadata associated with the transferred data.

2. Store the media files transferred from the car.

3. A software equipped with basic user friendly database maintenance capabilities (database backup, cleanup, etc.) shall be provided to SEPTA along with the TWDT database.

G. The TWDT database structure and the TWDT shared file subsystem structure shall both be implemented to allow for simultaneous access by multiple external programs.

18.4 Wayside IT Infrastructure

18.4.1 Wayside Servers

A. Coordinate with SEPTA'S IT department for specific wayside server requirements. Submit wayside server details for Approval. The following requirements are provided as guidance based on the current understanding of SEPTA’s IT requirements but do not relieve the need for Approval:

1. Virtualization:

a. All servers are deployed as virtual machines using VMware vSphere hypervisor.

b. No hardware servers will be deployed

c. All server hardware is managed by SEPTA IT.

2. Operating Systems:

   a. Windows servers must use Windows Server 2016 or later.

   b. Linux servers must use Ubuntu 20.04 LTS or later LTS release (only LTS releases are deployed).

   c. Server operating systems are managed by SEPTA IT.

3. CPU: Up to 96 cores running at 2.4 GHz can be provided per server.

4. Memory: Up to 512 GB of RAM can be provided per server.

5. Storage:

   a. The following physical storage types are available:

      (1) Spinning disk

      (2) SSD

6. Database: Microsoft SQL Server 2014 or later is the preferred database platform

7. Management

   a. All servers will be joined to SEPTA's domain

   b. All Windows servers will have SEPTA's Group Policy Objects applied.

   c. Software updates for operating systems and COTS software will be automatically performed by SEPTA in accordance with SEPTA’s update schedule.

8. Security:

   a. All servers will have SEPTA's endpoint protection (EDR, antivirus, antimalware, etc.) software installed.

   b. All server admin work will only be performed using Privileged access Workstations that are physically separate from normal workstations.

9. Remote Access

   a. Remote access, if necessary, will be supplied through SEPTA’s privileged remote access system.

   b. No other forms of remote access will be allowed.

10. Network:

a. The TCP/UDP ports and application protocols used by the application must be identified.

b. Estimated bandwidth usage and throughput requirements must be provided.

11. Encryption

a. Traffic must be encrypted in transit with TLS.

(1) TLS minimum version is 1.2.

12. Data access/interchange

a. All interfaces with other SEPTA systems used to exchange data must be identified and described.

b. All communications with other SEPTA systems must be encrypted.

c. TCP/UDP ports and application protocols for these data transfers must be identified.

B. The use of Contractor or subcontractor software as a service or cloud-hosted is subject to Approval. If Approved, the solution shall be a turn-key secure hosted web-based wayside server solution which enables the required TWDT functionality, while respecting existing infrastructure at SEPTA specific to Video Surveillance System (VSS) and Automatic Passenger Counting system specified in Section 13, Communications.

1. The Contractor shall arrange for required hosting services commencing no later than the commencement date of Conditional Acceptance testing of the first rail car and continuing through the Term of the Contract. Prior to expiration of the hosting period, Contractor shall cooperate and assist in the transfer of hosting services to SEPTA's virtualize environment, its designated contractor, or successor provider, to ensure that there is no lapse in service.

2. The Contractor shall provide secure electronic web-based access to SEPTA and its designees through a single-sign on system integrated with SEPTA’s existing identity system.

3. The Contractor shall follow Best-Practice Methods regarding security for any connection to an external network, including connection to a third-party Internet Service Provider or Wide Area Network. A “Best-Practice Method” is defined as one that follows the recommendations of the server hardware manufacturer and network operating system vendor, in areas including but not limited to, routers, firewalls, user permissions, virus scanning, e-mail content filtering, and protection of key network passwords.

4. The Contractor shall maintain the security methods in a current state at all times throughout the term of the Contract, which shall include applying virus and worm patches at a frequency recommended by the software vendor,

applying operating system and application software patches at a frequency recommended by the software vendor, and modifying policies and procedures as necessary to prevent unwanted human access to any software and the network, as well as to prevent human-initiated events from causing harm to, or preventing the normal operation of the equipment and system.

5. The system shall be hosted in an environment certified to meet the requirements of the International Standardization Organization (ISO) 27002 or Federal Risk and Authorization Management Program (FedRAMP).

6. The Contractor shall provide complete and validated Interface Control Documents (ICDs) for all communication between the on-board components and the hosted wayside server solution.

7. At the end of the hosting period, the Contractor shall be responsible for delivering all collected data and all software programs necessary for SEPTA to operate the web-based wayside server solution on an alternative hosting platform, along with instructions and support to install and configure on-board and wayside systems for the alternative hosting arrangement.

8. The Contractor shall designate a single entity responsible for the maintenance of all subscriptions required to support all wayside components of this specification, including but not limited to VMDS, Communications/PIS, and dynamic advertising system updates.

18.4.2 Wayside Workstations

A. Coordinate with SEPTA's IT department for specific wayside workstation requirements. Submit wayside workstation details for Approval. The requirements in TS 18.4.1 can be referred to for guidance but do not relieve the need for Approval.

18.4.3 SEPTA-Provided Network Infrastructure

A. Coordinate with SEPTA’s IT department for specifics of SEPTA-Provided Network Infrastructure. Use the information provided in TS 18.4.1 as a baseline.

18.4.4 Contractor-Provided Network Infrastructure

A. Coordinate with SEPTA's IT department for specific requirements. If SEPTA determines it necessary, the Contractor shall provide the following:

1. Firewalls and VPN gateways

2. Data diodes

3. Core network switches

18.4.5 Contractor-Provided Servers

A. The Contractor shall provide the following:

1. MDS servers

a. Fault logging servers

b. Software updates servers (Option)

2. Network services servers:

a. 802.1x authentication server

b. Active Directory (Windows)/LDAP (Linux) servers

c. WSUS server (Windows Updates)

d. Antivirus server

e. Backup server

18.5 Contract Deliverable Requirements List (CDRL)

The following contract deliverables have been identified in this section; however, the Contractor is responsible for providing and submitting anything necessary to fulfill the requirements of this contract, including those not identified by CDRL number.

CDRL 18-01, VMDS Design Document 18-2
CDRL 18-02, VMDS Subsystem Interface Documents 18-2
CDRL 18-03, VMDS Self-Test Capability 18-2
CDRL 18-04, VMDS Fault Management Plan 18-9
CDRL 18-05, Ride Quality Monitoring System Design Document 18-16
CDRL 18-06, TWDT Design Package 18-16
CDRL 18-07, TWDT Self-Test Capability 18-17
CDRL 18-08, TWDT Diagnostic Subsystem 18-18

18.6 CDRL Details

This section lists the expected content for each CDRL required above. The lists provided for each CDRL are an outline only and should not be considered exhaustive, all CDRLs are subject to SEPTA review and approval.

CDRL 18-01 VMDS Design Document:

1. Submit a detailed design description document covering the VMDS architecture, protocols, and functionality. Include a network diagram showing typical wired and wireless connections.

2. Submit a detailed description of the User Interface for the VMDS.

3. Submit a functional description of the following screens with a depiction of their layout:

    a. TOD Operating Screen

    b. TOD Monitoring Screen and it's sub-screens

    c. TOD Combined Mode Screen and it's sub-screens

CDRL 18-02 VMDS Subsystem Interface Documents:

1. Submit documents providing detailed descriptions of the interfaces between the VMDS and each TCDN connected subsystem.

CDRL 18-03 VMDS Self-Test Capability:

1. Define the capabilities of all self-test functions.

CDRL 18-04 VMDS Fault Management Plan:

1. Submit at Preliminary Design Review (PDR), and updated at Final Design Review (FDR), as changes to the subsystem require, and as necessary based on design developments throughout the design, production, testing, commissioning, and warranty periods.

2. Each fault or event shall include a packet of data associated with that fault or event the VMDS shall log. The data-set shall be as Approved. The proposed list of attributes in the data packet shall be submitted for review and shall be as Approved in design review. An example of the data is shown below:

    a. VMDS Date – UTC

    b. VMDS Time – UTC

    c. VMDS Date – local time, as defined by TS 18.2.3

    d. VMDS Time – local time, as defined by TS 18.2.3

    e. Car Number (location of fault)

    f. Subsystem Name (where fault exists)

    g. Unique component identifier, in the case that the car has more than one of the same type of equipment

    h. Fault Level

    i. Fault Name

    j. Fault Description

k. Corrective Action (Operator and Maintenance Staff)

l. Snap Shot file name

m. Snap Shot data associated with the fault/event

n. Car Mileage

3. The Fault Management Plan shall list all faults, fault hierarchy, fault logic, and train state data with a detailed description of each fault.

   a. The Contractor shall be responsible for determining all of the faults and events required for the car and to be documented in the Fault Management Plan. In certain sections of the Specifications, specific faults have been required. These specific faults shall be incorporated into the Fault Management Plan.

   b. Faults shall be organized into component and operational groups, each with a unique event/fault code.

   c. The fault details shall list a detailed description of the triggering conditions for each fault, including time delays, filtering, and event counts.

   d. Provide conditions required for fault reset.

   e. In the event of a subsystem lockout, a detailed description shall be provided as to what has caused the lockout and which relevant subsystem components are affected.

   f. Provide conditions required for lockout reset.

   g. Determine whether a fault is shown to the Operator, or only to maintenance personnel.

   h. For faults shown to the Operator:

      i. Determine whether it is Critical (red), Warning (yellow), or Information (white)

      ii. Determine whether a fault should be accompanied by an alarm, and what type of alarm. At least three types of alarms shall be included to follow the accompanying Critical, Warning, and Information priority visual scheme.

4. Where faults, events, etc. are logically combined for purposes of display and annunciation, include this logic.

   a. Determine whether a fault should be noted as information only.

   b. Determine whether a fault should be immediately transmitted to the wayside, considering availability of wayside communications, or if it should be part of a heart-beat packet that is routinely transmitted to the wayside.

5. Include documentation of all vital cross checks performed by ATC and PTC as specified in Section 20, Automatic Train Control – Positive Train Control.

6. Submit the list of assets or subsystems subject to predictive maintenance data as part of design review.

CDRL 18-05 Ride Quality Monitoring System Design Document:

1. Submit a comprehensive design package, including the following:

   a. Datasheets and specifications for all subsystem equipment

   b. A description of the subsystem's functional capabilities

   c. Submit a detailed description of the User Interface for the PTU.

CDRL 18-06 TWDT Design Package:

1. Submit a comprehensive design package, including the following:

   a. Datasheets and specifications for all subsystem equipment

   b. A description of the subsystem's functional capabilities

   c. A description of the subsystem's security measures

   d. Submit a detailed description of the User Interface for the TWDT subsystem.

CDRL 18-07 TWDT Self-Test Capability:

1. Define the capabilities of all self-test functions.

CDRL 18-08 TWDT Diagnostic Subsystem:

1. Defining the capabilities of this subsystem including the following:

   a. Functional description of the fault logic.

   b. List of faults.

   c. Functional description of the real-time data subsystem.

   d. List of triggering faults.

   e. Include a network diagram showing typical wired and wireless connections.

18.7 Referenced Standards

The following standards are referenced in this Section:

49 CFR Part 213.333	Automated Vehicle-Based Inspection Systems

FedRAMP	Federal Risk and Authorization Management Program
ISO 27002	Information Security, Cybersecurity and Privacy Protection - Information Security Controls

SECTION 19
SOFTWARE ENGINEERING

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19.1 General

A. All software (i.e., software and firmware) to be provided under this Contract is subject to the requirements specified in this Section, whether resident within a microprocessor-controlled intelligent subsystem, provided as part of test or interface equipment, provided for the purpose of post-download data analysis and processing, incorporated within training technology and manuals, or incorporated into non-generic bench test equipment (BTE). These requirements apply to all subsystems that include processors or other programmable components such as programmable logic devices (e.g., CPLDs).

B. Ensure Subsystem Functional Description (SSFDs) are developed, as specified in Section 25, Program Management and Commissioning, and contain the identification of all Contract software components.

19.2 Contractor and Supplier Qualification

A. Comply with the following:

1. The Contractor, as the systems and software integrator, shall implement disciplined systems engineering, integration, and supplier management processes. To demonstrate its capability, the Contractor shall submit the results of a current, independent, CMMI Benchmark Appraisal **(CDRL 19-01, Benchmark Appraisal Disclosure Statement, Final Findings Presentation, and Performance Report)**.. The appraisal shall use the latest valid Capability Maturity Model Integration, as defined by ISACA at the time of the appraisal. The appraisal reference model scope, at a minimum, shall be the following Target Profile: Capability Level 2 in the following Practice Areas:

    a. Configuration Management

    b. Managing Performance and Measurement

    c. Process Quality Assurance

    d. Estimating

    e. Planning

    f. Monitor and Control

    g. Requirements Development and Management

    h. Supplier Agreement Management

    i. Technical Solution

    j. Product Integration

    k. Peer Reviews

l. Verification and Validation

m. Governance

n. Implementation Infrastructure

2. Suppliers and their subsuppliers shall implement disciplined software engineering processes.

   a. Sub-supplier: Anyone other than the Contractor or its direct suppliers who provides software on this Contract. Regardless of who provides software, the Contractor shall ultimately be responsible for all software provided under this Contract.

   b. To demonstrate software engineering capability, the Contractor shall submit, for each supplier and sub-supplier providing software, the results of a current, independent, CMMI Benchmark Appraisal for the aforementioned Target Profile, as defined by the valid ISACA CMMI Method Definition Document at the time of the appraisal. **(CDRL 19-01)**

3. If the results of a current, independent appraisal (Benchmark Appraisal as defined above) that documents a rating of Capability Level 2 in the Target Profile are unavailable for the Contractor, supplier, or any entity providing software, submit:

   a. The results of a current, independent CMMI Evaluation Appraisal **(CDRL 19-02, Evaluation Appraisal Results: Organizational Unit Practice Characterizations and Final Findings Presentation)**. and a Project-Specific Remedial Action Plan **(CDRL 19-03, Project-Specific Remedial Action Plan)**.. The appraisal Model scope, at a minimum, shall be the following Target Profile: Capability Level 2 in the following Practice Areas:

      (1) Configuration Management

      (2) Managing Performance and Measurement

      (3) Process Quality Assurance

      (4) Estimating

      (5) Planning

      (6) Monitor and Control

      (7) Requirements Development and Management

      (8) Supplier Agreement Management

      (9) Technical Solution

(10) Product Integration

(11) Peer Reviews

(12) Verification and Validation

(13) Governance

(14) Implementation Infrastructure

4. The Contractor shall monitor its suppliers and sub-suppliers for their progress in effectively implementing their respective Remedial Action Plan.

5. To be considered independent, the Lead Appraiser shall not be affiliated with the Contractor or the suppliers/sub-suppliers and shall not have been involved with their improvement activities. To be considered current, the Appraisal Disclosure Statement (ADS) shall be dated no more than two years prior to Contract Award.

6. The appraisal organizational scope shall cover the parts of the organization that are responsible for the entire range of activities performed by the Contractor or supplier/sub-supplier in the domains of systems engineering, product integration, supplier management, software engineering, and microprocessor-based subsystems.

7. The independent appraisals shall include the use of a Lead Appraiser certified by ISACA.

8. The suppliers' and sub-suppliers' (and Contractor's if applicable) software engineering processes, including proprietary or internal procedures, and software work products including source code, shall be available for inspection and review by SEPTA during any regularly scheduled site visit, such as Software Quality Assurance/Quality Assurance (SQA/QA) audits.

19.3 Software Requirements for Microprocessor-Based Subsystems

19.3.1 Scope

A. This section provides requirements for the Contractor as well as its suppliers who are providing subsystems or components that include software.

19.3.2 General

A. Comply with the following:

1. Software requirements depend on the degree to which the software is custom designed for or applied to this project.

a. “Commercially available” software shall be readily available in the US through retail and wholesale sources and shall be subject to documentation and training requirements of the Specifications.

b. "Non-commercially available" software is defined as being part of a standard product or software developed or modified according to the requirements in this section. It shall be subject to all design, documentation, and training requirements of this section.

2. Software shall be applied, designed, or modified by implementing formal software processes, using modern programming techniques, and commonly available development environments and tools. As part of the formal processes, rigorous and documented testing, QA processes, and version controls shall be performed.

3. Software shall be reviewed as an integral part of each design review for each subsystem that uses software. The correlation between design reviews and required software documentation CDRLs shall be as specified in Table 19-1.

4. Submit a list of Contract software, executing outside of embedded subsystems, that is incompatible with 64-bit processors **(CDRL 19-04, Software Not Compatible With 64-Bit Processors)**.

19.3.3 Time and Date

A. Comply with the following:

1. All software delivered or developed under this Contract shall be capable of handling dates in the range from 2000 to 2099. The date data processing shall not experience abnormal ending or invalid or incorrect results from the software, data repository, or firmware in operation at SEPTA. Each software, data repository, or firmware's date data interface shall support a four-digit year format.

2. All software resident in carborne subsystems shall use a common network clock. See Section 18, Monitoring and Diagnostics, for date and time synchronization detailed requirements.

3. All time displayed to the train crew, maintenance personnel, or passengers shall be adjusted to the local time. The start and end dates for daylight savings time shall be adjustable, or completely removable, by SEPTA via PTU configuration, BTE, VMDS, and TWDT.

4. Software documentation, including test procedures and reports, shall demonstrate how common predictable future issues have been mitigated by appropriate design methodologies, including:

a. Year 2038 problem

b. GPS Week Number Rollover

c. Other common time formatting and storage bugs

19.3.4 Transfer of Software to Replacement Devices

A. Comply with the following:

1. To ensure the long-term maintainability of programmable devices, submit the following with **(CDRL 19-05, Programmable Device Hardware)** :

   a. Master copies of the compiled executable for all programmable devices and Read Only Memory Devices.

   b. Provide software, if any is necessary, that is used to transfer the compiled software to new devices and to verify the integrity of the copy.

   c. Submit the necessary hardware and cables necessary to program all devices (e.g., in the event memory devices on PCBs are corrupted or replaced), according to the quantities defined in Section 27, Special Tools and Test Equipment.

2. If the above requirement cannot be met for any programmable device, submit a proposed alternative. (**CDRL 19-05)**

19.3.5 Software Basic Functions

A. Software shall perform the following basic functions:

1. Implement the desired control scheme such that the specified performance is achieved.

2. Monitor inputs, including parameters, for unsafe, erroneous, or unknown conditions or combinations of conditions.

3. Sample input conditions at rates sufficient to detect and remedy unsafe or damaging conditions in the shortest possible time. Sampling rates and program execution times shall be such that the control system is not the limiting factor in response to unsafe or damaging conditions.

4. Limit output commands to safe levels regardless of the combination of input conditions.

5. Perform self-diagnostic routines and respond promptly, safely, and predictably to detected faults.

6. Respond safely and predictably when powering up or recovering from power interruptions. Detect power interruptions likely to have corrupted temporary storage and cause the subsystem to re-initialize affected routines and temporary data. Detection of power interruptions may be by hardware.

7. Permit thorough interrogation of input, output, and internal conditions by external diagnostic equipment.

8. Present all user-accessible features and logs in clear English.

9. Software version numbers shall be included within the firmware code and shall be accessible to the subsystem and car-level diagnostic subsystems. If the software includes data or Operation Parameter Files (OPFs) that can be modified by the suppliers or by SEPTA, a modification to such files shall be reflected in the software version numbers.

10. Multi-chip programs shall self-test during initialization to ensure that the correct complement of chips is installed. The use of multi-chip programs shall be minimized to facilitate software upgrading.

11. Use watchdog timers or similar approaches to detect processor hung states and other processor execution failures. The subsystems shall then reset to a normal state. All such resets shall result in a fault being logged, and clear English debug information, e.g., exceptions, to facilitate problem investigation and repair. Watchdog resets shall not be considered part of normal acceptable operation of a subsystem.

12. Software patches (quick/partial modification to fix a software bug) of embedded software are prohibited. For all software changes, generate complete software executables, meaning updated versions following the full development processes, including validation, defined in the Approved supplier's and Contractor's plans.

13. Memory use and processor use are software requirements that shall be tracked and easily tested, such as by use of self-test, with display of actual use on the VMDS and PTU screens.

    a. For each memory device and each processor, provide detailed calculations that show compliance with the memory and processor requirements of Section 16, Materials and Workmanship. Calculations shall take into consideration worst-case levels of memory usage and processor speed. **(CDRL 19-06, Software Baselining)**.

14. High CPU processor and high memory usage by a subsystem shall be logged as a fault. The Contractor shall include all Section 19 fault requirements, including the levels for high CPU and high memory usage, in the Fault Management Plan specified in Section 18, Monitoring and Diagnostics.

19.3.6 Software Subsystem Adjustability

A. All software-controlled subsystems shall include the ability to adjust key parameters. All parameters shall be adjustable on a temporary basis for testing, as specified below, but only a subset of parameters shall be included in a parameter file for uploading to the subsystems. It shall not be possible for parameter adjustment to create unsafe conditions or cause damage to equipment.

    1. Maintenance staff shall be able to safely make temporary adjustments to parameters using the PTU, for maintenance and investigation purposes. Such temporary changes shall automatically revert to the programmed values upon

removal and reapplication of low-voltage power to the subsystem. It shall not be possible to adjust the parameters outside of a set range, as required by Item 3 below.

2. The parameter file shall allow SEPTA to permanently adjust subsystem operation without recompiling software and without the support of the supplier or Contractor.

3. Key parameters shall be submitted. The listing of parameters shall define each parameter name, range, scale, values, values meaning, parameter meaning, and to what subsystem it is applicable. Include the identification of software parameters, including whether or not the parameter is included in the parameter file. **(CDRL 19-07)**

4. Submit utility software for creating, reading, and modifying parameter files. **(CDRL 19-07, Software Parameters Utility)**.

    a. The utility software shall ensure that parameter values are valid and within the Approved adjustment range required by Item 3 above.

    b. All parameter files shall be stored in a human-readable format. If the native version of the parameter file is not human readable, the utility software shall convert the parameter file into a human-readable format for reviewing and updating by the user.

5. Parameter files shall be version-controlled and treated as software. See TS 19.3.10 for requirements regarding version control.

6. Submit **CDRL 19-08, Software Parameter File.**

7. Implement user access restrictions for uploading parameters to the subsystems. See Section 24, Cybersecurity.

8. Software parameter upload is subject to requirements specified in TS 19.3.10.

9. The read and write parameter function shall be described in the SFD and in each applicable SSFD (see Section 25, Program Management and Commissioning). See Section 27, Special Tools and Test Equipment, for PTU and BTE function for subsystems where PTU or BTE can be used for uploading parameters.

10. The location and scaling of all operational adjustment parameters within the user interface shall be clearly defined for authorized personnel. The procedure and the effect of changing a parameter shall be fully explained in the Software User Manual (SUM). It shall also be possible to gain a high-level understanding of the effects of parameter scaling by looking at the user interface.

11. Numeric parameter values shall be in decimal notation and expressed in US customary units of measure.

19.3.7 Operating Systems, Languages, and Compilers

A. Comply with the following:

1. Software shall be written in a high-level language, unless Approved on a case-by-case basis. A high-level programming language is a programming language that is close to human language rather than low-level machine language (e.g., assembly language).

2. Source code shall be frequently and clearly commented in English.

3. The language, and its implementation for the selected microprocessor subsystem, shall be commercially available in English.

4. All languages and operating systems shall have an acceptable customer base (widespread use) and be Approved.

5. For software embedded in subsystems, the Contractor and its suppliers shall use the current versions of operating systems available at the time of FDR. However, if an operating system becomes obsolete (defined as no longer supported by its manufacturer) during the life of the Contract, the Contractor shall furnish SEPTA with a migration plan to a current version for Approval. The migration plan shall describe the consequences of the migration to all affected hardware and software. Once Approved, the Contractor shall implement the migration plan.

6. Compilers and other software development tools shall be commercially available and shall be most recent versions fully supported by the tool supplier. Use of proprietary compilers is prohibited.

19.3.8 Testing and Testability

19.3.8.1 Testing Capabilities

A. All features and functions of software that affect vehicle operation and maintenance procedures shall be testable using PTUs and procedures provided under this Contract, with the intent that SEPTA can use this capability for future internal testing.

1. Submit for Approval the list of features required by the Specifications that is not testable in the SEPTA operating environment using equipment provided to SEPTA.

2. For features that are testable only off the car with special equipment, furnish the necessary equipment as test equipment (Section 27, Special Tools and Test Equipment) that becomes the property of SEPTA.

a. The number of units shall be Approved in each case where this equipment is necessary.

b. This equipment shall provide the logic, sequencing, and emulation necessary to verify that the software functions as intended.

c. In lieu of separate equipment, appropriate test functions may be provided within the PTU.

19.3.8.2 Software Testing Process

A. Type tests of all processor subsystems shall verify the proper operation of all software features, including diagnostics:

1. The type tests shall demonstrate that the subsystem under test can successfully recognize and report all faults and events to the VMDS specified in Section 18, Monitoring and Diagnostics.

2. Where such tests may result in damage to the subsystem hardware, the fault or event shall be simulated to avoid damage to the hardware. Such testing shall be performed whenever the software is changed prior to putting it into service.

3. Software testing shall be part of the total project testing process. Test procedures, testing, and test reports shall be subject to the review, witnessing, and documentation processes. Software testing shall be a prerequisite to higher-level testing, such as subsystem-level and system-level tests. Software test procedures shall be Approved prior to the execution of the tests.

4. After the initial version of software is installed on the cars:

a. All software revisions shall be tested by the supplier in the supplier's facility (i.e., laboratory) in accordance with its testing process and procedures.

b. All software revisions shall be tested on the car, in addition to the lab. A test version of the software revision shall be dynamically tested on the car after successful lab testing.

c. After successful, Approved completion of dynamic testing, SEPTA will determine the extent to which a software update is rolled out: full (fleet-wide) or partial (portion of the fleet).

d. Application of any software revision to any portion of the fleet at any time shall be in conformity with the Approved Configuration Management Plan (Section 25, Program Management and Commissioning).

19.3.9 Delivery of Software

A. Comply with the following:

1. Each software release shall be provided to SEPTA via official project correspondence and shall include executables, updated software

documentation, updated user documentation, an SVD attesting that no undocumented code changes have been implemented since the last release, and an updated SVVR. **(CDRL 19-09, Software Package)**

a. Provide software and documentation via a secure file-sharing application as Approved. The requirement to provide software and documentation shall apply to every delivery of software for car and non-car equipment (e.g., PTU and BTE).

2. Submit all software documents listed in Table 19-1 in their final as-built condition. **(CDRL 19-10, As-Built Software Documents)**.

3. Update the software and documentation throughout the life of the Contract, including the warranty period, at no additional cost to SEPTA.

4. At the acceptance of all cars, and at the end of the warranty period and for each software release thereafter, submit all executables, updated software documentation, updated user documentation, an SVD, and an updated SVVR. **(CDRL 19-09)**

a. Provide software and documentation (for car and non-car equipment (e.g., PTU and BTE)) via a secure file-sharing application as Approved. Also provide a copy on an external solid state drive, with a minimum 15-year design life unless otherwise Approved.

19.3.10 Software Update

A. Comply with the following:

1. After original Approval, changes to the software shall be formally submitted to SEPTA for Approval prior to implementation of the changes in the source code. New versions of software shall be accompanied by revised, reviewed, and released software documentation and an SVD.

2. Software shall be designed to be N-1 backwards compatible – both with itself local to the component, as well as with other component the device might interact with (e.g., through network messages), so that a manual rollback can be performed without reconfiguration of the component, and to provide flexibility for software rollouts. Exceptions to backwards compatibility, such as in the event of operating system obsolescence and upgrade, shall be Approved on a case-by-case basis.

3. It shall be possible to update all software via the PTU connected directly to the component.

4. Partial or interrupted software updates shall automatically return the device to the previous version of software and not leave the device in an unconfigured state.

5. Software updates shall be performed using a password-protected function. See Section 24, Cybersecurity.

6. For network connected components, provide remote delivery of software updates to the cars; however, software shall not be automatically installed. Installation of software shall be triggered via the TOD.

7. All network connected components of all subsystems shall send their software status to the VMDS, and to the wayside via the TWDT. See Section 18, Monitoring and Diagnostics.

8. The term "software complement" designates configuration items such as product or application software, parameters files, databases, configuration files, and any data file resident on the hardware components of the car subsystems.

9. For all items in the software complement, the TOD screen shall display software subsystem name, version, expected version, checksum, and expected checksum. See Section 18, Monitoring and Diagnostics.

10. A checksum verification shall be calculated after each update to determine whether the update was successful. See Section 18, Monitoring and Diagnostics.

11. Provide a wayside software update application that shall store all software version and parameter file version information for all components in software baselines, which shall be assignable by SEPTA to one or more married pairs in the fleet. The software and parameter file version information, including checksums, shall be transmitted to the VMDS via the TWDT periodically based on the configured software baseline for that married pair. The VMDS shall compare version information received from the components with the version information received via the TWDT. If there is a mismatch between expected version from the wayside application and the version reported by the component, an event shall be reported on the TOD.

12. The component shall report to users if the software installed was successful or not. See Section 18, Monitoring and Diagnostics.

13. The function to update software complements shall be available:

    a. From BTE connected to the subsystems.

    b. From PTU connected directly to the subsystem to be updated.

    c. From PTU connected to a central port on the carborne network.

    d. From the wayside via the VMDS (for staging only, to be activated train-wide by action on the TOD).

14. The software update function:

a. Shall be proposed by the Contractor and presented to SEPTA for Approval during design reviews.

b. Shall be designed in compliance with the safety and security, and cybersecurity analyses.

c. Shall define simultaneous update constraints and opportunities at the car level, train level, and fleet level.

d. Shall be described in the SFD, at system level; see Section 25, Program Management and Commissioning.

e. Shall be described in the SSFD for each software subsystem whether the subsystem is the target or if the subsystem is supporting the function for updating another target subsystem. Section 25, Program Management and Commissioning.

f. Shall be validated and included in the SVVP and SVVR by the Contractor and suppliers.

g. Shall provide the ability to roll out software on a per-pair basis.

h. Shall provide the ability to roll back software version after testing is complete.

15. The performance of the software update function shall be analyzed as part of the design review. Submit **CDRL 19-11, Software Update Timing Analysis**.

16. The time required to upload the entire software complement for a given subsystem shall be no more than 1 hour, per train, including time to replace firmware embodied in programmable devices.

17. Submit a plan for carrying out software upgrade campaigns fleet-wide on an expedited basis. See **CDRL 19-12, Fleet-Wide Software Upgrade Campaigns Plan.**

    a. The plan shall incorporate provisions in individual subsystems, in the PTUs, BTEs, or in onboard networks that will permit individual technicians to upload new software to multiple processors in a simultaneous or overlapping manner.

    b. The purpose of this requirement is to eliminate the idle or waiting time of each technician and thus to maximize use of SEPTA's resources when a software upgrade must be expedited.

19.3.11 Configuration Control

A. Comply with the following

1. Develop and submit **CDRL 19-13, Software Configuration Control Plan (SCCP)** for tracking software changes to individual cars on SEPTA's property until Acceptance of the entire fleet.

    a. The SCCP shall also control software on non-car equipment such as PTUs, BTE, and the like, and shall include a mechanism to ensure continuing compatibility between car software and non-car software.

    b. The plan shall be consistent with the Contractor's approach to configuration control of hardware and require similar Approvals and tests.

2. Identify all software executables by a name/part number, a unique version number, and date.

    a. The name/part number shall identify the equipment into which the software is installed.

    b. Establish a standard naming/numbering system for all the subsystem suppliers to follow. Define in the SCMP. (**CDRL 19-21**)

    c. Every change to software shall be reflected in an update to the version number and date.

3. Maintain a database of the software version of every software item on each car and in each piece of non-car equipment.

    a. Keep the database current at all times.

    b. The database application shall be capable of generating reports showing configuration of the following items in terms of software history and status:

        (1) Car subsystem

        (2) Complete car

        (3) Train

        (4) Fleet

    c. Make these reports available starting at delivery of the first car.

    d. Maintain the SCCP and the database application through completion of the Warranty period.

    e. Provide the database to SEPTA at the end of the warranty period. **(CDRL 19-14, Software Version Database)**

    f. Configuration report documents shall include an indexed list of software licenses.

g. Submit the software version status of every software item on the car at the time of Conditional Acceptance/Acceptance of each car. **(CDRL 19-15, Car Software Configuration Report)**

h. Furnish the software version status of every software item on each piece of non-car equipment at the time of Conditional Acceptance/Acceptance of that piece of equipment. **(CDRL 19-16, Non-Carborne Equipment Software Configuration Report)**

4. Furnish a utility with all PTUs, BTEs, and Software Workstations by which a unique Version ID value can be calculated a signed code manifest and hash on the executable file for each SCI. Include the calculated Version ID, signature fingerprint, and hash in the SVD of each software release.

   a. Submit **CDRL 19-17, Software Verification Utility**, for each SCI delivered to SEPTA.

5. Following installation of software, continue to provide software revisions when software is updated by the Contractor or by subcontractors. Keep revisions current until the end of the warranty period.

6. Submit all software versions referenced in the final software configuration to SEPTA at the time of acceptance of all cars. See TS 19.3.9.

19.4 Software Documentation

19.4.1 Non-Commercially Available Software

A. Comply with the following:

1. For non-commercially available software:

   a. Furnish sufficient documentation to permit SEPTA to fully comprehend and analyze the operation of the equipment in which the software is to be installed and to enable SEPTA to maintain and modify the software to correct problems, adapt it to changing requirements, add features, and port it to a new hardware platform.

   b. In any case, delivered documentation shall be sufficient to allow SEPTA to operate and change the software including, but not limited to, source code changes, parameter adjustment, and troubleshooting of software issues.

2. For Category A: For application-specific software and configuration files developed or adapted specifically for this Contract, software documentation shall be in accordance with IEEE Std 1558-2004, Procurement Type 5, and with the additional specified requirements.

3. For Category B: Application-independent software, that is, fixed system software that is used in multiple applications (e.g., operating systems), or

defined as being part of a standard product line (i.e., reused and unmodified), is subject to the documentation and process requirements of IEEE Std 1558-2004, Procurement Type 3. Category B software shall be of an existing, service-proven design.

4. Classification of software as Category A or B shall be subject to Approval. Submit **CDRL 19-18, Classification of Software.**

5. All documentation shall use names, acronyms, and units consistent with those in the Specifications and as defined in the SSFD, and Interface Control Documents (ICD).

6. Ensure that the documentation produced provides for the straightforward traceability of requirements of the Specifications throughout the design documentation and including the final tests.

7. The problem reporting and corrective action process shall provide reports allowing the easy tracing of problems found at each development stage back to changes in the requirements, design, or implementation in source code.

8. Ensure ICDs are developed as specified in Section 25, Program Management and Commissioning, including ICDs required between Contractor-supplied equipment and SEPTA applications.

19.4.2 Contractor's Software Documentation Requirements

A. Comply with the following:

1. Submit the following documentation:

a. Single software documentation methodology for the project that complies with IEEE Std 1558-2004 **(CDRL 19-19, Software Documentation Methodology (SDM))**.

(1) Within IEEE Std 1558-2004 Annex A, each document structure and the content is provided in a table that references another IEEE standard's section numbers. The specified IEEE reference revision shall be as specified In IEEE 1558-2004 Section 2, References, with the exception of IEEE 830, which shall be 1998. See TS 19.10.

(2) When evaluating compliance to IEEE 1558-2004, SEPTA will use the revision of the standards quoted in IEEE 1558-2004 Section 2 and added in TS 19.10 for convenience.

(3) If the Contractor chooses to use another revision of referenced standards, then it will be required to perform a gap analysis and submit it to SEPTA for Approval. This gap analysis shall contain, for each CDRL compliant with IEEE 1558-2004, the corresponding Annex A table redlined with the proposed changes required when using an alternative revision of the reference standard. Any

intentional deviation to IEEE 1558-2004 Annex A shall be documented within this CDRL and submitted.

(4) In the Contractor's Software Documentation Methodology CDRL, the Contractor may identify an approach which supports the submission of documentation prepared according to the requirements of alternative European Standards EN 50567:2017, EN 50128:2011, or EN 50716:2023. If the Contractor chooses to incorporate these alternative standards in their proposed software documentation methodology, the methodology shall include a gap analysis which identifies, for each CDRL requirement aligned with IEEE 1558-2004, a corresponding Annex A table redlined with the proposed methodology for meeting the requirements when applying the alternative standard to submitted software documentation. The proposal shall be consistent across all software documentation suppliers, and in no way shall reduce the information required to be submitted under these requirements.

b. **CDRL 19-20, Software Project Management Plan (SPMP)**

c. **CDRL 19-21, Software Quality Assurance Plan (SQAP)**

d. **CDRL 19-22, Software Configuration Management Plan (SCMP)**

e. **CDRL 19-23, Software Verification and Validation Plan (SVVP)**

f. **CDRL 19-24, Software Verification and Validation Report (SVVR)**

2. The Contractor's SVVP and SVVR, specified above, shall reflect the verification and validation related to integration of subsystems at the system level.

3. If CASE tools are used that automatically generate documentation, they shall be consistent with the Contractor’s documentation methodology. Verify that the CASE documentation meets the Specifications. Furnish descriptions to enable SEPTA to understand the documentation methodology. Software documentation training for specialized CASE tools shall be included within the formal training.

19.4.3 Supplier's Software Documentation Requirements

A. The software suppliers shall submit the following documentation as required per IEEE 1558-2004 Procurement Type (See IEEE 1558-2004, Table 1 – Deliverables) as approved in the Classification of Software CDRL:

1. **CDRL 19-20, Software Project Management Plan (SPMP)**

2. **CDRL 19-21, Software Quality Assurance Plan (SQAP)**

3. **CDRL 19-22, Software Configuration Management Plan (SCMP)**

4. **CDRL 19-23, Software Verification and Validation Plan (SVVP)**

5. **CDRL 19-24, Software Verification and Validation Report (SVVR)**

6. **CDRL 19-25, Software Test Plan (STP)**

7. **CDRL 19-26, Software Requirements Traceability Matrix (SRTM**)

8. For each SCI:

    a. **CDRL 19-27, Software Requirements Specification (SRS)**

    b. **CDRL 19-28, Software Design Description (SDD)**

    c. **CDRL 19-29, Software Test Procedure (STPr)**

    d. **CDRL 19-30, Software Test Report (STR)**

9. For each subsystem:

    a. **CDRL 19-31, Software Version Description (SVD)**

    b. **CDRL 19-32, Software User Manual (SUM)**

10. Each supplier shall identify in the Software Summary Table (SST) specified in Section 25, Program Management and Commissioning, each Software Configuration Item (SCI) by assigned part number.

    a. The SST shall identify all software used by the subsystem including Category A, Category B, and Commercially Available Software.

    b. The SST shall also identify separately all software tools needed to produce the subsystem software.

    c. A listing of programmable devices in the applicable SST and SSFD, as specified in Section 25, Program Management and Commissioning.

B. See Table 19-1 for deliverables schedule.

19.4.4 Commercially Available Software

A. Comply with the following:

1. Some software supplied under this Contract may be commercially available to a wide variety of users. Examples include operating systems supplied by chip manufacturers and database software for wayside fault analysis.

2. Submit the list of software that is commercially available. **(CDRL 19-33, List of Any Commercially Available Software)**,

3. For the Approved list above, software documentation requirements are limited to the following:

a. A description in the applicable SSFD of the functions of the item and its interfaces.

b. The original data storage/transfer media, functional and usage details.

c. All documentation provided with the software.

d. All licenses required for SEPTA's site use.

e. Descriptions of any configuration or customization such as the selection of options or features or the setting of parameters.

4. As part of the training program specified in Section 26, Manuals and Training, incorporate training on how the software is to be used in the specific situation for which it was provided.

19.5 Maintenance and Related Tools

19.5.1 Portable Test Unit Software

A. Comply with the following:

1. Design of the PTU software shall include consideration of future ease of upgrade and ease of migration to newer replacement computers during the life of the cars, at no cost to SEPTA. This includes the possible use of open systems and tools.

2. The operating system shall be defined as specified in TS 19.3.7. The operating system must be supported by its manufacturer.

3. Multiple levels of passwords shall be provided, with a minimum of one allowing access to data for analysis and troubleshooting (view/maintenance function), another allowing temporary modification and reloading of software (test/update function) and the other allowing permanent modification of parameters and reloading of software (engineering function). Additional levels shall be as Approved during design review for each system based on SEPTA and subsystem requirements.

4. The PTU software application usability shall account for maintenance and engineering functions.

a. The PTU software applications for each subsystem shall be end-user-friendly with unambiguous display formats.

b. The navigation feature shall include a help menu with content, index, and search capabilities, and “tool tip” display for tool bar icons and categories.

c. The end user application displays shall have easy-to-follow functionality that presents logically synthetic components with applicable headings.

d. The PTU software application shall have an interrogation functionality that will allow diagnostic displays and drill down capabilities.

e. The PTU software application shall automatically adapt to all standard PC screen sizes and resolutions.

f. PTU software applications, when given invalid input by the user, shall display an error noting this input and what was expected and shall otherwise continue to operate normally without the provided input.

g. Submit the master PTU concept, and document, demonstrate, and provide all requirements listed above as a mock-up. See Section 27, Special Tools and Test Equipment, CDRL 27-2, PTU Demonstration.

5. It is expected that multiple versions of the same onboard software package will be in service, such as during testing or implementation phases of software releases. PTU software packages shall be designed with forward and backward compatibility with onboard software versions, and between various versions of the same PTU software packages, to facilitate maintenance of disparate onboard software versions from a single PTU device.

19.5.2 Bench Test Equipment Software

A. Comply with the following:

1. BTE software shall comply with the same requirements as other software as specified in the preceding sections.

2. Design of the BTE shall include consideration of future ease of upgrade and ease of migration to newer replacement computers during the life of the cars; this includes the possible use of open systems and tools.

3. The operating system shall be defined as specified in TS 19.3.7.

4. Two levels of passwords shall be provided, one allowing access to data for analysis and troubleshooting and the other allowing modification or reloading of software.

19.6 Quality, Safety, and Security

19.6.1 Software Quality Assurance Audits

A. Comply with the following:

1. The SQA process may be integrated with the overall project QA process and as such, QA and SQA audits need not be separate events. At its discretion, SEPTA will participate as a member of the SQA audit team.

2. Conduct, at a minimum, the following SQA audits at the supplier's location for each supplier (entity/entities providing the software):

a. Qualification Audit (external suppliers only)

b. Initial Audit

c. In-Process Audit

d. Functional Audit

3. Submit the status and details of audits to SEPTA within 30 calendar days after the audit.

4. If the Contractor/supplier has demonstrated process capability by providing the results of a current, independent CMMI Appraisal (per TS 19.2), that documents a rating of Capability Level 2 in the Target Profile, submit the results of the in-process audits performed as part of the supplier's or subsupplier's process (e.g., audit reports that include identified non-compliances) in lieu of the Contractor conducting the in-process audit.

19.6.2 Software Metrics Collection Plan

A. Coordinate with each supplier and provide a software metrics collection plan that categorizes software defects by density, class, and phases (to be included in the Software Quality Assurance Plan per IEEE Std 1558-2004, Section 5.2, SQAP).

B. Submit the collected metrics to identify supplier software quality from module through subsystem levels throughout the software life cycle, and comparisons between life cycles. Submit **CDRL 19-34, Software Quality Metrics Report**.

19.6.3 Safety and Security

A. All software provided under this Contract shall comply with the requirements of Section 24, Cybersecurity.

19.7 Deliverables

Table 19-1 defines the list of deliverables for this Section, in order of the project milestones and with key attributes.

Table 19-1, Deliverables Schedule

Milestone	CDRL	Title	Section	Contractor	Suppliers	Quantity
Prior to Conceptual Design Review (CDR)	19-01	Benchmark Appraisal Disclosure Statement, Final Findings Report, and Performance Report	19.2	X		1
Prior to CDR	19-02	Evaluation Appraisal Results: Organizational Unit Practice Characterizations and Final Findings Presentation	19.2	X		1
Prior to CDR	19-03	Project-Specific Remedial Action Plan (if no CMMI rating; CDRL 19-2 is submitted)	19.2	X		1
Conceptual Design Review (CDR)	19-19	Software Documentation Methodology	19.4.1.1	X		1
CDR	19-20	Software Project Management Plan (SPMP)	19.4.1.1	X		1
CDR	19-21	Software Quality Assurance Plan (SQAP)	19.4.1.1	X		1
Prior to PDR	19-01	Benchmark Appraisal Disclosure Statement, Final Findings Report, and Performance Report	19.2		X	1/Software supplier or subsupplier
Prior to PDR	19-02	Evaluation Appraisal Results: Organizational Unit Practice Characterizations and Final Findings Presentation	19.2		X	1/Software supplier or subsupplier
Prior to PDR	19-03	Project-Specific Remedial Action Plan (if no CMMI rating; CDRL 19-2 is submitted)	19.2		X	1/Software supplier or subsupplier
Preliminary Design Review (PDR)	19-11	Software Update Timing Analysis	19.3.10	X		1
PDR	19-18	Classification of Software	19.4.1	X		1
PDR	19-20	Software Project Management Plan (SPMP)	19.4.1.2		X	1/Software supplier
PDR	19-21	Software Quality Assurance Plan (SQAP)	19.4.1.2		X	1/Software supplier *Category A

Table 19-1, Deliverables Schedule						
Milestone	**CDRL**	**Title**	**Section**	**Contractor**	**Suppliers**	**Quantity**
PDR	19-22	Software Configuration Management Plan (SCMP)	19.4.1.1 19.4.1.2	X	X	1 at Contractor Level 1/Software supplier *Category A
PDR	19-23	Software Verification and Validation Plan (SVVP)	19.4.1.1 19.4.1.2	X	X	1 at Contractor Level 1/Software supplier *Category A
PDR	19-25	Software Test Plan (STP)	19.4.1.2		X	1/SCI Category A
PDR	19-26	Software Requirements Traceability Matrix (SRTM) –SSFD to SRS columns complete	19.4.1.2		X	1/Subsystem Software supplier
PDR	19-27	Software Requirements Specifications (SRS)	19.4.1.2		X	1/SCI
PDR	19-28	Software Design Descriptions (SDD) – Preliminary	19.4.1.2		X	1/SCI Category A
PDR	19-32	Software User Manual (SUM) – Preliminary	19.4.1.2		X	1/Subsystem
PDR	19-33	List of Any Commercially Available Software	19.4.2	X		1
PDR	19-04	List of any software not compatible with 64-bit processors	19.3.2	X		1
Final Design Review (FDR)	19-06	Software Baselining	19.3.5	X		1
FDR	19-07	Software Parameters Utility	19.3.6	X		1
FDR	19-08	Software Parameter File	19.3.6		X	1/Software Controlled Subsystem
FDR	19-12	Fleet-Wide Software Upgrade Campaigns Plan	19.3.10	X		1
FDR	19-13	Software Configuration Control Plan (SCCP)	19.3.11	X		1
FDR	19-17	Software Verification Utility	19.3.11	X		1
FDR	19-26	Software Requirements Traceability Matrix (SRTM) – SSFD through STPr columns complete	19.4.1.2		X	1/Subsystem Software supplier

Table 19-1, Deliverables Schedule						
Milestone	**CDRL**	**Title**	**Section**	**Contractor**	**Suppliers**	**Quantity**
FDR	19-28	Software Design Descriptions (SDD) – Final	19.4.1.2		X	1/SCI Category A
FDR	19-29	Software Test Procedure(s) (STPr)	19.4.1.2		X	1/SCI Category A
FDR	19-32	Software User Manual (SUM) – Final	19.4.1.2		X	1/Subsystem
FDR	19-34	Software Workstation Documentation	19.5.1.1	X		1/Subsystem as applicable
Prior to Qualification Testing or FAI whichever occurs first	19-24	Software Verification and Validation Report (SVVR)	19.4.1.1	X	X	1 with each software release and with any SVD. 1 car level revised per SVD updates.
Prior to Qualification Testing or FAI whichever occurs first	19-26	Software Requirements Traceability Matrix (SRTM) – All columns complete	19.4.1.2		X	1/Subsystem Software supplier
Prior to Qualification Testing or FAI whichever occurs first	19-30	Software Test Report(s) (STR)	19.4.1.2		X	1/SCI
Prior to Qualification Testing or FAI whichever occurs first	19-31	Software Version Description (SVD)	19.4.1.2		X	1 with each software release
Quarterly	19-03	Project-specific Remedial Action Plan Quarterly Report (if no CMMI rating)	19.2	X	X	1/Quarter
Quarterly	19-34	Software Quality Metrics Report	19.6.2	X		1/Quarter
Conditional Acceptance/ Acceptance of each car	19-15	Car Software Configuration Report	19.3.11	X		1/Car

Table 19-1, Deliverables Schedule						
Milestone	**CDRL**	**Title**	**Section**	**Contractor**	**Suppliers**	**Quantity**
Conditional Acceptance/ Acceptance of a piece of non-carborne equipment	19-16	Non-Carborne Equipment Software Configuration Report	19.3.11	X		1/non-carborne equipment as applicable
For Every Software release	19-09	Software Package	19.3.9		X	1/Subsystem as applicable
As Built Review	19-10	As Built Software Documents	19.3.9	X	X	1 set for the car level 1 set per software supplier
End of warranty Period	19-14	Software Version Database	19.3.11	X		1

19.8 Contract Deliverable Requirements List (CDRL)

The following contract deliverables have been identified in this section; however, the Contractor is responsible for providing and submitting anything necessary to fulfill the requirements of this contract, including those not identified by CDRL number.

CDRL 19-01, Benchmark Appraisal Disclosure Statement, Final Findings Presentation, and Performance Report 19-1
CDRL 19-02, Organizational Unit Practice Characterizations and Final Findings Presentation 19-2
CDRL 19-03, Project-Specific Remedial Action Plan 19-2
CDRL 19-04, Software Not Compatible With 64-Bit Processors 19-4
CDRL 19-05, Programmable Device Hardware 19-5
CDRL 19-06, Software Baselining 19-6
CDRL 19-07, Software Parameters Utility 19-7
CDRL 19-08, Software Parameter File 19-7
CDRL 19-09, Software Package 19-10
CDRL 19-10, As-Built Software Documents 19-10
CDRL-19-11, Software Update Timing Analysis 19-12
CDRL 19-12, Fleet-Wide Software Upgrade Campaigns Plan 19-12
CDRL 19-13, Software Configuration Control Plan (SCCP) 19-13
CDRL 19-14, Software Version Database 19-13
CDRL 19-15, Car Software Configuration Report 19-14
CDRL 19-16, Non-Carborne Equipment Software Configuration Report 19-14
CDRL 19-17, Software Verification Utility 19-14
CDRL 19-18, Classification of Software 19-15
CDRL 19-19, Software Documentation Methodology (SDM) 19-15
CDRL 19-20, Software Project Management Plan (SPMP) 19-16
CDRL 19-21, Software Quality Assurance Plan (SQAP) 19-16
CDRL 19-22, Software Configuration Management Plan (SCMP) 19-16
CDRL 19-23, Software Verification and Validation Plan (SVVP) 19-16
CDRL 19-24, Software Verification and Validation Report (SVVR) 19-16
CDRL 19-25, Software Test Plan (STP) 19-17
CDRL 19-26, Software Requirements Traceability Matrix (SRTM) 19-17
CDRL 19-27, Software Requirements Specification (SRS) 19-17
CDRL 19-28 Software Design Description (SDD) 19-17
CDRL 19-29, Software Test Procedure (STPr) 19-17
CDRL 19-30, Software Test Report (STR) 19-17
CDRL 19-31, Software Version Description (SVD) 19-17
CDRL 19-32, Software User Manual (SUM) 19-17
CDRL 19-33, List of Any Commercially Available Software 19-17
CDRL 19-34, Software Quality Metrics Report 19-20

19.9 CDRL Details

This section lists the expected content for each CDRL required above. The lists provided for each CDRL are an outline only and should not be considered exhaustive, all CDRLs are subject to SEPTA review and approval.

CDRL 19-01 Benchmark Appraisal Disclosure Statement, Final Findings Presentation, and Performance Report:

1. Submit results of a current CMMI Benchmark appraisal as per the requirements of TS 19.2.

CDRL 19-02 Evaluation Appraisal Results: Organizational Unit Practice Characterizations and Final Findings Presentation:

1. This CDRL is required only if CDRL 19-01 is not submitted. Submit at the same time as CDRL 19-03.

CDRL 19-03 Project-Specific Remedial Action Plan:

1. This CDRL is required only if CDRL 19-01 is not submitted. Submit at the same time as CDRL 19-02.
2. The Remedial Action Plan shall provide the following information for each Improvement Opportunity/Weakness identified in the Final Findings Presentation:
    a. Practice Area
    b. Practice Statement(s)
    c. Finding(s) (i.e., verbatim finding text)
    d. Impact Description (i.e., a textual description of the negative consequences to the Project if the practice(s) are not implemented by a process used on the Project)
    e. Project-Specific Action
    f. Responsible Individual
    g. Progress Completion Percentage
    h. Due Date
3. During execution of the Remedial Action Plan, the Contractor shall submit for itself, suppliers, and subsuppliers, quarterly progress reports (i.e., updated Remedial Action Plan) identifying progress on the above, risks and mitigations, as well as any changes to the Plan.
    a. The reports shall demonstrate a concerted effort and tangible results in implementing the remedial activities.

CDRL 19-04 Software Not Compatible with 64-bit Processors:

1. Submit the list of software delivered for this Contract that is not compatible with 64-bit processors.

CDRL 19-05 Programmable Device Hardware:

1. Provide hardware and software necessary to program all devices as required by TS 19.3.4.

CDRL 19-06 Software Baselining:

1. Provide detailed calculations demonstrating compliance with memory and processor requirements of Section 16, Materials and Workmanship, for each software configuration item.

CDRL 19-07 Software Parameters Utility:

1. Submit utility software for creating, reading, and modifying parameter files.

2. Parameter files shall be version-controlled and treated as software complements.

CDRL 19-08 Software Parameter File:

1. All software-controlled subsystems shall include the ability to adjust key parameters by providing each subsystem with a parameter file.

2. The parameter file shall allow SEPTA to adjust subsystem operation without recompiling software and without the support of the supplier or Contractor.

CDRL 19-09 Software Package:

1. For every software release, provide software executables, updated software documentation, updated user documentation, an SVD, and an SVVR.

2. Parameter files shall be provided as applicable.

3. Include the PTU software in the onboard software package, such that if a PTU that contains an incompatible or out of date version is connected to a car subsystem, the car subsystem will provide the necessary installation or upgrade files to provide the latest update of the PTU software package. Alternatively, subsystems may provide standard-compliant web-based PTU software to be hosted onboard a particular subsystem such that no client application on the PTU device is required.

CDRL 19-10 As-Built Software Documents:

1. Update versions for all software documents for as-built review.

CDRL 19-11 Software Update Timing Analysis:

1. Analysis of the time to update software in each subsystem.

2. Provide breakdown for each subsystem, car, and train.

3. Provide the breakdown depending on the update source connection.

4. Provide breakdown to show time depending on whether the equipment is on-car or off-car.

5. Provide the options in terms of what can be done in parallel and what would be the maximum performance possible for time to complete.

CDRL 19-12 Fleet-Wide Software Upgrade Campaigns Plan:

1. Submit a plan for carrying out software upgrade campaigns fleet wide on an expedited basis.

2. The plan shall incorporate provisions in individual subsystems, in the PTU, or in onboard networks that will permit individual technicians to upload new software to multiple processors in a simultaneous or overlapping manner.

3. The purpose of this requirement is to eliminate the idle or waiting time of each technician and thus to maximize use of the SEPTA's resources when a software upgrade must be implemented urgently.

CDRL 19-13 Software Configuration Control Plan (SCCP):

1. Develop and maintain a Software Configuration Control Plan (SCCP) for tracking software changes relative to cars, PTUs, and BTEs on SEPTA's property.

2. The SCCP shall control software on cars and non-car equipment.

3. The SCCP shall include a mechanism to ensure continuing compatibility between car software and non-car software.

CDRL 19-14 Software Version Database

1. Furnish a database of the software version of every software item on each car and in each piece of non-car equipment.

CDRL 19-15 Car Software Configuration Report:

1. Submit this report starting at the delivery of the first car.

2. Furnish the software version status of every software item on the car at the time of Conditional Acceptance/Acceptance of each car.

3. Configuration reports documents shall include an indexed list of software licenses.

CDRL 19-16 Non-Carborne Equipment Software Configuration Report:

1. Submit this report starting at the delivery of the equipment.

2. Submit for every software item on each piece of non-carborne equipment.

3. Furnish the software version status of every software item on each piece of non-car equipment at the time of Conditional Acceptance/Acceptance of that piece of equipment.

4. Configuration report documents shall include an indexed list of software licenses.

CDRL 19-17 Software Verification Utility

1. Provide a utility with all PTUs, BTEs, and software workstations by which a unique version ID value can be calculated, with verification of the code signature along with output of an appropriate hash, on each software package, and software executable file for each software configuration Item.

2. The calculated version ID shall be included in the SVD of each software release.

3. The software verification utility shall be installed on the workstation.

4. The software verification utility shall determine software version mismatch, signature issue, and incorrect hash.

CDRL 19-18 Classification of Software:

1. Classification of software as Category A or B.

CDRL 19-19 Software Documentation Methodology (SDM):

1. This document shall provide a compiled presentation of the car software design, documentation, and delivery requirements to assist supplier project teams in planning, resources, and executing and closing software portions of railcar projects.

2. This document shall provide initial specification of a uniform methodology of project software documentation.

3. The document shall help SEPTA to understand the software documentation approach.

4. This document shall define the approach that each supplier and the Contractor's internal Software Development Group must follow to document their software development processes and their software development products.

5. The end goal of this document is to achieve a common understanding of the proposed software documentation methodology and its benefits, to eliminate possible confusion about requirements in the Specifications relating to software documentation, and to obtain SEPTA Approval for the proposed methodology.

6. The document shall provide in appendices generic templates with instructions for all software documents to be developed for this project and cited in this Section.

7. This document shall clearly establish the framework for all the project software documentation. With this goal, all stakeholders will have the opportunity to assess if the proposed documentation will comply with Section 19 requirements. This document shall identify possible gaps to this Section 19 requirement and record all details of the alternative to be Approved equal.

8. This document shall identify any differences between the Contractor's software development methodology and IEEE 1558-2004, including differences from Annex A reference standard revision. Any differences between the Contractor's software development methodology and IEEE 1558-2004 shall be submitted for Approval.

CDRL 19-20 Software Project Management Plan (SPMP):

1. The SPMP shall define the software project roles and responsibilities, activities, and work products, including those to be delivered.

2. The SPMP shall describe the applicable processes and procedures methods, standards, and practices.

3. The SPMP shall conform to IEEE Std 1058-1998 as customized in IEEE 1558-2004, Table A.1, including all items identified as Applicability: “Mandatory” and “Recommended.”

4. It shall include a schedule showing the key tasks/milestones defined for the software development.

    a. A Gantt chart shall be used showing the timing and interrelationships between tasks.

    b. The schedule shall include the allocation of time and resources for realistically addressing issues raised by internal reviews, Contractor reviews, or by SEPTA.

5. It shall include detailed descriptions of the metrics to be used to monitor and control the project. This shall include monitoring project progress on intermediate tasks and triggering management corrective actions with sufficient time to ensure required deliveries are met.

6. As part of the Methods, Tools, and Techniques section(s), include details on the languages and operating systems used, and include acknowledgement that a migration plan is required in the event of operating system obsolescence, as specified in the Operating Systems, Languages, and Compilers requirements in TS 19.3.7.

7. Contractor level: Furnish details describing monitoring of supplier activities to ensure development tasks are completed and delivery requirements are met for each development phase from concept development to warranty support.

8. Supplier level: Refer to the Contractor SPMP requirements and SDM, and demonstrate compliance.

CDRL 19-21 Software Quality Assurance Plan (SQAP):

1. The SQAP shall define the software project roles and responsibilities, activities, and work products applicable to software quality assurance.

2. The SQAP shall specify the applicable processes and procedures that are used.

3. The Software Quality Assurance Plan shall comply with IEEE 730-2002, as modified by IEEE 1558-2004, Table A.2, including all items identified as Applicability: "Mandatory" and "Recommended."

4. The SQAP shall incorporate a procedure for making changes to Approved software.

5. The SQAP shall describe what quality metrics will be produced and how they will be reported to SEPTA. (see **CDRL 19-35**).

6. Contractor level:

    a. The scope of this document shall cover the entire software lifecycle for the project.

    b. It shall describe the software quality assurance responsibilities of the Contractor and be linked to the suppliers' SQAPs.

7. Supplier level: Refer to the Contractor SQAP requirements and SDM and demonstrate compliance.

CDRL 19-22 Software Configuration Management Plan (SCMP):

1. The SCMP shall define software project roles and responsibilities, activities, and work products applicable to software configuration management.

2. The SCMP shall identify the software configuration items to which software configuration management shall be applied. The SCMP shall describe the relationship of software configuration management to other configuration management activities.

3. The SCMP shall conform to IEEE Std 828-1998 as customized in IEEE 1558-2004, Table A.3, including all items identified as Applicability: "Mandatory" and "Recommended."

4. Contractor level:

    a. Establish or reference the standard naming system for all subsuppliers to follow.

    b. Submit a Software Change Request (SCR) for Approval before making any changes to Approved software.

        i. The SCR shall describe why changes are required and what steps the Contractor plans to follow to ensure the integrity of the software change.

ii. The SCR shall describe what regression testing will be employed to validate the software.

iii. The SCR shall list the software components (e.g., modules, parameters, etc.) to be changed in the software application.

c. Describe the details of the validation process when software is changed:

i. Bench testing of the specific change

ii. Subsystem functional bench testing

iii. On-site static and dynamic tests

d. If a change to car software requires a change to PTU or BTE software as well, then that software shall be supplied for the PTU and BTE before the car software is applied to a revenue service car.

5. Supplier level:

a. Refer to the Contractor SCMP requirements and demonstrate compliance.

CDRL 19-23 Software Verification and Validation Plan (SVVP):

1. The SVVP shall define the software project roles and responsibilities, activities, and work products applicable to software verification and validation (V&V).

2. The SVVP shall specify the applicable processes and procedures that are used.

3. The SVVP shall conform to IEEE Std 1012-1998, as customized in IEEE 1558-2004, Table A.4, including all items identified as Applicability: “Mandatory” and “Recommended.”

4. Contractor level:

a. This document shall describe the Contractor's verification and validation activities related to integration of the subsystems that produce the desired behavior of the complete system.

b. Describe the details of the validation process:

i. Bench testing of the specific change

ii. Subsystem functional bench testing

iii. On-site static and dynamic tests

c. Verification and validation shall be done as early in the project cycle as possible.

d. The Contractor's SVVP shall reflect the verification and validation related to integration of subsystems at the system level.

5. Supplier level:

    a. The supplier's SVVP shall require internal peer reviews of each version of the documents.

    b. The SVVP shall also require reviews of each design or source code change prior to test and release.

    c. Comply with the Approved SDM.

CDRL 19-24 Software Verification and Validation Report (SVVR):

1. The SVVR shall be a compilation of the results of the V&V activities, as planned in the SVVP.

2. The SVVR shall conform to IEEE Std 1012-1998 as customized in IEEE 1558-2004, Table A.5, including all items identified as Applicability: “Mandatory” and “Recommended.”

3. Contractor level:

    a. Submit an SVVR for each release of software.

    b. Software revisions shall be tested on the car, not just in the lab.

    c. The Contractor's SVVR shall reflect the verification and validation related to integration of subsystems at the system level.

    d. The SVVR shall include time measurements for train level functions or train-to-wayside functions over networks, such as file transfers.

    e. Refer to the individual suppliers' SVVR.

4. Supplier level:

    a. Summary reports of the internal peer reviews specified for the supplier's SVVP shall be included in the SVVR:

        i. The reports shall state the version of the documents reviewed.

        ii. The reports shall state the versions of all related documents used in the review, including, for example, documents that the document was reviewed against, such as SRS, or related interface specifications used in the review of an SDD.

        iii. The reports shall list for each verification and validation task, the type of review, the participants, the date, and all issues from the review.

    b. Summaries of the reviews of each design or source code change specified for the supplier’s SVVP shall be included in the SVVR.

CDRL 19-25 Software Test Plan (STP):

1. The STP shall provide a listing of the qualification testing to be performed on the SCI(s).

2. The STP enables SEPTA to assess if the testing is adequate for the SCI(s).

3. The STP shall conform to IEEE Std 829-1998 as customized in IEEE 1558-2004, Table A.12, including all items identified as Applicability: “Mandatory” and “Recommended.”

CDRL 19-26 Software Requirements Traceability Matrix (SRTM):

1. The SRTM shall be used to trace software requirements backward to SSFD or ICD and other source documents as applicable, and forward to the software design and software test documents.

2. During the software requirements analysis activity, the supplier shall enter each software requirement into the SRTM and shall map the software requirements to the appropriate section(s) of the SRS with a unique identifier.

3. The SRTM shall be as described in IEEE 1558-2004, Table A.10.

4. The SRTM shall provide cross-referencing between the requirements of the SRS and the corresponding sections of the SSFD, SDD, and the Software Test Procedures.

5. It shall include one table for each SCI:

    a. Within each table there shall be a row for each SRS requirement.

    b. The columns shall include the following:

        i. The unique identifier for the individual requirements defined in the SRS

        ii. A short description of the requirement

        iii. The reference to the corresponding SSFD section

        iv. The reference to the SRS section

        v. The reference to the SDD section or sections

        vi. The reference or references to the Software Test Procedure(s) (STPr)

    c. Since the references are dependent on the version of the documents referenced, the specific versions of all referenced documents shall be stated for each table.

    d. All references to documents shall specify the location to a specific section of text.

CDRL 19-27 Software Requirements Specification (SRS):

1. The SRS shall document the software requirements such that each can be objectively verified and validated.

2. The SRS shall also document the assumptions and design constraints imposed on the software implementation. The SRS shall conform to IEEE Std 830-1998 as customized in IEEE 1558-2004, Table A.6, including all items identified as Applicability: “Mandatory” and “Recommended.”

3. The SRS shall identify software parameters, as described by the requirements for software subsystems adjustability, see TS 19.3.6.

CDRL 19-28 Software Design Description (SDD):

1. The SDD shall define and record software design decisions, such as behavioral design and other decisions affecting the selection and design of software components.

2. The SDD shall describe the software architectural design, provide SEPTA visibility into the design, and provide information needed for software maintenance.

3. The SDD shall conform to IEEE Std 1016-1998 as customized in IEEE 1558-2004, Table A.7, including all items identified as Applicability: “Mandatory” and “Recommended.”

CDRL 19-29 Software Test Procedure (STPr):

1. The STPr shall provide the customized procedures used in testing the SCIs including test cases and specific pass/fail criteria.

2. The STPr shall enable SEPTA to assess the procedures used.

3. The STPr shall conform to IEEE Std 829-1998 as customized in IEEE 1558-2004, Table A.13, including all items identified as Applicability: “Mandatory” and “Recommended.”

CDRL 19-30 Software Test Report (STR):

1. The STR shall provide a record of the testing performed on the SCIs.

2. The STR shall enable SEPTA to assess the testing and its results.

3. The STR shall conform to IEEE Std 829-1998 as customized in IEEE 1558-2004, Table A.14, including all items identified as Applicability: “Mandatory” and “Recommended.”

CDRL 19-31 Software Version Description (SVD):

1. The SVD shall identify and describe a software version consisting of one or more SCI(s).

2. The SVD shall be used to release, track, and control software versions.

3. The term “version” may be applied to the initial release of the software, to a subsequent release of that software, or to one of multiple forms of the software released at approximately the same time (e.g., to different sites).

4. The SVD shall conform to EIA/IEEE J-STD-016-1995 as customized in IEEE 1558-2004, Table A.15, including all items identified as Applicability: “Mandatory” and “Recommended.”

5. The SVD shall contain the version ID and hash that is generated by the software verification utility provided to SEPTA.

6. The SVD shall contain a description of problems addressed, known problems yet to be addressed, features added, requirements added or changed, design changes, changes to related software documents and evidence of document review, test plan, and test results.

CDRL 19-32 Software User Manual (SUM):

1. The SUM describes how to install and use SCI(s), a group of related SCIs, or a software subsystem.

2. The SUM may also cover a particular aspect of software operation, such as instructions for a particular position or task.

3. If the software is a part of user manuals or operating procedures for a subsystem that may make a separate SUM unnecessary, the information may be integrated in system level maintenance and operations manual.

4. The SUM shall conform to EIA/IEEE J-STD-016-1995 as customized in IEEE 1558-2004, Table A.16, including all items identified as Applicability: “Mandatory” and “Recommended.”

CDRL 19-33 List of Any Commercially Available Software:

1. Submit a list of software being provided that is commercially available. SEPTA will determine which software will then be classified as commercially available.

2. Include Open Source and Freeware in this CDRL, if Approved and used for this Contract.

CDRL 19-34 Software Quality Metrics Report:

1. Report collected metrics to SEPTA to identify supplier software quality from module through subsystem levels throughout the software life cycle, and comparisons between life cycles.

19.10 Referenced Standards

The following standards and white paper are referenced directly or indirectly in this Section:

IEEE Std 1558-2004	Standard for Software Documentation for Rail Equipment and Systems
EN 50657:2017	Railway Applications – Rolling Stock Applications – Software On Board Rolling Stock
EN 50128:2011	Railway Applications – Communication, signaling and processing systems – Software for railway control and protection systems
EN 50716:2023	Railway Applications – Requirements for software development
IEEE Std 730-2002	IEEE Standard for Software Quality Assurance Plans.
IEEE Std 828-1998	IEEE Standard for Software Configuration Management Plans.
IEEE Std 829-1998	IEEE Standard for Software Test Documentation.
IEEE Std 830-1998	IEEE Recommended Practice for Software Requirements Specifications.
IEEE Std 1012-1998	IEEE Standard for Software Verification and Validation.
IEEE Std 1016-1998	IEEE Recommended Practice for Software Design Descriptions.
IEEE Std 1058-1998	IEEE Standard for Software Project Management Plans
IEEE/EIA Std 12207.0-1996	IEEE/EIA Standard – Industry Implementation of International ISO/IEC 12207:1995 Standard for Information Technology – Software Life Cycle Processes
EIA/IEEE J-STD-016-1995	Trial-Use Standard for Information Technology Software Life Cycle Process Software Development Acquirer-Supplier Agreement
CMMI Product Suite V2.0	Capability Maturity Model Integration Product Suite V2.0
CMMI Product Suite V3.0	Capability Maturity Model Integration Product Suite V3.0

SECTION 20
AUTOMATIC TRAIN CONTROL – POSITIVE TRAIN CONTROL

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20.1 Equipment Requirements

A. Due to FRA mandated rules and regulations and the safety critical nature of the Automatic Train Control – Positive Train Control (ATC/PTC) system, the Contractor shall supply equipment that is compatible with SEPTA's current ATC/PTC system and FRA Type Approved. Listed below are the part numbers of the Ansaldo STS (ASTS) ATC/PTC system as used by SEPTA:

Table 20-1, Part Numbers Used by SEPTA

Part Number	Description	Vendor
MCP-System-3	Complete Mobile Communications Package	STI-CO
MCP-SEPTA	Mobile Communication Package including Digi Modem,Power-One Power Supply, PTC Data Radio (with activation key as a Mobile Communication Manager), Filters, and Cabling	STI-CO
MCP-PWR	External Power and Serial Bracket	STI-CO
HDLP-MB-PLLG25-SEPTA	Antenna System, SEPTA Configuration PTC/CEL/CEL/Wi-Fi	STI-CO
HDLP-GPS	GPS Sensor for Antenna System – Vehicle Tracking	STI-CO
HDLP-RDM	Radome for SEPTA Antenna System	STI-CO
PKIT-LMR-240-UF-FR-SEPTA	Cable Kit Antenna to MCP, SEPTA Configuration, Fire Rated	STI-CO
370-3100-ant-sep	Roadway Worker Alert Systems (RWAS) Antenna Assembly	ProTran
370-3100ND-SEP	Vehicle Mounted Controller	ProTran
D604217-A08	ATC/PTC Kit	Siemens
C070G230	CTV Cable	Siemens
C070G293R2	CTV Coax Cable	Siemens
C070G294R2	CTV Twin Axial Cable	Siemens
D5664H61R0	Vehicle ID Module	Siemens
RBS3AW	ASTS PTC RedBOX Star Event Recorder	Deuta Werke
Note: Final part numbers may differ from this list		

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B. The above supplied ATC/PTC equipment shall meet all functional requirements as outlined in the Ansaldo PTC System Functional Description document number S820661-01300-2100 latest revision.

C. Contractor shall provide to SEPTA the latest SEPTA software for each ATC/PTC, MCP and event recorder systems.

1. The new software supplied shall be designed such that all Contractor supplied ATC/PTC, MCP and Event Recorder System (ERS) components are interchangeable with SEPTA's existing ATC/PTC devices. This software shall be backwards compatible with existing fleet equipment from the same subcontractor(s).

20.2 General System Description

A. The Automatic Train Control (ATC) and Positive Train Control (PTC) systems shall enforce the safe operation of the train primarily through forced acknowledgement and overspeed protection. **(CDRL 20-01, ATC/PTC General System Description)**

1. Each system can initiate a penalty brake application in order to stop the train if the operator is unable or unwilling to do so.

2. The combined equipment provides the function of traditional cab signal and modern Positive Train Control (PTC) with Civil Speed Enforcement.

   a. The cab signal portion is based on an NORAC 9-aspect system with overspeed protection.

   b. The PTC portion shall be a SEPTA PTC system which will provides the Civil Speed Enforcement.

   c. The ATC/PTC equipment is designed for use on SEPTA property and is compatible with NEC / Amtrak operation.

   d. It shall be designed utilizing fail-safe techniques to provide a vital platform that can be relied upon to perform safety-critical functions.

3. The ATC equipment uses track receivers to continuously monitor coded carrier signal in the rail. Coded carrier information is translated to signal aspect information, which is used for traffic control.

4. The PTC equipment is a transponder-based system that enforces civil speed restrictions for fixed locations such as curves, bridges, stations, etc. as well as temporary speed restrictions and Positive Train Stop.

   a. While cab signal equipment enforces vehicle operation based on speed and time; the PTC equipment enforces operation based on speed and distance (position).

5. A single ATC/PTC system shall be located on-board.

   a. User input to the system shall come from devices within the Operator's cab.

   b. Normally input can only be produced from an activated cab, which occurs when the cab is made up as the lead locomotive in the consist. In order to accomplish its control tasks, the equipment interacts with other systems on

the vehicle, such as the air brake, diagnostic and the vehicle control systems.

c. Where feasible, ATC/PTC equipment shall be installed at only one location on the semi-permanently joined car set. Equipment that is functionally required to be at the F-End of a train, such in cab controls or antennas behind the plow, shall be installed at every cab end.

6. The ATC/PTC system shall have an integrated alerter system which shall be responsible for monitoring the train operator vigilance.

7. The ATC/PTC system shall interface with an FRA compliant stand-alone event recorder.

   a. All FRA required ATC and PTC system inputs, outputs and messages will be communicated and stored within the event recorder.

8. The ATC and PTC equipment shall be installed at an accessible location in each locomotive.

9. The equipment of each of these systems shall be designed to be packaged in one equipment cubicle.

   a. The equipment enclosure shall be fitted with a restricted access key lock. The key to unlock this enclosure shall be an Illinois Lock Co. model G341 key.

10. The Contractor shall supply all necessary auxiliary devices, pressure transducers/ switches, cutouts, brake system interfaces, etc., to provide a complete functional system.

20.3 ATC/PTC System Requirements

A. The ATC/PTC system shall abide by all FRA rules and regulations and conform to all Northeast Operating Rules Advisory Committee (NORAC) rules and regulations.

B. As part of the system design, either ATC or PTC will be capable of operation as an individual system.

   1. If the ATC system is cutout, the PTC system shall stay active. If the PTC system is cutout, the ATC system shall stay active.

C. The ATC system shall perform the following functions:

   1. Vitally detect, at all times, block signal information transmitted from the running rail into the active cab of the train, and shall enforce the speed limits associated with the signal information received.

   2. Measure vehicle speed using a dedicated speed sensor.

3. Incorporate two (2) Aspect Display Units (ADU).

4. Perform ATC protection in the form of forced acknowledgement in response to signal aspect downgrades.

5. Allow operation in non-cab signaled territory at speeds up to 79 MPH.

6. Enforce a Positive Train Stop (PTS) as defined by the SEPTA PTC system.

7. Perform an automated departure test when activated by the ADU key switch. This onboard test feature shall be capable of testing the cab signal, ATC and alerter systems. The cab signal test function shall operate in the presence of 25 Hz traction power, constant or sporadic 100 Hz and/or 250 Hz carrier, and with a valid cab signal (coded100 Hz with or without 250 Hz) coded rate within the rails.

8. Report all FRA and SEPTA specified real-time data to an external FRA-compliant Event Recorder.

9. Record system operation within an internal data logger. Access to this information shall be available by Portable Test Equipment (PTE), the MCP Wi-Fi function or over locomotive's cellular network or the MCP cellular function.

10. Perform real-time event monitoring. Access to this information shall be available by Portable Test Equipment (PTE) the MCP Wi-Fi function or over locomotive's cellular network or the MCP cellular function**.**

D. The PTC system shall perform the following functions:

1. Acquire wayside transponder data and translate it into civil speed restrictions.

2. Acquire wayside signal / route data and translate it into civil speed restrictions.

3. Acquire Temporary Speed Restriction (TSR) package data and apply corresponding speed restrictions.

4. Measure vehicle speed and distance traveled using a dedicated speed sensor.

5. Automatically compensate for wheel wear. The ATC system shall receive and incorporate the updated wheel diameter in all speed calculations.

6. Report Maximum Authorized Speed (MAS), vehicle speed, and PTC operating status to the operator via the ADU.

7. Enforce Civil speed requirements as required by the Onboard Computer (OBC).

8. Enforce Positive Train Stop (PTS) as defined by the PTC system.

9. When activated by the ADU key switch, perform an automated on-board departure test. This onboard test feature shall be capable of testing the PTC system including transponder antenna, MCP and OBC. The cab signal test function

shall operate in the presence of 25 Hz traction power, constant or sporadic 100 Hz and/or 250 Hz carrier, or with a valid cab signal (coded100 Hz with or without 250 Hz) coded rate within the rails.

10. Report real-time data to an external FRA-compliant Event Recorder.

11. Record system operation within an Internal data logger. Access to this information shall be available by Portable Test Equipment (PTE), Wi-Fi or over locomotive's cellular network or the MCP cellular function.

12. Perform real-time event monitoring. Access to this information shall be available by Portable Test Equipment (PTE), Wi-Fi or over locomotive's cellular network or the MCP cellular function.

20.4 ATC System Operation

20.4.1 Cab Signal Decoding

A. Cab signal aspect information is communicated to a vehicle using coded carrier signals in the rail. The on-board cab signal equipment inductively receives this information through track receiver antennas mounted over the rails, ahead of the lead axle. **(CDRL 20-02, ATC System Installation and Operation Details)**

1. The SEPTA ATC system uses dual carrier frequencies (100 and 250 Hz) modulated to represent unique signal aspects. The signal aspect enforced by the on-board cab signal equipment is derived from the decoded carrier signals received.

   a. In dual-carrier operation (100Hz and 250Hz), either only the modulated 100Hz carrier is utilized in the rail, or both the 100Hz and 250Hz carriers are used.

   b. When both carriers are used, the 250Hz signal is present only during the off time of the 100Hz signal.

20.4.2 Aspects, Indications, And Authorized Speeds – NEC

A. Listed below are the carrier code rates, aspects, and permitted speeds:

Table 20-2, Part Numbers Used by SEPTA

F1 Code Rate (91.67/100Hz)	F2 Code Rate (250Hz)	Cab Signal Aspect	Speed Limit*
180	180	Clear	100 MPH/ MAS
180	No Code	Clear	100 MPH/ MAS
270	270	Clear	100 MPH/ MAS

F1 Code Rate (91.67/100Hz)	F2 Code Rate (250Hz)	Cab Signal Aspect	Speed Limit*
120	120	Cab Speed 80	80 MPH/MAS
270	No Code	Cab Speed 60	60 MPH
120	No Code	Approach Medium	45 MPH
75	75	Approach	30 MPH
75	No Code	Approach	30 MPH
No Code	No Code	Restricted	20 MPH
No Code	No Code	Non-Cab Signal Territory	79 MPH

20.4.3 Departure Test Required Mode

A. When the power is removed from the ATC system, the system will restart in a Departure Test Required mode.

1. This mode shall stay active until a departure test has been completed successfully.

B. While in departure test required mode, all cab signal aspect displays are dark.

C. The system shall enforce a 10 mph (16 km/h) speed limit while in this mode.

D. The ADU shall display a "ATC, DEPT TEST REQD" message while in this mode.

E. A bypass switch shall be provided within the equipment enclosure. To initiate a bypass, the switch must be pressed each time after the equipment is reset or powered-up.

20.4.4 Speed Sensing Requirements

A. Vehicle speed shall be measured using dedicated speed sensors.

B. The configured vehicle type and wheel size data shall be incorporated within the vehicle I.D module for use by the ATC/PTC systems.

20.4.5 Non-Cab Signal Territory

A. Provision shall be made to permit operation in territory without cab signals.

1. When an input is provided to the cab signal/speed control system indicating entry to non-cab signal territory, the system shall darken all cab signal aspects, deactivate acknowledgment circuits and impose a 79 mph (127 km/h) speed limit.

2. The input shall be manual from a Non-Cab Signal territory button/switch located in the cab.

3. Upon entering cab signal equipped coded territory, any code received shall cancel the Non-Cab Signal Territory condition and cause the cab signal to be displayed.

a. At this time, it shall be necessary to acknowledge the change in operating mode.

b. The 79 mph (127 km/h) speed limit shall be removed, and the speed limit shall be as determined by the cab signal.

20.4.6 Signal Carriers

A. The cab signal equipment shall operate using two carrier frequencies:

1. F-1, a nominal 100 Hz and

2. F-2, a nominal 250 Hz.

B. Operation shall be such that the equipment shall interpret the F-1 carrier as specific speed commands for each coding rate and shall interpret the same F-1 coding rates as separate and distinct higher speed commands when the F-2 carrier is present during the "off" coding periods of the F-1 carrier.

C. The cab signal equipment shall respond to and operate successfully with the following carrier frequencies and tolerances:

1. F-1 100 Hz 90 Hz to 102 Hz

2. F-2 250 Hz 247 Hz to 253 Hz

D. The minimum in-rail coded carrier current over which the cab signal equipment shall successfully operate are:

1. F-1 2.0 amperes

2. F-2 1.25 amperes

E. The calibration point is 1.65 amps for F1 and 0.9 amps for F2.

F. The system shall be arranged to provide an indication to the ATC/PTC data logger if the in-rail coded carrier current is sensed to be more than 20 amperes or less than the minimum tolerances for F-1 or F-2.

G. The cab signal from the pickup bars shall be monitored and recorded for current level, code and carrier frequency. The geographic location, when available, and time shall also be indicated within the recorded event.

H. The cab signal equipment installed on the locomotive will operate in Amtrak and SEPTA territories. As such the equipment shall be capable of operating in the presence of up to 0.5 amperes of in-band noise for the 91.67 Hz/100 Hz system and up to 0.25 amperes for the 250 Hz system, as defined on the Amtrak EMI Limit curve A-60-7659.

20.4.7 Codes

A. The cab signal/ATC equipment shall respond to and operate successfully within the following tolerances:

Table 20-3, Signal Tolerances

Signal	Operating Range	Signal Recognition
250 Hertz carrier	247Hz – 253Hz	
91.67/100 Hertz carrier	90Hz to 102Hz	
270 Code Rate	268 – 283 CPM	11 half cycles
180 Code Rate	178-188 CPM	6 half cycles
120 Code Rate	118-125 CPM	4 half cycles
75 Code Rate	71-77 CPM	3 half cycles
Cab Signal Aspect Hold Time	3.2 seconds	
Code Rate Duty Cycle (worst case)	75/25	
Onboard Equipment Minimum Rail Current Detection	1.65 ± 0.15 Amps (91.66/100 Hz) 0.9 ± 0.1 Amps (250 Hz)	

B. The OBC shall be designed such that it is possible to adjust the F1 and F2 threshold values manually.

20.4.8 Power Supply

A. The ATC and PTC equipment shall each be powered by isolated power supplies.

1. Each power supply shall provide complete isolation from each other along with isolations from all vehicle circuits.

2. If either the ATC or PTC power supply enters a fault condition, the non-faulted system shall continue to operate.

3. The locomotive battery system shall be designed to be floating from ground. The ATC/PTC system shall be totally independent of positive, negative, or combined battery ground faults.

20.4.9 Track Receivers

A. With new wheels installed on locomotive the track receivers shall be mounted 8 inches (20.3 cm) from top of rail.

B. The track receivers shall have a minimum height adjustment of 0.5 inch (12.7 mm) increments over a 4 inch (10.1 cm) range. Specific maximum and minimum mounting heights and horizontal positioning with respect to rail to be determined during design review.

20.4.10 Aspect Display Unit (ADU)

A. An Aspect Display Unit shall be fitted in each cab.

1. The ADU shall incorporate a photosensitive device that senses ambient light intensity.

a. Utilizing this sensor, the ADU display intensity shall be automatically adjusted to compensate for changes in the ambient light.

b. In order to override this feature, the ADU shall contain a pushbutton switch that will manually control the auto dimming feature of the ADU.

c. The manual mode of adjustment will remain in effect until the time the unit is no longer the controlling locomotive.

d. The ADU shall default to automatic brightness control each time the locomotive cab is activated.

2. The SEPTA ADU is pictured along with a brief description of the respective ADU functions:

a. Table 20-4 describes the ADU front view functional items.

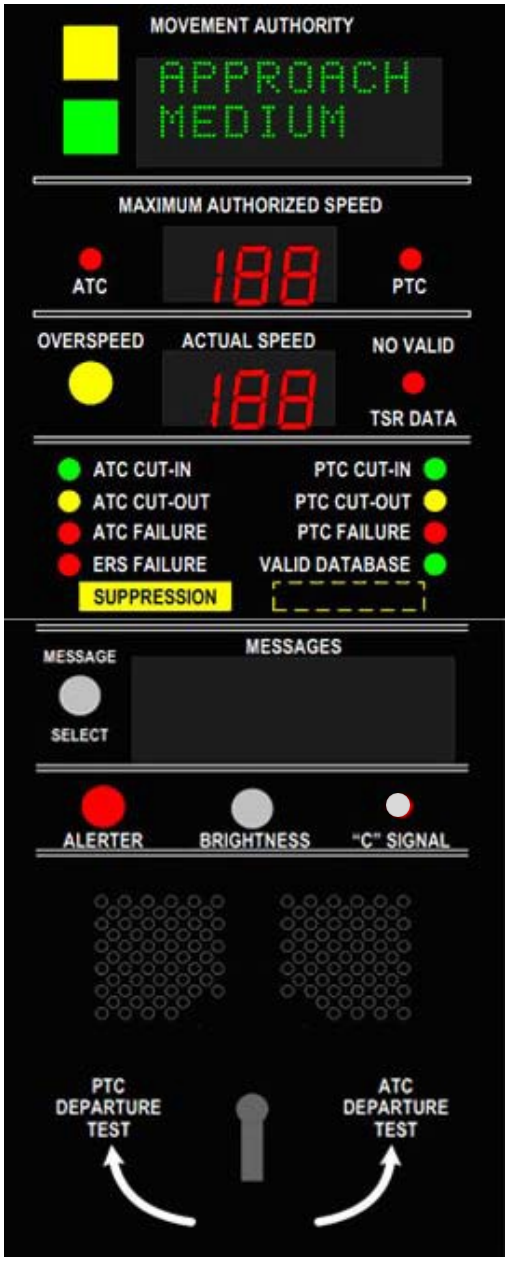

MOVEMENT AUTHORITY
APPROACH MEDIUM
MAXIMUM AUTHORIZED SPEED
ATC
188
PTC
OVERSPEED
ACTUAL SPEED
188
NO VALID
TSR DATA
ATC CUT-IN
ATC CUT-OUT
ATC FAILURE
ERS FAILURE
SUPPRESSION
PTC CUT-IN
PTC CUT-OUT
PTC FAILURE
VALID DATABASE
MESSAGE
SELECT
MESSAGES
ALERTER
BRIGHTNESS
"C" SIGNAL
PTC DEPARTURE TEST
ATC DEPARTURE TEST

Table 20-4, ADU Front View Functional Items

Item	Function	Description
1	MOVEMENT AUTHORITY	This is a 2 row X 8 character alphanumeric display and a two (2) square LED signal indicators. The 2 square LED signal indicator shall be capable of a Green, Yellow and Red Display. These 2 square LEDs shall display the NORAC certified cab signal aspect The 2 row X 8 character display is a green LED dot matrix device with an overall character height of at least 7mm. The LED based display shall indicates the cab signal aspects and worded according to NORAC Rules. This includes a positive stop aspect indication from PTC.
2	MAXIMUM AUTHORIZED SPEED	This is a red LED display that indicates the maximum authorized vehicle speed (MAS). This will be the lower of the maximum authorized speed permitted by the ATC or PTC system, with the governing system being indicated by LEDs to the left side (ATC) or right side (PTC) of the MAS display. This speed indication shall track the brake warning curve enforced by the PTC system.
3	ACTUAL SPEED	This is a red LED display that indicates the actual vehicle speed.
4	ATC	This is a yellow LED that when lit indicates that the ATC system is generating an MAS lower than the PTC system. If there is currently a penalty associated with the ATC system, this LED will flash.
5	PTC	This is a yellow LED that when lit indicates that the PTC system is generating an MAS lower than the ATC system. If there is a penalty currently associated with the PTC system, this LED will flash.
6	OVERSPEED	This is a yellow indicator, that when lit, indicates that the vehicle speed is in excess of either the ATC MAS or the PTC MAS.
7	NO VALID TSR DATA	This is a red LED that when illuminated indicates that there is no valid temporary speed restriction (TSR) data. This is typically caused by the PTC transponder or the data radio not picking up correct TSR messages. Under this condition, the MAS display will indicate “- -“.
8	ATC CUT-IN	This is a green LED, that when illuminated indicates that the ATC system is cut in and operational.
9	PTC CUT-IN	This is a green LED, that when illuminated indicates that the PTC system is cut in and operational.
10	ATC CUT-OUT	This is a yellow LED, that when illuminated indicates that the ATC system is cut out.
11	PTC CUT-OUT	This is a yellow LED, that when illuminated indicates that the PTC system is cut out.
12	ATC FAILURE	This is a red LED that when illuminated indicates that there is a failure in the ATC system. This is an indication that the Train Engineer should manually cut out the ATC system, and subsequently follow all relevant operational rules.
13	PTC FAILURE	This is a red LED that when illuminated indicates that there is a failure in the PTC system. This is an indication that the Train Engineer should manually cut out the ATC system, and subsequently follow all relevant operational rules.

Item	Function	Description
14	ERS FAILURE	This is a red LED that when illuminated indicates that there is a failure in the event recorder system (ERS).
15	VALID DATABASE	This is a green LED, that when illuminated indicates that a valid database has been uploaded from the PTC transponder.
16	SUPPRESSION	This is a yellow LED, that when illuminated indicates that the brake system is in suppression.
17	(SPARE)	This is a SPARE orange LED.
18	MESSAGES	This is a textual display that is used to pass messages to the Train Engineer. These messages are related to PTC and ATC departure test, TSR Messages, fault annunciation, NON-CAB SIGNAL TERRITORY operation and ADU indicator DIMMING Mode control.
19	MESSAGE SELECT	This is a pushbutton switch that is used in conjunction with the message display. The Train Engineer can also select indication illumination intensity using this switch
20	ALERTER	This is red LED that is caused to flash by the alerter (vigilance) system.
21	ATC/ALERTER SONALERT	This is a dual tone alarm. One tone shall sound when the alerter system reaches a time-out. A different tone shall sound when the ATC system annunciates an overspeed condition or downward code change.
22	PTC SONALERT	This is a single tone alarm that sounds when the PTC system annunciates an overspeed.
23	'C' SIGNAL	This is a lunar white LED that when illuminated indicates that ATC is cut out, and that there is no wayside cab signal present, and PTC is providing authority via the data radio to proceed to the next home signal.
24/25	PTC/ATC DEPARTURE TEST	This is a key switch that when rotated 90° initiates a PTC or ATC departure test, depending on direction rotated.
26	BRIGHTNESS	This is a pushbutton switch that overrides the auto dimming feature of the ADU. It is used to control the brightness of the display. Repeated pushing of the button shall cycle the brightness of the display through 5 different brightness levels. All brightness levels shall be approved by SEPTA.

20.4.11 Secure Positive Train Stop Release (SPTSR) Keypad

A. Provisions for a Secure Positive Train Stop Release (SPTSR) Keypad shall be included in all cabs unless otherwise noted below. These provisions shall include:

1. Clear space on the rear cab wall for a keypad with approximate dimensions of 6.5 inches in length, 4.5 inches in width, and 2 inches of depth.

    a. For maintenance purposes, the rear of the keypad shall be accessible without necessitating the removal of the keypad.

2. Mounting locations for one Onboard Secure Code Computer (OSCC) interface box and one OSCC computer in each married pair with the following approximate dimensions:

    a. OSCC interface box: 15 inches by 10 inches by 8 inches

b. OSCC computer: 15 inches by 10 inches by 6 inches

3. One sealed cutout switch adjacent to the keypad with appropriate wiring to the OSCC interface box.

4. Install the following cabling with appropriate terminations:

   a. Shielded Category 6A Ethernet cables between the OSCC computer location and the SPTSR keypads.

   b. Two 4-pin RS485 shielded twisted cable configured for full-duplex communication between the OSCC interface box location and the OSCC computer location.

   c. One shielded Category 6A Ethernet cable between the OSCC interface box location and the OSCC computer location.

   d. One pair of wires suitable for a DC power source and load from the LVPS (essential load) to the OSCC interface box location and one pair of power wires from the OSCC interface box location to the OSCC computer location.

   e. One shielded Category 6A Ethernet cable between the OSCC computer and the MCP.

   f. All Cables shall be secured and protected at both ends. Sufficient slack shall be present to allow for future re-termination.

   g. The above cabling requirements are draft expectations. Changes in specific cabling may be modified by SEPTA at PDR.

5. Prior to the conclusion of PDR, SEPTA may inform the Contractor that the SPTSR keypads, OSCC computers, and OSCC interface boxes will be free issued. If SEPTA informs the Contractor that this equipment will be free issued, the Contractor shall install this equipment on all vehicles using these provisions.

20.5 Departure Test

A. A departure test is a sequence of cab test functions that are performed to verify the operational integrity of the equipment as well as external control devices and operator controls and indicators. **(CDRL 20-03, ATC/PTC Testing Details)**

   1. The provided ATC/PTC system shall include provision for separate ATC and PTC departure tests that are sufficient in scope and design so as to meet all FRA requirements. As part of the departure test, the system shall verify communication with the odometer.

   2. In order to initiate a departure test, the operator shall first move the ADU key switch in the PTC or ATC direction.

a. If all pre-requisite entry conditions are met, the departure test will proceed.

b. If the pre- requisite entry conditions are not satisfied, the ADU will display the fault condition to the Operator.

3. In order to perform a departure test, the following pre-requisite conditions are required:

a. The no motion indication is present;

b. The Brake Pipe is charged;

c. An air brake application of Suppression or greater is present; and

d. Cab active.

4. If a fault is detected during the operation of either departure tests, the ATC/PTC system shall display the fault condition to the operator on the ADU and record the fault within the Event Recorder.

20.6 Equipment Hardware and Labeling

A. Visual indications, such as LED lamps, shall demonstrate that the system is functioning properly; similarly, failure and diagnostic indications shall be provided.

1. Indications shall isolate a failure to a particular function, or to the interface between two functions.

B. Inputs for the equipment shall be de-bounced and shall be electrically isolated from one another.

1. A visual indication, such as an LED lamp, shall be provided on the input board to each input to indicate when the input is activated.

C. Vital outputs for the equipment shall be electrically and physically isolated from one another.

1. A visual indication, such as an LED lamp, shall be provided on the input board to each input to indicate when the output is activated.

D. Labels shall be provided by each input and output indication which clearly denote the respective function of each for ease of maintenance and troubleshooting.

20.7 Modular Design

A. Modular design of components shall be incorporated to the maximum practical extent, per Section 2, Design and Performance Criteria.

1. Components or subassemblies with discrete function shall be plug-in modules and shall be labeled for ready identification.

2. The circuit board rack shall be easily and quickly removed and replaced as a unit and shall be designed for handling.

3. Plug connectors shall be of rugged design suitable for the safety related circuits involved.

4. Positive retention of plug-in modules shall be provided.

5. Functionally interchangeable modules shall be physically interchangeable and those that are not functionally interchangeable shall be provided with positive means to prohibit physical interchangeability.

6. The design shall be such that failure to install a module shall cause a more restrictive than normal system operation.

20.8 Alerter System

A. The Contractor shall provide an FRA-mandated Alerter within the ATC/PTC system.

1. The alerter shall be an OBC based system that is designed to enhance the safe operation of the locomotive by monitoring the alertness of the engineer.

2. The system shall continuously monitor the actions taken by the engineer.

3. In the absence of the detectable movement of the engineer in the specified time period, the alerter system notify the engineer by means of Overspeed light located on the ADU.

   a. The visual Overspeed light shall flash at a predetermined rate.

   b. After 4 seconds in the visual alarm cycle, a second, audio alarm located within the ADU will activate.

   c. Failure to acknowledge the two alarms within the allotted time (10 seconds) shall result in a penalty brake application.

4. The alerter system shall activate the alarm sequence whenever any one of the following conditions occur:

   a. No monitored input has changed within 30 seconds with a Restrictive Aspect present.

   b. No monitored input has changed within 30 seconds in non-cab signal territory mode.

   c. No monitored input has changed within 30 seconds when either ATC or PTC is in the CUTOUT mode.

   d. No monitored input has changed within 30 seconds in "Departure Test Required" mode.

e. The alerter while in cab signal territory shall, with an aspect greater than Restricting, activate the alarm sequence when no monitored input changes within (2400 ÷ train speed) seconds.

5. The following operator actions shall reset the alerter function and deactivate an alarm sequence:

   a. Activating the Horn

   b. Activating the ATC/PTC acknowledgement (switch or pedal)

   c. Brake cylinder bail off, if present

   d. Moving the Throttle handle

   e. Moving the Brake Controller

   f. Change of operating direction

   g. Ringing the bell, if present.

6. The alerter shall become inactive and the timing cycle shall reset when any one of the following conditions are present:

   a. The cab is deactivated

   b. The parking brake is applied

   c. A Brake cylinder application of 25 psi or greater is present

   d. The Brake Pipe is at 0 psi

   e. The speed is at 0 mph.

20.9 Odometer

A. A new cumulative mileage odometer with a visual display shall be installed in all vehicles.

B. The odometer display shall utilize ATC/PTC system data for display.

C. The information shall be displayed and recorded to the nearest mile.

D. This odometer shall be distinct from any odometer integrated into the vehicle control or diagnostic systems.

20.10 Roadway Worker Alert System

A. A Roadway Worker Alert System (RWAS) as manufactured by ProTran, Inc., shall be installed at each cab end of the locomotive.

B. The operation and configuration of the RWAS shall be identical to SEPTA's current RWAS system.

20.11 Event Recorder System

A. All FRA required ATC and PTC system inputs, outputs and messages will be communicated and stored within the event recorder. **(CDRL 20-04, ATC/PTC Event Recorder Signals and Alerter Function)**

B. Access to Event Recorder data shall be available by Portable Test Equipment (PTE), the MCP Wi-Fi feature and over the locomotive's cellular network or the MCP cellular function.

C. The Event Recorder shall provide all functions necessary to comply with the requirements in the Code of Federal Regulations (CFR), Title 49, Parts 218 and 229 as published in the Federal Register.

1. In addition to the data elements listed in Title 49 CFR section 229.135 SEPTA shall have the option of adding additional data elements.

D. The final ERS configuration, including additional SEPTA specified events and sampling rate shall be subject to approval by SEPTA during periodic design reviews of these systems.

E. The event recorder shall be designed to meet all self-monitoring event recorder requirements as described in Title 49 CFR 229.

20.11.1 Vehicle Configuration

A. The event recorder shall determine which type of vehicle it is installed based on the vehicle number sent by the SEPTA PTC system to the event recorder over the RS422 interface.

B. The Contractor shall be responsible for creating a new vehicle configuration for this contract and shall be responsible for the supply of revised software to SEPTA.

20.11.2 Time Management

A. The ERS time shall come from the MCP (Mobile Communications Package).

1. When the time is not available from the MCP, the event recorder shall utilize its internal clock until time is received.

B. The real time clock shall be buffered by a super capacitor which shall last a minimum of 10 days.

20.11.3 Digital Inputs

A. There shall be a minimum total of 35 digital inputs.

B. The digital inputs shall be checked every 100 ms and a change shall be validated after 40ms.

20.11.4 Analog Inputs

A. There shall be a minimum total of 8 analog inputs.

1. 6 analog inputs shall be 4-20mA,

2. 1 analog input shall be 0-10V and

3. 1 analog input shall be -5V to 5V.

20.11.5 Download Log

A. Wireless

1. The log shall be able to be downloaded wirelessly via the MCP Wi-Fi or cellular feature.

B. Ethernet Connection

1. The log shall be able to be downloaded with a laptop directly connected to the Ethernet service interface X13 on the recorder.

2. The log shall also be downloadable via RJ-45 from the Maintenance Access Panel.

C. USB Flash Drive

1. Standard USB flash drive download the last 48 hours.

2. Deuta-Werk playback software configured USB flash drive.

D. Depending on the user selected configuration, the following will be available for download:

1. All data;

2. All new data (From last download); or

3. Most recent 48 hours of operation.

E. For all downloads, the status of download process shall be indicated.

F. The event recorder ethernet download ports shall be easily accessible from inside the vehicle.

20.11.6 ERS 92 Day Activity Check

A. The event recorder shall have internal software designed to check for activity of each FRA required input.

B. Each FRA required input shall change a minimum of one time during the 92 day period.

1. A failure of an input to change state of a 92 day period shall display an event recorder fault status on the ADU.

C. The Contractor shall identify signals which are likely to not change over 92-days, and suggest the activity check on these inputs not be used.

20.11.7 ERS FRA Inspection Report

A. The event recorder playback software shall be capable of producing an FRA INSPECTION REPORT generated by the push of a button.

B. The inspection report shall provide the date, car number and activity of each FRA required input for the last 48 Hours of operation.

C. This inspection report shall be able to be saved electronically and/or printed for SEPTA's records.

20.11.8 ERS-MDS Interface

A. The event recorder shall be monitored by the MDS**.** Failure of the ERS self-monitoring, as required by 49 CFR 229, shall be indicated on the MDS.

20.12 Maintenance Access Panel

A. A Maintenance Access Panel (MAC Panel) shall be provided. It shall include:

1. Three easily accessible RJ45 plugs for direct connection to the On-Board Computer (OBC), Event Recorder (ER), and Mobile Communication Package (MCP);

2. An easily visible Indicator for ER health status; and

3. An easily accessible ER USB-A download port.

B. The MAC Panel shall be mounted in a convenient interior location for maintenance personnel access; however, it shall be inaccessible to passengers.

20.13 Contract Deliverable Requirements List (CDRL)

The following contract deliverables have been identified in this section; however, the Contractor is responsible for providing and submitting anything necessary to fulfill the requirements of this contract, including those not identified by CDRL number.

CDRL 20-01, ATC/PTC General System Description.....20-2
CDRL 20-02, ATC/PTC System Installation and Operation Details 20-5
CDRL 20-03, ACT/PTC Testing Details.....20-13
CDRL 20-04, ATC/PTC Event Recorder Signals and Alerter Function 20-17

20.14 CDRL Details

This section lists the expected content for each CDRL required above. The lists provided for each CDRL are an outline only and should not be considered exhaustive, all CDRLs are subject to SEPTA review and approval.

CDRL 20-01 ATC/PTC General System Description

1. The description shall include a high-level hardware configuration diagram showing all hardware included in the installation along with general locations of hardware. All wire/pneumatic connections between components should be shown.

2. The description shall include a list of Cab Signal/ATC codes and aspects along with code frequency tolerances.

3. Basic operations of the major components will be provided.

CDRL 20-02 ATC/PTC System Installation and Operation

1. The description will list show the main components of the ATC System and provide details regarding the installation of each piece of equipment. Installation/Operational tolerances will be included.

2. Details of the operation of the individual components will be described. Components to be described include:

    a. Track Receivers

    b. ADU Displays

    c. Speed Sensors

    d. PTSR Keypad

    e. Roadway Worker Alert System

    f. Maintenance Access Panel

    g. Portable Test Equipment, and connections.

3. Details of the brake applications will be provided, including parameters for application as well as roles of each component in the ATC/PTC Braking System.

4. Details of how the system operates in non-cab-territory will be described.

5. The wheel wear compensation process will be described.

CDRL 20-03 ATC/PTC Testing Details

1. The Departure Test will be described in detail.

2. Any periodic tests such as daily tests etc., to be performed on the equipment will be described.

CDRL 20-04 ATC/PTC Event Recorder Signals and Alerter Function

1. The description shall include a list of signals recorded by the event recorder, as well as the type of signal and the range of the signals.

2. The alerter operation will be described, including signals monitored and actions taken by the alerter.

20.15 Referenced Standards

49 CFR 218	Railroad Operating Practices
49 CFR 229	Railroad Locomotive Safety Standards

SECTION 21
RELIABILITY, AVAILABILITY, AND MAINTAINABILITY

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21.1 General Requirements

A. Ensure that the level of reliability, availability, and maintainability provided by the cars supplied under this Contract comply with the minimum requirements of SEPTA as defined within the Specifications.

B. Provide a design that:

1. Achieves close to failure-free operation under all operating conditions

2. Minimizes maintenance interventions

3. Achieves high levels of availability

4. Improves inspection and component service intervals

5. Ensures ease of maintenance

C. Failure to achieve the reliability, availability, or maintainability requirements shall require modification of car, subsystem, or component design, modification of maintenance manuals, additional training, or other action at no additional cost to SEPTA until all RAM requirements specified in this Section are fully complied with. Modification plan shall be submitted to SEPTA and must be Approved before implementation.

21.1.1 RAM Design Criteria

21.1.1.1 Reliability Design Criteria

A. Include the following in the car design criteria to ensure maximum reliability:

1. Standard and proven circuits are used where possible and required adjustments have been minimized.

2. Solid-state devices are used wherever possible and heat-transfer devices or designs are efficient.

3. Mechanical support structures are adequate.

4. Where possible, equipment shall be designed to eliminate the need for shock mounts and the installation of vibration isolators.

5. Reliability trade-offs shall be considered and employed to improve the design.

6. Redundancy shall be provided where needed to meet reliability goals.

7. All active and passive electronic devices shall be derated to operate within the acceptable region for electrical and temperature stress as specified in "System Reliability Toolkit-V."

a. If there is a conflict between guidelines given elsewhere in the Specifications and the Reliability Toolkit, the more restrictive condition shall govern.

b. Other service-proven devices may be submitted for approval.

8. Condition monitoring to allow degraded operation to be identified and reported prior to complete failure.

21.1.1.2 Availability Design Criteria

A. The achievement of a high degree of availability shall be a design objective for all equipment and subsystems for use on the cars.

1. Take into account the intended and anticipated operating regime including duty cycles, frequency of use, maintenance policy, environment, and interfaces with other equipment and subsystems.

2. Take into account unusual, abnormal, and emergency operations as well as the normal designed operational usage. Consider the range of likely system usage and abuse.

3. Adopt a proactive approach for managing availability. Identify potential subsystem failures at the earliest stage and determine the consequential effect on subsystem availability. Take a risk-based approach to ensure that the deleterious effect of equipment and component failures on overall system availability is minimized.

4. Design subsystems to incorporate fault tolerance, where practicable, to ensure that as far as practicable, individual faults on equipment, subsystems, and modules do not cause a significant disruption to safe car operation.

5. Consider how faults can be detected, diagnosed, and corrected to minimize their effect on system performance.

21.1.1.3 Maintainability Design Criteria

A. Include the following in the car design criteria to optimize maintainability:

1. Employ modular design principles to the greatest extent practicable. Package components together in replaceable subassemblies according to their logical function. Standardize dimensions and components to achieve flexibility in use.

2. Components or subassemblies requiring occasional removal shall be plug-in units where possible. Plug-in units shall be adequately identified, secured, and keyed to prevent misapplication.

3. A minimum number of different lubricants and other consumables shall be required for the car. Use different styles or sizes of fittings to prevent the inadvertent introduction of the wrong substance at any point. Where possible,

consumables for equipment provided under this Contract shall be the same as those used for equipment on the existing cars.

4. The design shall incorporate fittings and connectors with adequate keying to ensure that inadvertent misconnection of adjacent items is prevented.

5. All subsystems and components serviced as part of periodic preventive maintenance shall be readily accessible for service and inspection.

   a. Components requiring more frequent maintenance, repair, or replacement shall be readily accessible without the need for special tools or equipment.

   b. No active electrical or mechanical components that can possibly require maintenance shall be structurally embedded without convenient access for repair or replacement.

6. All PTU connections and cabling shall be identical through the cars unless otherwise Approved.

21.1.1.4 Maintenance Periods

A. The car shall be designed and constructed to have a minimum period of 184 days between periodic maintenance servicing by shop personnel, except for HVAC filter replacement.

   1. Programmed car interior cleaning will take place at 15 day intervals.

   2. Subsystems shall be selected for maximum endurance between inspections, and for ease and quickness of inspection.

   3. Car structure and equipment shall not require periodic undercar washing to obtain proper functioning, long life, or to avoid corrosion.

   4. Friction brake and pneumatic system components shall be designed for extended life between maintenance overhaul periods, as further detailed in Section 12, Friction Brake, and the Contractor shall support SEPTA's effort to obtain approvals from the Federal Railroad Administration for such extensions.

21.1.1.5 Equipment Access

A. All car equipment which requires inspection or maintenance must be readily accessible and replaceable.

B. All underfloor equipment where possible shall be arranged to provide simple, easy access from the side of the car.

C. Major equipment shall not be located outboard of the trucks, if possible, due to the increased possibility of accident and debris damage in this location.

D. If maintenance pit access is required, special attention shall be given for access such that opened covers, access doors, etc., provide sufficient room for a maintainer to stand within the running rails of the pit.

E. Any equipment which requires Operator attention or access in the event of an emergency during car operation, unless otherwise specified, shall be accessible from the car interior. If Approved on a case-by-case basis, access from the side of the car may be used.

F. In general, frequency of required service shall determine the degree of equipment accessibility.

G. The Contractor shall prepare for Approval during the Preliminary Design Review sessions a tabulation of all controls or resets which an Operator may need to access in order to restore a disabled car or train to service.

21.1.1.6 Interchangeability

A. All similar parts on each car, and among all other cars and their spare parts, shall designed and manufactured to be identical, both as individual parts and as subassemblies.

B. Model numbers for identical components shall be identical.

C. Replaceable components of any such apparatus shall be fully interchangeable, without adjustments to any part or system being necessary.

D. Microprocessor hardware units which are physically identical except for the software shall have identical part numbers. An Approved subpart number may be used to identify differences by software.

E. Such units which require location-specific module inputs shall have this performed by carbody wiring configuration, and not by the use of DIP switches or similar.

F. Specific Approval shall be obtained from SEPTA during Conceptual Design Review for each part whose replacement may require an adjustment, and such Approval may be granted only where it can be shown to be absolutely necessary.

21.2 Reliability, Availability, and Maintainability (RAM) Program

A. Develop and implement a program to ensure that the car and its subsystems meet or exceed the reliability, availability, and maintainability requirements specified in this Section. Provide all measures required to meet the specified requirements, including design, manufacture, installation, retrofit of the entire fleet, and all changes. **(CDRL 21-01, RAM Program Plan**)

B. The Contractor shall align its subsystem and component breakdown structure with SEPTA's component coding system to establish a failure data management process that will be utilized throughout the FRACAS process and during the Reliability Demonstration.

1. Development of the breakdown structure, alignment of failure codes, reporting formats, etc. shall be agreed upon between SEPTA and the Contractor prior to PDR.

    a. Ensure that component coding and component failure report coding and report forms are consistent with SEPTA system.

2. Make use of this breakdown structure for recording and reporting all RAM issues associated with the Contract.

21.3 Reliability Requirements

A. Design the car and all of its subsystems and components to perform the required functions under the full range of specified operating and design conditions as outlined in this specification.

    1. The car design and implementation of the design shall provide SEPTA with equipment that meets the Mean Distance Between Delay (MDBD) requirements.

    2. Compliance with the MDBD requirement shall include all failure modes for subsystems and components, to meet the following requirement:

        a. Car level MDBD = 150,000 miles (241,402 km)

        b. Car level MDBF-ALL = 10,000 miles (16,093 km)

B. MDBD and MDBF-ALL are based on Chargeable Failures (see Definitions Section in Section 1, General Topics and Definitions).

C. The introduction of the fleet shall provide SEPTA with increasingly reliable performance during the reliability demonstration period as specified in Table 21-1. See TS 21.7, for specific details regarding the Reliability Demonstration Test.

Table 21-1, Fleet Reliability during Reliability Demonstration Period

Fleet Reliability	Mean Distance Between Delay (MDBD)
10% of base order cars have entered reliability demonstration period	25,000 mi (40,234 km)
Six months after 10% of base order cars have entered the reliability demonstration period	50,000 mi (80,467 km)
One year after 10% of base order cars have entered the reliability demonstration period	150,000 mi (241,402 km)

Table 21-2, MDBF-ALL and Availability during Reliability Demonstration Period

Requirement	10% of base order entered	6 months after	12 months after
MDBF-ALL	≥ 35% of Requirement	≥ 60% of Requirement	≥ 100% of Requirement
Availability	≥ 60% of Requirement	≥ 70% of Requirement	≥ 90% of Requirement

D. Provide highly reliable cars and subsystems, in compliance with the requirements specified in Table 21-3.

Table 21-3, Subsystem Reliability Requirements for MDBF-ALL

System	MDBF-ALL (miles)
Coupler and Drawbar	450,000
Operator's Cab	250,000
Door Subsystem and Controls	100,000
Heating, Ventilation, and Air Conditioning (HVAC)	150,000
Lighting	1,000,000, and as per Note 2
Auxiliary Power	180,000
Propulsion Subsystem and Control	150,000
Truck Assemblies	300,000
Friction Brake Subsystem	100,000
Communication Subsystems	100,000
Interior and Exterior Appointments	150,000
Network and Trainline Controls	300,000
Monitoring and Diagnostics	500,000
Automatic Train Control	300,000
Notes to Table: 1. The assignment of components shared by two or more subsystems will be determined by SEPTA. 2. Component requirements for the lighting subsystem are as follows: – Interior LED lights and LED drivers shall have a minimum service life of 50,000 hours of operation to 70% of original luminosity. – Interior LED indicators and conditioning power supplies external to LED fixtures shall have a minimum service life of 100,000 hours of operation. – Exterior LED indicators, signal lights, platform lights and marker lights, shall have a minimum service life of 100,000 hours of operation. – Headlights and auxiliary lights shall have a minimum service life of 50,000 hours of operation.	

21.3.1 Reliability Prediction

A. Submit a Reliability Prediction Report. **(CDRL 21-02, Reliability Prediction Report)**

1. Reliability Prediction shall be supported by an allocation of the reliability requirements to each subsystem and major component.

   a. The reliability allocation, once approved, will be used to judge the compliance of the car and subsystems with the reliability requirements.

   b. Any adjustment to the reliability allocation must be approved.

2. The Reliability Prediction shall be for the entire car and for each major subsystem (including SEPTA-furnished equipment) down to at least the lowest line replaceable unit (LLRU).

3. Once the initial Reliability Predictions are Approved they shall be used by the Contractor and SEPTA to monitor progress towards achievement of the specified reliability requirements. The Contractor's prediction and performance against the major subsystem criteria shall be reported on a regular basis. The submission frequency must be approved.

4. Predictions shall be expressed in terms of MDBD and MDBF-ALL.

5. Predictions are based on one of the following, in order of availability:

   a. Historical field service data on identical or similar equipment or components. The use of historical field service data shall be supported by an assessment of any environmental and operating condition differences. Submit sufficient information to allow SEPTA to review the applicability of the historical data.

   b. Use the Part Stress Analysis method of MIL-HDBK-217 for electrical and electronic equipment. Where sufficient information is not available to perform a part stress analysis, the Parts Count Analysis method may be submitted with prior approval. The operating environment for all predictions shall be assumed to be the Ground Mobile (G_M) environment.

   c. For non-electronic equipment, “Nonelectronic Parts Reliability Data (NPRD),” may be used.

   d. Requests for the use of alternate reliability prediction methods (e.g., RIAC-HDBK-217Plus, IEC) must be Approved, together with justification to support their applicability to SEPTA's operating conditions and environment.

21.3.1.1 Reliability Block Diagrams

A. Submit a Reliability Block Diagrams as part of **CDRL 21-2** and update as necessary throughout the Contract to accurately reflect the configuration of the car and its constituent subsystems.

21.4 Availability Requirements

A. SEPTA requires high availability of its cars, in particular to meet the requirements of the a.m. and p.m. peak periods.

1. The fleet Availability shall be at least 90%.

2. SEPTA will generate Fleet Availability reports on a daily basis and provide them to the Contractor as needed.

3. The Availability requirement shall be subject to monitoring throughout the Reliability and Availability Demonstration period. The fleet Availability shall be reviewed with SEPTA at the designated RAM Review Board (RRB) meetings. The Contractor shall identify corrective actions to address non-compliance with the measured Availability.

4. Failures may be considered to affect the Availability of a consist if the ability to separate cars or make operational consists is impaired. Such failures will be reviewed by the RRB.

21.5 Maintainability Requirements

A. Ensure that the design of the car and its subsystems gives maximum consideration to maintenance, troubleshooting, component removal, repair, and inspection requirements.

1. The objective shall be to minimize maintenance labor and materials costs, passenger car downtime, and the need for specially trained or highly skilled service personnel.

2. Provide ease of maintenance for all items within the car scope of supply. Where significant improvements to maintainability may be available to SEPTA, furnish detailed justification for the amendment of designs and maintenance practices to SEPTA. This shall be furnished at CDR, for acceptance no later than FDR.

3. In the design of the car, the Contractor shall not require that maintenance (such as topping off fluids or adjusting parts), be performed more frequently than at 30,000 mi (48,280 km) intervals, except for washer fluid or where permission has been given by SEPTA for a shorter interval.

4. The Contractor shall ensure that all routine maintenance and replacement components, or materials, are readily available in the United States either from the OEM or multiple sources of supply.

5. The Mean Time To Repair (MTTR) for the major subsystems within the car shall be compliant with the requirements of Table 21-4.

Table 21-4, Subsystem Maintainability Requirements in Mean Time To Repair (MTTR)

Subsystem	MTTR
Coupler and Drawbar	1.5
Operator's Cab	1.0
Door Subsystem and Controls	1.0
Heating, Ventilation, and Air Conditioning (HVAC)	2.0
Lighting	0.5
Auxiliary Power	1.5
Propulsion Subsystem and Control	2.0
Truck Assemblies	1.5
Friction Brake Subsystem	2.0

Communication Subsystems	1.0
Interior and Exterior Appointments	1.5
Network and Trainline Controls	1.5
Monitoring and Diagnostics	1.0
Automatic Train Control	1.0

21.5.1 Maintainability Analysis

A. Submit a Maintainability Analysis and Maintenance Allocation Chart. **(CDRL 21-03, Maintainability Analysis and Maintenance Allocation Chart)**

1. This analysis shall establish the maintenance concepts to be incorporated into the design, taking into consideration safety, reliability requirements, accessibility of apparatus for maintenance, and the skills available for performing maintenance tasks.

2. The Maintainability Analysis shall make use of field data and experience on similar equipment, technical papers, engineering reports, and MIL-HDBK-472 predictions.

3. The Maintainability Analysis shall be a continuing effort during design and shall furnish data for consideration in review of the design of each subsystem.

4. The Maintainability Analysis shall include a preventive maintenance schedule with tasks and estimated labor-hours for each maintenance interval.

    a. Preventive maintenance tasks shall be scheduled in multiples of 92days to conform to SEPTA's existing preventive maintenance cycle.

    b. The total labor-hours for 184 Day maintenance shall be less than 24 hours per car.

5. The Maintainability Analysis shall include corrective maintenance tasks and estimated labor-hours.

6. The Maintenance Analysis shall be in compliance with the Contractor-furnished Maintenance Manuals.

7. The maintainability predictions shall verify the car and subsystems meet or exceed the maintainability requirements specified in Table 21-3, Subsystem Maintainability Requirements in Mean Time To Repair (MTTR).

    a. Calculate the subsystem predictions taking into account the failure rates of the subsystems and their respective MTTR.

    b. Submit the calculation method for the subsystem maintainability predictions within the RAM Program Plan. **(CDRL 21-01)**

8. Include a Maintenance Allocation Chart, as defined in APTA PR-IM-RP-002-98, Rev. 2.

21.6 Reliability and Availability Demonstration and Reporting

21.6.1 Reliability and Availability Demonstration Plan

A. Submit a detailed Reliability and Availability Demonstration Plan. **(CDRL 21-04, Reliability and Availability Demonstration Plan)**

1. The Reliability and Availability Demonstration Plan will list the requirements related to the demonstration and discuss the process that will ensure all requirements are met.

2. The Reliability and Availability Demonstration Plan shall list the requirements for cars to enter the demonstration, discuss the failure data management and FRACAS processes that will be implemented during the demonstration and list the criteria for passing the demonstration.

21.6.2 Reliability and Availability Progress Reporting

A. Submit a monthly report; see Section 21.7.1, Reliability and Availability Demonstration Test, for detail. **(CDRL 21-05, Reliability and Availability Demonstration Progress Report)**

1. Closely monitor the failure modes of all subsystems to ensure that the cars will meet required goals.

2. Report on the MDBD, MDBF-ALL and Availability at the sub-system and car level.

3. Report on the top failing LRUs.

4. If at any time during the test, the failure rate of any subsystem exceeds the allowable rate (including the reliability and availability allocated by the Contractor for major components), seek modifications and changes to bring the subsystem into compliance.

21.6.3 RAM Review Board

A. Contractor and SEPTA representatives shall form a RAM Review Board (RRB) during the pilot car fabrication phase of the program.

1. The RRB shall meet regularly, beginning at the conditional acceptance of the first car, through to the completion of the Reliability and Availability demonstration. SEPTA reserves the right to specify the frequency of RRB meetings to enable appropriate review of the failure data generated throughout the Contract performance.

2. The RRB shall review all reliability, availability, and maintainability test data and failure reports, review failure analyses, report progress towards meeting RAMS requirements, identify areas needing improvement, and propose actions to

ensure the successful completion of the Reliability and Availability demonstration.

3. The RRB shall verify that all FRACAS data is correct and updated.

4. The core members of the RRB shall be the Contractor Warranty Manager and Reliability Engineers, and SEPTA's assigned Warranty Officer and RRB Chairperson.

5. The core members shall be supplemented by appropriate personnel from SEPTA, Contractor, and subcontractors, as required, to facilitate a thorough and accurate review of all data.

6. The Contractor shall require the participation of poor-performing sub-suppliers to ensure clear understanding of the problem component/subsystem and to expedite resolution.

21.6.3.1 Dispute Resolution

A. If the RRB is unable to reach agreement on the categorization of failures (chargeable/non-chargeable) or on the corrective action to be undertaken for an item, SEPTA's assigned Reliability Representative will forward the issue, together with the relevant records and documentation, to SEPTA's RRB Chairperson.

B. The RRB Chairperson will act as the arbitrator for all RRB issues. Where appropriate, the RRB Chairperson will meet with the Contractor's representative to review and determine the way forward. Upon agreement, the decision will be formally communicated to the Contractor and the RRB.

21.6.4 Failure Reporting Analysis and Corrective Action System (FRACAS)

A. Maintain a documented, Approved, closed-loop FRACAS in accordance with MIL-HDBK-2155:

1. The FRACAS shall commence at the start of factory acceptance testing of the first car and continue through the completion of the Reliability and Availability Demonstration.

2. Submit monthly FRACAS reports. **(CDRL 21-06, FRACAS Report)**

3. The FRACAS reporting shall record the cause of all unscheduled part removals and shall maintain a cumulative summary of all failure analyses, identifying the failed parts and the pertinent data and actions relating to each failure.

4. The FRACAS Report shall include calculated monthly and cumulative KPI values; specifically, MDBF-ALL, MDBD and Availability.

5. The FRACAS Report shall provide failure trend analysis on top failing LRUs and identify which LRUs can be classified as a Fleet Defect.

6. The FRACAS Report shall capture SEPTA furnished equipment in the KPIs, unless otherwise approved.

7. Track all equipment subject to failure analysis due to unscheduled maintenance (including consumables replaced in advance of the planned maintenance schedule).

    a. Tracking shall include the correct SEPTA component and failure codes.

    b. Failed parts shall be subject to investigation and failure analysis to determine the failure causes and determine the requirement for design or redesign effort.

    c. Provide detailed failure analysis reports within 30 days of the failure being reported by SEPTA.

    d. Submit a corrective action plan for approval.

8. The FRACAS shall follow the subsystem breakdown structure used by SEPTA's maintenance recording system (VMIS).

9. Work with SEPTA to ensure that the closed-loop aspect of the FRACAS is sufficiently rigorous to provide accurate and timely management information.

10. Assign one full-time reliability specialist to SEPTA's maintenance facilities to participate in the FRACAS activity, from initial delivery of cars on-site through to the end of the reliability demonstration period.

11. Subcontractor representatives shall be made available to observe failed or faulty equipment at a SEPTA maintenance facility, as required, addressing issues identified within the FRACAS.

12. The FRACAS shall include the following information as a minimum:

    a. Work order number

    b. Contractor tracking number aligned with SEPTA’s VMIS component codes

    c. Warranty parts tracking number

    d. Date of occurrence

    e. Car number

    f. Component part number

    g. Component serial number

    h. Component description

i. Incident description

j. Fault code

k. Root cause analysis

l. Failure categorization

13. Provide an ongoing continuing assessment of the FRACAS data to identify and monitor failure trends and new failure effects.

a. Failure Trends:

(1) A failure trend is defined by repeated failures of the same part or component in the same or similar circuit, equipment location, or application.

(2) A repeated failure occurs at a rate above the failure rate declared or implied for the part or component.

(3) The Contractor's FRACAS data evaluation shall promptly identify every failure trend and determine its cause.

(4) With Approval, implement corrective action for each trend.

b. New Failure Effects:

(1) Evaluate FRACAS data to identify each previously unknown or undocumented mode of failure and determine and evaluate its failure effects.

B. If any such failure effect is previously unknown or undocumented, identify any changes that are needed in reliability, maintainability, safety analyses, design, design criteria, maintainability procedures or criteria, and test procedures or criteria.

21.7 Reliability, Availability and Maintainability Demonstration Tests

21.7.1 Reliability and Availability Demonstration Test

A. The Reliability and Availability Demonstration Test shall commence after the first car is conditionally accepted and has accumulated at least 10,000 service miles (16,093 service km). From this point on, all additional cars that are conditionally accepted and have completed their 10,000 service miles (16,093 service km) will be included in the fleet evaluation. This test shall show that the cars and their subsystems meet the quantitative service and component reliability and availability requirements defined in this section. All cars shall remain in the test until its successful completion.

1. While failures and delays occurring during the burn-in and initial 10,000 mi (16,093 km) operation will not be included in the Reliability Demonstration,

failures occurring during these periods shall be monitored with the normal FRACAS process.

a. Failures shall be monitored and reviewed by the RRB.

b. Car mileage accumulated prior to entering the test shall not be included in the calculation of MDBD/MDBF-ALL.

2. All equipment failures during the warranty period will be reviewed by the RRB and classified as either chargeable or non-chargeable (see definitions in Section 1, General Topics and Definitions).

3. Prepare, maintain, and submit a report recording the performance of the reliability fleet, including RAM trends as part of the Reliability and Availability Demonstration Progress Reports. **(CDRL 21-05)**

4. As a minimum, the report shall discuss the following:

a. The predominant failure modes of those subsystems exceeding the allowable goal.

b. Technical assessment of the furnished data, with remedies where needed.

c. A complete list, with descriptions, of all modifications already performed, or in progress on each subsystem.

d. Proposals for additional modifications to bring noncompliant subsystems into compliance.

e. A specific program plan to perform additional studies or modifications if such work is required.

21.7.1.1 Reliability Growth Monitoring

A. Maintain a reliability growth monitoring program throughout the Contract.

1. Make use of the full range of RAM requirements and analyses to identify those items requiring reliability growth action, and proactively manage the design, development, testing, training, and procedures to facilitate reliability growth.

2. Submit the reliability growth status as part of the monthly Reliability and Availability progress reports. The growth modeling shall be in compliance with the System Reliability Toolkit-V.

3. Use distance (MDBF-ALL and MDBD) for all modeling.

4. The Contractor and SEPTA shall agree on the start point for the reliability growth plot (number of chargeable failures vs. operational miles/hours).

5. Include all chargeable failures in the determination of reliability growth until such time as an agreed corrective action has been implemented on the reliability fleet, for a period of no less than 60 days, to prove the root cause has been removed, subject to Approval.

6. Prepare appropriate documentation to demonstrate the effectiveness of corrective actions for submission to the RRB. Upon review of such submissions, the RRB may allow the failures to be removed from the reliability calculation and demonstration. The RRB shall treat these on a case-by-case basis.

7. Maintain the reliability growth plots for the car and major subsystems throughout the reliability growth program as an indicator of the effectiveness of the actions undertaken and the ability of the program to achieve the required levels of reliability (and thereby availability) at the stages defined in the Specifications.

8. The actions from the reliability growth program and the car and subsystem level growth plots shall be reviewed as an agenda item at the RRB.

21.7.1.2 Reliability and Availability Test Completion

A. Successful completion of the Reliability and Availability Demonstration shall be defined as a 12-month cumulative average where all MDBD, MDBF-ALL and Availability requirements are met or exceeded, regardless of car warranty completion.

1. SEPTA assumes that the Contractor will be making modifications to subsystems that are clearly underperforming.

2. The decision on reliability compliance shall be on a subsystem basis and shall rest with SEPTA.

3. A subsystem shall be eligible to be judged as passing the reliability test when it meets the following criteria:

   a. All cars have been in reliability test for at least 12 consecutive months.

   b. The subsystem has been in its final configuration for at least 12 months and has achieved the acceptable goal for at least 12 consecutive months.

4. Perform modifications necessary to bring the car and subsystems into conformance with the reliability and availability requirements.

   a. It is the Contractor's responsibility to implement the modifications, unless otherwise approved.

   b. The Contractor's responsibility for these modifications shall include costs for materials, necessary labor for removal and replacement, and testing associated with the required corrective action.

21.7.2 Maintainability Demonstration

21.7.2.1 Maintainability Demonstration Test

A. The Contractor shall perform a Maintainability Demonstration on the Pilot Cars or at subsystem First Article Inspections (FAIs), as Approved. The Contractor shall demonstrate the preventive and corrective repair time (MTTR) for maintained items for every subsystem with an MTTR requirement, unless otherwise approved.

B. The Maintainability Demonstration Plan shall include Technical Specification requirements, purpose/scope of the demonstration, required documentation, special tools, facility requirements, and a Maintainability Demonstration Report template.

1. Submit a detailed plan for the maintainability demonstration **(CDRL 21-07, Maintainability Demonstration Plan)** .

    a. Define the specific maintainability demonstration activities to be performed on the pilot cars.

2. The Maintenance Instructions used in the maintainability demonstration shall be the basis for those included in the manuals delivered per Section 26, Manuals and Training.

3. Maintenance Instructions must be provided to SEPTA at least 30 days prior to any maintainability demonstration to allow time for review. The instructions must then be updated and resubmitted after the demonstration, as required.

4. The demonstration shall include preventive maintenance, corrective maintenance, train recovery, and accessibility.

5. The preventive maintenance demonstration shall include the periodic inspections and servicing identified by the Contractor during the Maintenance Analysis.

6. The corrective maintenance demonstration shall include change-out of line replaceable units (LRUs) and LLRUs and use of special tools where special emphasis, instruction, or proficiency is needed.

    a. Special tools shall come with the pilot cars to enable the Maintainability Demonstration.

    b. LRU and LLRU change-out shall include items from each subsystem element listed in Table 21-4, Subsystem Maintainability Requirements in Mean Time To Repair (MTTR), and special requirements demonstration.

    c. The LRU and LLRU change-outs shall demonstrate compliance with the MTTR requirements of each subsystem element.

    d. The special requirements demonstration shall include removal and replacement of fresh air filters, side window, windshield, seat bottom

cushions, seat back cushions, side door threshold, axles, calipers, and de-trucking and re-trucking.

7. Document the demonstration by video recording and submitting to SEPTA. SEPTA may elect to verify the ease of maintenance, troubleshooting, and special tools by using its own maintenance personnel.

21.7.2.2 Maintainability Demonstration Progress Reporting

A. Submit a monthly report; see Section 21.7.2, Maintainability Demonstration, for detail. **(CDRL 21-08, Maintainability Demonstration Progress Report)**

21.7.2.3 Fleet Maintainability Monitoring

A. Monitor maintainability performance of the fleet until end of the reliability and availability demonstration test.

1. The effect of Field Modification Instructions (FMIs) on car maintainability shall be analyzed and reported as part of each FMI submittal.

2. Maintainability issues identified during FMI, preventive maintenance and corrective maintenance shall be documented and reported.

3. Submit maintainability findings with the RAMs Progress Reports.

4. Where the Contractor fails to achieve the maintainability objectives, SEPTA may require such corrective action as necessary to achieve compliance.

   a. SEPTA will consider the ease of maintenance of the overall car and the time required for each planned maintenance period to determine the extent of any corrective action required.

   b. Provide corrective action in cases where the MTTR puts at risk SEPTA's ability to operate under its existing maintenance policies.

21.8 Contract Deliverable Requirements List (CDRL)

The following contract deliverables have been identified in this section; however, the Contractor is responsible for providing and submitting anything necessary to fulfill the requirements of this contract, including those not identified by CDRL number.

CDRL 21-01, RAM Program Plan 21-4
CDRL 21-02, Reliability Prediction Report 21-6
CDRL 21-03, Maintainability Analysis and Maintenance Allocation Chart 21-9
CDRL 21-04, Reliability and Availability Demonstration Plan 21-10
CDRL 21-05, Reliability and Availability Demonstration Progress Report 21-10
CDRL 21-06, FRACAS Report 21-11
CDRL 21 07, Maintainability Demonstration Plan 21-16
CDRL 21-08, Maintainability Demonstration Progress Report 21-17

21.9 CDRL Details

This section lists the expected content for each CDRL required above. The lists provided for each CDRL are an outline only and should not be considered exhaustive, all CDRLs are subject to SEPTA review and Approval.

CDRL 21-01 RAM Program Plan:

1. The RAM Program Plan shall be submitted 30 days prior to CDR and updated throughout the design process.
2. The plan shall include, but is not limited to:
    a. Program objectives.
    b. Program schedule, including milestones for design manufacturing and testing, including Operational Characteristics Analysis Testing (see Section 15, Test Program).
    c. Organizational structure.
    d. RAM requirements.
    e. Methodologies used for analyses to ensure plan requirements are met.
    f. RAM allocations.
    g. RAM analyses.
    h. Program controls and review.
    i. Monitoring and controls of subcontractors and suppliers.
    j. RAM Demonstration Test plans.
    k. Pass-Fail criteria.
    l. Part selection and design criteria.
    m. RAM Review Board.
    n. Corrective action procedures.
    o. Documentation procedures for capturing failure data to include factory testing. Failure Reporting Analysis and Corrective Action System (FRACAS) and reporting.
    p. RAM progress reporting, which details implementation of the approved program. Reports shall be submitted to SEPTA on at least a monthly basis.
    q. RAM definitions.

r. Preliminary submittal schedule for RAM CDRLs.

s. Reliability Demonstration, including testing and reporting.

3. Include the calculation method for RAM predictions.

CDRL 21-02 Reliability Prediction Report:

1. The Reliability Prediction Report shall be submitted 30 days prior to PDR and 30 days prior to FDR.

2. Demonstrate how the car will achieve compliance with the specified reliability requirements.

3. Include Reliability Block Diagrams in support of the analysis.

CDRL 21-03 Maintainability Analysis and Maintenance Allocation Chart:

1. The Maintainability Analysis and Maintenance Allocation Chart shall be submitted 30 days prior to PDR and 30 days prior to FDR.

2. The Maintainability Analysis shall contain a maintainability prediction and analysis of the maintenance actions required for preventive maintenance and corrective maintenance for all subsystems on the car.

3. The Maintainability Analysis shall identify the following:

a. For preventive maintenance:

i. The performance of scheduled maintenance tasks to postpone or prevent anticipated occurrence of failures and deterioration.

ii. The basis for development of the following described in the Maintenance Manuals:

(1). Maintainability tasks

(2). Maintenance procedures

(3). Maintenance intervals

(4). Time required

(5). Skill levels

(6). Methods and techniques

iii. Methods to minimize major tasks and maximize minor tasks in order to produce a schedule that makes efficient use of shop resources and minimizes car down time. Maintenance intervals shall be time-, mileage-, or cycle-based, depending on what is appropriate for each subsystem.

(1). If cycle-based, the cycle shall be 30,000 miles (48,280 km).

(2). If time-based, inspections, shall not be less than every 184 days.

b. For corrective maintenance:

i. Time to identify the failure (troubleshoot) and fault isolate LRU/LLRU failures, repair or replace the failed LRU/LLRU, and test/confirm the restored function.

ii. All tasks required at each level of maintenance.

iii. Skill levels and the necessary tools and support equipment.

iv. Compliance with the maintainability requirements listed in Table 21-3.

4. The Maintenance Allocation Chart shall include a description of what consumable parts, spare parts, and special tools are required for each maintenance activity.

CDRL 21-04 Reliability and Availability Demonstration Plan:

1. The Reliability and Availability Demonstration Plan shall be submitted 30 days prior to PDR and 30 days prior to FDR.

2. Define the specific procedures, facilities, staffing, and protocols to be employed by the Contractor during the RAM demonstration test to monitor, test, adjust, and report progress towards achieving the specified Reliability and Availability requirements.

CDRL 21-05 Reliability and Availability Demonstration Progress Report:

1. The Reliability and Availability Demonstration Progress Report shall be submitted monthly following the first RAM Review Board Meeting. Reports may be required more frequently during the car delivery phase.

2. The format of the report and specific content shall be agreed by the RAM Review Board, and shall include at least the following items:

a. RAM activities within the reporting period, including minutes and actions of all RAM Review Board meetings.

b. Reliability and Availability Test Report, including summaries for all defined requirements:

i. MDBF-All

ii. MDBD

iii. Availability

c. RAM achievements/problems.

d. Components that contribute greater than 5% to the failure rate of the subsystem of which they are part.

e. Expected RAM activities in the next reporting period.

f. A summary and schedule of corrective actions, both those in progress and planned.

3. Performance of the Reliability Fleet:

a. The report shall contain all the information required to calculate MDBF-ALL and MDBD.

b. In addition, submit electronic copies of the report including FRACAS database.

c. The report shall include FRACAS information listing the failure rate in FPMM and MDBF-ALL for each of the subsystems under test and the car level MDBD.

d. This report shall cover the most recent 12-month period. After 12 months, the report shall be a rolling 12-month report with the oldest month being dropped and the new month added.

e. The report shall continue the failure analyses of failed components throughout completion of the Reliability Demonstration.

CDRL 21-06 FRACAS Report:

1. The FRACAS Reports shall be submitted monthly from the start of conditional acceptance of the first car through the completion of all RAM demonstrations.

a. The submitted data shall be current within one week.

b. The FRACAS Report shall include calculated monthly and cumulative values for MDBF-ALL, MDBD and Availability.

c. The Report shall provide failure trend analysis on top failing LRUs and identify which LRUs can be classified as a Fleet Defect.

d. The FRACAS Report shall capture SEPTA furnished equipment in the KPIs, unless otherwise approved.

CDRL 21-07 Maintainability Demonstration Plan:

1. The Maintainability Demonstration Plan shall be submitted 30 days prior to PDR and 30 days prior to FDR.

2. The plan and procedure shall be based on MIL-HDBK-470.

3. The plan shall include scope, specifically preventive and corrective maintenance MTTR, required maintenance documentation, special tools, facility requirements,

required personnel and qualifications and a Maintainability Demonstration Report template.

CDRL 21-08 Maintainability Demonstration Progress Report:

1. Submit Maintainability Demonstration reports monthly from the start of the first demonstration activity through the completion of all Maintainability demonstrations, unless otherwise approved.

2. The report shall contain calculated MTTRs, predicted MTTRs from the Maintainability Analysis **(CDRL 21-3)**, maintenance instruction references, special tools, facility requirements, required personnel and qualifications.

21.10 Referenced Standards

The following standards are referenced in this Section:

APTA PR-IM-RP-002-98, Rev. 2	Passenger Rail Equipment Technical Documentation
MIL-HDBK-217	Reliability Prediction of Electronic Equipment
MIL-HDBK-470	Designing and Developing Maintainable Products and Systems (Volume 1)
MIL-HDBK-472	Maintainability Prediction
MIL-HDBK-2155	Failure Reporting Analysis and Corrective Action Taken
NPRD	“Non-Electronic Parts Reliability Data,” Reliability Analysis Center (RAC)
Reliability Toolkit	System Reliability Toolkit-V
RIAC-HDBK-217Plus	Handbook of 217Plus Reliability Prediction Models

SECTION 22
QUALITY ASSURANCE

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22.1 Quality Assurance Requirements

A. This Section establishes criteria for the development and implementation of a Quality Assurance (QA) Program to optimize the quality, reliability and maintainability characteristics, and safety aspects of components, subsystem elements, completed cars and married pairs, and related items such as BTE.

B. The cars, married pairs, and related items shall provide a high degree of safety and reliability, and shall minimize downtime during preventive and corrective maintenance activities. Design shall ensure that cars, married pairs, and related items perform as required without excessive failures, delays, service interruptions, or hazards to passengers.

22.1.1 General Requirements

A. Plan and implement a QA Program to ensure delivery of a quality product under the terms of this Contract. The elements of the program shall be imposed on the Contractor's entire organization and all manufacturers, subcontractors, and suppliers that perform Contract work. The Contractor and SEPTA shall develop a documented procedure for the control of any SEPTA supplied material.

1. The QA Program shall ensure that all aspects of the work performed are in conformance with the design, materials, and workmanship requirements and that those requirements are performed in a timely manner. Quality project meetings shall be held monthly.

2. The QA Program shall require the Contractor to document inspection of design, manufacturing, assembly operations, testing and commissioning and warranty.

3. The Contractor shall be solely responsible for all of the quality assurance functions required by this Contract.

    a. Ensure QA Program compliance by subcontractors and suppliers. Surveillance of subcontractors shall include sampling and review of products, records, procedures, processes, manufacturing and assembly operations, and Quality Control methods.

    b. Maintain documented evidence of these activities and make it available to SEPTA upon request.

4. Ensure the appointment of a dedicated QA Manager at each facility, subject to Approval, who has appropriate training, experience, and qualifications to oversee the QA process, and SEPTA to accept or reject and stop work, if necessary.

5. The Contractor QA Manager will serve as the single point of coordination of Project QA for all Contractor facilities.

6. All Contractor, subcontractor, and supplier QA efforts, including the QA Program Plan of each, shall be in compliance with the requirements of the

following standards. Where those requirements differ from the terms of the Contract, the more stringent requirements shall take precedence:

a. ISO 9001

b. FTA-PA-27-5194-12.1

22.1.2 Quality Assurance Program

22.1.2.1 Assessment of Quality Assurance Program

A. QA responsibilities required by the Specifications include planning, establishing, and maintaining a QA Program; performing all work required by the QA Program; and conducting regular QA Program audits.

1. After Notice to Proceed (NTP), SEPTA shall have free access to shops of the Contractor and subcontractors where related work is performed to assess their quality management system and QA programs, and to perform required or continuous quality inspections, assessments, and audits at SEPTA's discretion during the Contractor's execution of the Contract.

   a. SEPTA inspections, assessments, and audits will be performed independent of and in addition to the Contractor's QA function.

   b. These monitoring functions are to confirm that all deliverables under the Contract, and SEPTA-Approved Contractor drawings and documentation conform to the Specifications.

   c. SEPTA's QA activities will not replace, negate, override, or lessen the Contractor’s QA obligations.

2. During SEPTA-conducted inspections, assessments, and audits, SEPTA may inspect production facilities, examine operations in progress, and review documentation to ensure product compliance with Specification requirements.

3. If deficiencies are noted during inspections, assessments, or audits, ensure that corrective action is accomplished as per the corrective actions' schedule and Approved by SEPTA. Procedures addressing the incorporation of corrective measures and their documentation will be a condition for SEPTA's acceptance of the QA Program Plan.

22.1.2.2 Quality Assurance Program Plan

A. Submit a work-specific QA Program Plan. **(CDRL 22-01, QA Program Plan)**

1. The QA Manager shall report to an officer or top level manager within the Contractor's organization and be independent of and not report to the Contractor's Project Manager, nor to Production Management for this project.

2. Responsibility for the QA function shall be so placed within the Contractor's organization that meeting schedule and cost projections will not compromise the quality of products delivered under the terms of this Contract.

3. Management responsibility for the QA function shall be set forth in the Contractor's policy statement, which shall clearly define the organization's objectives and commitment to quality.

    a. The Contractor shall appoint a dedicated QA Manager with appropriate training, experience, and qualifications to oversee the QA process, and to accept or reject work and stop work, if necessary. The individual proposed for this position shall be Approved before starting work on the project.

        (1) If the Approved QA Manager is no longer able to perform the duties described above, the Contractor shall the appoint a replacement QA Manager. The individual proposed as the replacement QA Manager shall be Approved before continuing work on the project.

    b. QA responsibilities shall be established for every department.

4. QA Program Plan, including procedures pertaining to engineering and design and production shall be part of the project kick-off meeting (Section 25, Project Management and Commissioning).

22.1.2.3 Inspection and Test Plan

A. Submit a work-specific Inspection and Test Plan. **(CDRL 22-02, Inspection and Test Plan)**

1. The Inspection and Test Plan will be used by SEPTA's QA representative to identify the Contractor’s inspection and test witness points.

2. Note that this plan includes tests relevant to the inspections, and does not include the tests that are part of the Master Test Plan required in Section 15, Test Program.

3. Note that The Inspection and Test Plan shall include the SEPTA's QA representative control and hold points.

22.1.2.4 Quality Assurance Manuals

A. Submit QA manuals for the Contractor and major subcontractors. **(CDRL 22-03, Quality Assurance Manuals**) These manuals will be used for reference and guidance when performing inspections, assessments, and audits.

22.1.2.5 Design Control

A. Written procedures shall be implemented to ensure designs and design changes are clearly defined.

1. Design reviews implemented through a systematic program review at suitable stages of design and development shall verify adequacy of the designs.

2. Design inputs from the Specifications, regulatory requirements, industry codes, and military standards shall be identified and documented.

3. Procedures shall be developed for translating these design inputs into design specifications and drawings.

4. Design shall be thoroughly reviewed and approved and stamped as such by the Contractor prior to release for SEPTA Approval.

5. Design documents shall satisfy input requirements and shall be the basis for purchase, manufacture, fabrication, test, inspection, and quality standards of the Contractor and subcontractors.

6. Design changes shall be made using the same design and drafting procedures that controlled the original design.

7. Ensure that all the cars and married pairs intended for revenue service operation are identical, including the Pilot cars, and comply with the final design.

    a. Establish and maintain evidence of compliance with all the requirements of the Specifications and accepted design control procedures.

    b. Conduct verification activities to ensure that output requirements have been met, and validation activities to ensure the resulting product can meet the requirements for the specific application.

    c. Maintain records of verification and validation activities and results.

    d. Establish and maintain procedures for controlling all project documents and data.

    e. The procedures shall identify who is responsible to maintain its master document list, revision levels, and status.

    f. Ensure that documents are reviewed and Approved prior to release and that current versions are available where needed.

    g. Control obsolete/old revisions of documents to prevent unintended use. If obsolete documents are retained, they shall be segregated and suitably identified as obsolete. Maintain a change log of revised documents.

22.1.2.6 Purchasing

A. Comply with the following requirements:

1. Outline the methods to be used for selection and control of subcontractors and suppliers.

    a. Ensure that all supplies and services procured conform to Contract requirements. Subcontractor quality functions shall be reviewed and assessed by the Contractor at intervals consistent with product complexity and quality requirements.

    b. Submit a list of subcontractors and suppliers. **(CDRL 22-04, Subcontractor/Supplier List**) Once Approved, SEPTA shall be notified of any changes to this list.

2. Purchase specifications shall require all purchased materials, equipment, and services to comply with the Specifications requirements and the Contractor's material, quality, workmanship, and performance criteria.

    a. Purchase specifications shall transmit all quality requirements, the Specifications, and Contractor specifications and standards to subcontractors.

    b. Inspect purchased materials at subcontractor and supplier facilities or upon receipt, to verify conformance to design and test requirements identified in the Inspection and Test Plan in TS 22.1.2.3.

    c. Purchase order requirements shall ensure that the subcontractor will notify and obtain approval from the Contractor for design changes and use of certificates of compliance (where applicable), prior to implementation.

    d. Meet with subcontractors and suppliers as needed to clarify the provisions of the purchase contracts.

    e. Evidence of compliance with the purchase specifications shall be available for SEPTA review up to five years after the last Contract deliverable is furnished.

3. SEPTA reserves the right to inspect, at the source, any supplies furnished, or services rendered under the Contract.

    a. Ensure SEPTA's right to contact manufacturers, subcontractors, or suppliers to discuss scheduling, design, or quality issues.

    b. SEPTA will coordinate with the Contractor regarding any action required due to discussions with the Contractor's subcontractors and suppliers.

c. When SEPTA elects to inspect at a subcontractor's facility, such inspection shall not be used by the Contractor as evidence of effective quality control of the subcontractor.

22.1.2.7 Materials Control

A. The Contractor's written procedures shall be implemented to ensure purchased material conforms to requirements of the purchase specifications.

1. These measures shall include source inspection; receipt inspection; evaluation/audits of production facilities; and review of material certifications, QA manuals for suppliers of systems, and procedures.

2. There shall also be procedures for the qualification and acceptance of material suppliers. These data shall be made available to SEPTA upon request.

3. Submit written procedures for identification and control of product.

   a. The written procedures shall ensure items are marked, handled, stored, and shipped properly to prevent damage, deterioration, and loss.

   b. As a minimum, instructions for serialization, version level and part identification, precautionary signs, protection against weathering and corrosion, drying agents, moisture barriers, and means to manage shelf life shall be provided.

   c. Procedures shall ensure that cars do not enter service with items that have expired their shelf life.

   d. Procedures shall include information allowing for traceability of items and comply with FTA-PA-27-5194-12.1.

   e. These written procedures shall be applied, but not limited to, items installed on the car and items provided by the Contractor to SEPTA.

4. If defective work has occurred, or defective materials have been used, furnish the appliances and labor to investigate at no cost to SEPTA.

   a. Defective construction or materials shall be corrected promptly at the Contractor's cost.

   b. Parts and apparatus damaged during construction, testing, or shipment shall be made good at the Contractor's cost.

   c. Repair procedures shall be subject to Approval by SEPTA prior to proceeding with repair efforts.

5. Implement written procedures to prevent use of items that do not conform to the Specifications.

    a. These controls shall provide instructions to identify and document noncompliance.

    b. The procedures shall instruct personnel to identify and segregate noncompliant parts, require disposition by the appropriate department, and notify the affected organizations.

    c. As specified in TS 22.1.2.12, defective items shall be tagged, documented, and segregated in a bonded holding area pending disposition by the Material Review Board (MRB).

6. Establish a Material Review Board (MRB):

    a. It shall include representatives of the Contractor's quality control, manufacturing, purchasing, and engineering groups, and SEPTA's QA and Engineering representatives.

    b. The MRB shall recommend whether deficient items shall be completed, reworked, repaired, used as-is, or scrapped.

    c. Submit all recommendations for "repair" and "use as is" for nonconforming material for disposition. **(CDRL 22-05, MRB Documentation)**

    d. SEPTA-approved repairs shall not be construed as blanket Approvals. Each time a repair is required, it shall be submitted to confirm appropriateness for use and Approval.

    e. The MRB shall promptly identify and document causes of defects, recommend corrective actions to prevent recurrence, and follow-up to verify satisfactory response.

    f. Use of nonconforming materials requires prior Approval, as specified in TS 22.1.2.12.

    g. The MRB shall issue reports at least monthly to summarize its activities. These reports shall be a complete listing of items received into the MRB hold area, along with a description of part deficiencies and dispositions. Any on-going open deficient items shall have a responsible party assigned for the action and a resolution due date.

7. Submit an MRB procedure as part of the Quality Assurance Manual. **(CDRL 22-03)**

22.1.2.8 Manufacturing and Process Control

A. Submit a complete Manufacturing and Process Control plan as part of the QA Program Plan. It shall be Approved before the start of any work:

1. It shall include a production workflow diagram in a graph form.

2. It shall include a staffing plan for QC representatives and their assignments within the facility(ies). Each production site shall retain a qualified manufacturing/methods engineer.

3. It shall show production operations and related points for critical inspections, examinations, and tests.

4. Written procedures shall be developed to control manufacturing and production processes shown on the Approved manufacturing and inspection plans.

    a. Manufacturing and inspection procedures shall include control of the qualification of personnel during all stages of design, procurement, manufacturing, fabrication, and test.

    b. Procedures shall also control materials and equipment used during production and inspection activities, including calibration and maintenance activities.

    c. Certain special manufacturing and production processes shall be performed only by certified personnel using qualified procedures under specified conditions. These processes include, as a minimum, fastener torquing, welding, soldering, brazing, electrical crimping, heat treatment, non-destructive testing, painting, wheel pressing, and refrigerant handling.

    d. Procedures and work instructions shall be digital and controlled to ensure compliance with Specification requirements.

    e. Applicable codes, standards, regulations, and acceptance criteria for special processes and tests shall be cited by procedures, drawings, and checklists.

5. Establish and maintain procedures for identifying products and materials, where appropriate, during all stages of production, installation, and delivery.

    a. Documents that trace items throughout receipt, storage, fabrication, repair, and shipment shall be filed.

    b. Markings shall be transferred to each part of an identified item when subdivided. Markings shall not be obliterated or hidden by surface treatments.

c. The manufacturing history of items shall be documented on forms that accompany parts and assemblies as they are processed.

6. Control/hold points for inspections, examinations, and tests shall be established and agreed upon with SEPTA to prevent out-of-sequence installation and ensure that no work will be hidden from inspection or test by subsequent assembly.

7. Conditions that adversely affect product quality shall be identified, controlled, and eliminated. Evidence of corrective actions to prevent recurrence of such conditions shall be verified and documented.

22.1.2.9 Inspection and Test

A. Implement formal inspection and test procedures that shall be part of the inspection and test plan required in TS 22.1.2.3.

1. Written procedures shall be implemented to ensure all items will perform satisfactorily in service.

a. Test procedures shall reference test objectives and list prerequisites to be met.

b. Test instrumentation requirements shall be listed for each test procedure.

c. All inspection and test procedures shall be submitted to SEPTA for Approval prior to implementation.

2. All inspections and tests shall be performed to demonstrate compliance with Specification requirements, confirm elimination of deficiencies, and provide information on car technical characteristics.

a. Functional, operational, and acceptance testing shall be performed under controlled conditions, using appropriate test equipment.

b. Test equipment shall be maintained in serviceable condition and within correct calibration and be operated by persons who have received comprehensive training.

c. The Contractor's inspectors shall monitor tests and verify that specified conditions are satisfied.

3. All inspection and test results shall be documented, traceable to the product being tested and, when applicable, submitted to SEPTA for review and disposition.

22.1.2.10 Inspection, Measuring, and Test Equipment

A. Implement procedures to control, calibrate, and maintain inspection, measuring, and test equipment to demonstrate to SEPTA that products conform to Specification requirements.

1. Written procedures shall be implemented to ensure tools and inspection and test equipment are calibrated.

a. Tooling, fixtures, test software, and hardware used as a medium of inspection shall be included in these procedures.

b. Calibrations and adjustments shall be performed at prescribed intervals.

c. Calibration standards shall be traceable to the National Institute of Standards and Technology, or Approved equal and calibration laboratories shall be A2LA accredited.

d. Calibration status shall be labeled on the controlled item and recorded to ensure adherence to calibration schedules. Calibration labels shall be legible, and identify the date of latest calibration, who performed the calibration, and when the next calibration is due.

2. The procedures shall include provisions for determining the validity of previous inspection and test results when measurement equipment is found out of calibration, and taking appropriate corrective action, to include correction of all discrepant material.

3. Any work done using incorrect, unapproved, or out of calibration equipment will be considered invalid.

22.1.2.11 Inspection and Test Status

A. Furnish written procedures to identify the inspection and test status of work during production and installation.

1. The procedures shall be capable of identifying the progressive inspection status of components and materials as to their acceptance, rejection, or non-inspection status.

2. The procedures shall ensure that only work that has passed the required inspections and tests are accepted.

3. Nonconforming items shall be identified by physical segregation and status indicators such as markings, serialization, stamps, tags, and inspection records.

22.1.2.12 Nonconforming Material

A. Furnish written procedures for control of nonconforming material in all of its facilities.

1. The procedures shall address identification, segregation, and disposition of nonconforming material.

2. The Material Review Board shall evaluate and determine the disposition of nonconforming material. Disposition to use "as-is" or repair of nonconforming material shall require SEPTA Approval (Quality, Engineering, and Management) prior to being redirected into the production flow.

3. Nonconforming material shall be positively identified to prevent unauthorized use, shipment or mixing with conforming material. Bonded holding areas shall be established by the Contractor to isolate nonconforming items.

4. Present corrective action reports for all documented discrepant materials or activities.

a. Corrective action shall extend to all subcontractors and suppliers.

b. Methods to correct discrepant materials or activities in the Contractor, subcontractors', and suppliers' operations shall be documented and effective (i.e., feedback loop).

22.1.2.13 Engineering Change Control

A. Contractor inspection materials, procedures, and practices shall reflect the current configuration of the railcars and Spare Parts, including all engineering changes Approved to date. See change control requirements in Section 25, Program Management and Commissioning.

22.1.2.14 Records

A. Implement procedures for handling, maintaining, and disposing of quality records, including those of subcontractors.

1. Quality records shall be controlled by the Contractor, stored to prevent loss or damage, and available for SEPTA examination upon request.

2. All quality records shall be legible, easily retrievable, and traceable to the items they describe.

3. The procedures shall verify that QA records demonstrate compliance with requirements of the purchase specifications.

4. The procedures shall include a QA records list that defines which records will be kept. The records list shall include procedures and work instructions (to include every revision thereof) results of examinations, inspections, tests, process controls, certifications of processes and personnel, non-conformances

(including disposition), calibrations, corrective actions, audits, and any other quality requirements defined by the Contract.

5. Establish a means to obtain and translate input into corrective action.

6. Retention periods for quality records shall be no less than five years after the expiration of the last delivered carshell warranty period.

22.1.2.15 Qualification of Personnel and Training

A. Implement procedures to identify training and qualification needs as necessary to complete work successfully under this Contract.

1. Contractor personnel performing work, inspections, and tests shall be qualified for such activity by virtue of prior successful experience and training and verified by testing where applicable. Retrain employees working on the Contract at agreed intervals.

2. Maintain records of training needs, training completed, and personnel certifications and qualifications and make available for review.

22.1.2.16 Quality Assurance Procedures

A. As a minimum, submit the following written procedures to ensure effective implementation of the QA activities:

1. Design control, including technical documentation and engineering changes.

2. Transmission of all design, reliability, maintainability, system safety and QA requirements to procurement sources

3. Surveillance of subcontractors and suppliers

4. Receiving, source, in-process, production final inspections, and customer acceptance final inspections

5. Production and process control

6. Operator certifications and qualifications

7. Functional testing

8. Discrepancy control

9. Measuring and test equipment calibration and certification

10. Drawing control/Document control

11. QA record management and record retention

12. Shipping, handling, and storing

13. Selection and approval of procurement sources

14. Review and approval of subcontractor's QA program plan

15. Auditing QA Program performance with metric data on On-Time Delivery and Nonconforming Material

16. Problem feedback and resolutions provided to Contractor's Engineering and Production Departments (which shall include the use of root cause analysis via 8D, 5Y, or DMAIC).

17. Customer shipping inspection to include final car shipping preparation, and customer receipt.

18. Shipping Open Item List (SOIL)

22.1.3 Quality Control Functions

22.1.3.1 Contractor and SEPTA Roles

A. Inspection and verification of compliance shall be ensured by the Contractor at its own facilities and those of its subcontractors, other manufacturers, and acceptance and commissioning sites.

1. All entities within the Contractor's organization shall enforce the QA Program.

2. Schedule and cost decisions shall not compromise quality. If a conflict arises as a result of this provision, details shall be explained to SEPTA by the Contractor's QA designee. Such matters shall be resolved to the satisfaction of SEPTA before shipment of affected items.

3. The Contractor shall employ sufficient staff to perform effective quality control.

4. The Contractor's QA Program shall implement written procedures to enforce receiving, source, in process, first article, final, and acceptance inspections and tests.

a. Enforcement shall ensure that products are manufactured correctly, all appropriate documentation is complete and satisfactory, and products are marked with appropriate identification, successfully tested, and packed to preclude damage during shipment.

b. Preparation for shipment shall include presentation of appropriate and complete documentation and confirmation of car readiness through use of completed check lists for each shipment.

B. SEPTA will also make inspections of items, completed or in-progress, with, without, or in addition to the Contractor's inspection.

1. This shall in no way delete, lessen, or take the place of the Contractor's obligation to conduct thorough inspections.

2. SEPTA reserves the right to reject materials and workmanship that do not fully conform to the Specifications.

3. Repetitious rejections at either the Contractor's or subcontractor's facilities shall be cause to withdraw SEPTA's inspection. In such case, the work in question shall be stopped until a satisfactory corrective action agreement is reached between SEPTA and the Contractor.

4. SEPTA shall document any observed violations of the Contractor's Quality Plan or processes via a Surveillance Inspection Report (SIR).

    a. The SIR will document the observation(s) and the policy or process violation.

    b. SEPTA will formally deliver the SIR to the Contractor with a request for corrective action via Contract letter.

    c. The Contractor shall respond to each SIR within calendar 30 days with a comprehensive Failure Analysis Report (FAR) and a detailed plan for corrective action.

    d. At no time shall the Contractor or subcontractor have more than four open SIRs. If more than four open SIRs occur, the Contractor or subcontractor shall stop production to properly address and close the issue(s) in order to maintain consistent quality output.

    e. Upon validation of appropriate corrective action, the SIR will be considered closed.

    f. Open SIRs will be considered open items against any parts, equipment, cars, or other deliverables.

22.1.3.2 Scheduling Inspections

A. Comply with the following:

1. Give notice 14 days before each vendor shipment of major items to its plant so that SEPTA can be present during the pre-shipment inspection. After notice by the Contractor, SEPTA will advise within 7 days whether or not an inspector will be present for the inspection.

2. The Contractor shall not schedule more than two vendor inspections on the same date without prior Approval.

3. Work shall follow the Contractor's manufacturing and inspection plans and not be moved from assigned sites without prior notice to SEPTA.

4. Inspection and testing will not be conducted by SEPTA on Saturdays, Sundays, or SEPTA-observed holidays. Specific tests or inspections may be permitted, as agreed.

    a. Failure by the Contractor to recognize this restriction will be reason to reject the equipment involved. Inspections will then be rescheduled at SEPTA's convenience for normal daytime shifts.

    b. Availability of SEPTA for evening shift work, special tests, and special inspection on weekends and holidays will be at SEPTA's discretion and only if notified at least 48 hours in advance.

22.1.3.3 Contractor Provisions for SEPTA Inspection

A. Provide, at no cost to SEPTA, inspection facilities at Contractor's manufacturing and assembly plants, including any final assembly sites.

1. The facilities shall enable convenient inspection of materials, work, and equipment.

2. SEPTA's in-plant representatives shall have access to and be provided with copies of all drawings both hard and electronic, diagrams, inspection, test procedures, reports, schedules, changes, deviations, and Contract data. Data shall be adequate to verify design, configuration status, construction, assembly, installation, workmanship, clearances, tolerances, and functionality of the cars.

3. Furnish SEPTA's in-plant representatives with a heated, cooled, and adequately lighted secure private office, with convenient access to facilities. Furnish telephones for inspectors, a dedicated fax line, and access to the secured internet. Furnish computer access to the Contractor's drawing database and the capability to copy and print B size drawings. Furnish routine janitorial and maintenance services in SEPTA's designated office space.

4. For inspection and testing to be performed on SEPTA's property, schedule this activity during normal business hours. For work scheduled outside of these hours or on weekends, if SEPTA is required to support the Contractor's schedule, then the costs incurred by SEPTA shall be borne by the Contractor.

22.1.3.4 Levels of Inspection

A. Specify either 100% or sampling inspection for discrete items of work. Submit proposed sampling plans. **(CDRL 22-06, Sampling Plan)**

1. Perform sampling procedures that determine Acceptable Quality Levels (AQL) and Average Outgoing Quality Levels (AOQL) under ANSI/ASQ Z1.9, or other Approved plan.

2. SEPTA reserves the right to require 100% inspection of discrete items or work when deemed necessary.

22.1.3.5 Statistical Quality Control

A. Statistical quality control methods (SQC) shall be used to accept parts and materials and to evaluate processes.

1. Such methods shall be performed under ANSI/ASQ Z1.9 guidelines or other Approved standards or guidelines. Results shall be documented.

2. Submit a list of parts and materials to be inspected by SQC. **(CDRL 22-07, Statistical Quality Control Inspection List**)

22.1.3.6 Inspection Status

A. Maintain a system to identify acceptance, rejection, or non-inspection status of materials and components. Inspection status shall be identified by tags and stamps and be clearly visible.

22.1.3.7 Receiving Inspection and Source Inspection

A. Implement written procedures to ensure items are inspected at the source and upon receipt to verify conformance to acceptance criteria of specifications and drawings.

1. Inspections shall be performed to Purchase Order requirements and/or specification drawings and requirements.

2. The Contractor's procedures shall prohibit processing and use of purchased items and materials until they have been inspected per Approved procedures and verified with respect to requirements.

3. Material certifications and test reports shall be retained by the Contractor, subcontractors, and suppliers. Contractor shall specify 100% or sampling source inspection for all major subsystem equipment to be purchased.

22.1.3.8 First Article Inspections

22.1.3.8.1 General

A. A First Article Inspection (FAI) will be performed jointly by SEPTA and the Contractor on the first production major systems and components, subassemblies, one Pilot married pair A-car and B-car, and related items such as BTE.

1. All major systems, subsystems, components, and subassemblies shall go through the FAI process for SEPTA Approval. Note that successful FAI reduces the risk of non-compliance with the Specification requirements.

2. Notice: Furnish an individual notice to SEPTA for each joint FAI a minimum of 45 days prior to the joint FAI.

3. Scheduling:

a. The Contractor shall not schedule more than one joint FAI on the same date without prior Approval by SEPTA.

b. Prior to scheduling a joint FAI, the Contractor shall perform a pre-FAI to ensure the Contractor or subcontractor is prepared, and submit a pre-FAI report to SEPTA for review.

4. Prerequisites:

a. Before each FAI, submit an FAI package. **(CDRL 22-08, FAI Packages)**

b. Pre-shipment inspections shall be conducted for all items undergoing FAI.

c. An FAI will not be conducted until the design drawings of the article, and any control samples required to evaluate the subsystem characteristics, have been Approved.

d. If conditionally approved drawings and control samples are used, SEPTA's conditions for Approval shall be satisfied at the FAI and represented by the inspection article.

e. If required, the Contractor shall submit control samples of material and finishes to SEPTA for review and Approval prior to the FAI.

f. An FAI will be performed only on a component built using Approved production processes and tooling, materials, and labor, and shall establish the quality of workmanship for the balance of like components.

5. Documentation Required at FAI:

a. Make available a complete set of Approved or conditionally approved drawings with detailed Bill Of Materials and software documentation for the item to be inspected.

b. For purchased items, make available a copy of the vendor’s purchase order (with commercial items excluded).

c. Make available completed inspection forms from the vendor that control and document acceptance of in-process work.

d. Furnish completed final inspection reports, inclusive of the unit weight from the vendor and the Contractor, reflecting satisfactory disposition.

e. Furnish completed test documents that reflect that the FAI unit has passed testing, including watertightness (if applicable) and weighing tests.

f. Make available worker qualifications and certifications for all special processes performed on the unit inclusive of painting, torquing, crimping, welding, etc.

6. Workspace and Assistance at the FAI:

    a. The inspection workspace shall provide the proper environment for inspection of piece part, subassembly, or car final assembly.

    b. The inspection article shall be displayed on a stand or table in a well-lit workspace with all necessary inspection tools, Go/No-Go gauges, plug gauges and handling aids.

    c. FAI item shall have all electrical and pneumatic connections tested.

    d. Furnish correct tools and labor to take mechanical or electrical measurements.

    e. Furnish tools and labor for disassembly and removal of covers.

    f. During the FAI, the jigs, fixtures and instructions used to ensure repeatability of the assembly/manufacturing process shall be presented as part of the overall process.

7. Scope of FAI:

    a. Perform conformance testing using appropriate test/production personnel, in accordance with production process and final test procedures.

    b. FAI item shall be subjected to complete routine testing to demonstrate all features and functions are operational.

    c. The FAI will demonstrate and evaluate component and subsystem accessibility and maintainability, and line replaceable unit (LRU) replacement.

    d. FAI item shall, as appropriate, use all support equipment, such as PTUs.

    e. FAI item shall, as appropriate, demonstrate on-vehicle software.

    f. When conducting FAIs on BTE, all BTEs shall be networked together.

    g. Make available multiple samples of each type of electrical crimp connect for inspection and dissection. Make available internal quality documents for inspection that illustrate proper tool and die selection for crimping, and proper training of personnel performing crimps.

8. The quality level shall be established jointly by SEPTA and the Contractor through the establishment of a Book of Standards detailing quality criteria for the car.

    a. Photographs and/or video of the joint FAI shall be used to document results and shall be retained by the Contractor and SEPTA for reference during production.

(1) Photographs shall be in high-resolution electronic JPEG format.

(2) Filenames of photographs shall include the date the photograph was taken and include identifying information.

b. Approved FAI items shall establish the quality of workmanship for the remainder of the same items being produced and for the vehicle.

9. Subsequent to SEPTA Approval of the results of the initial FAI, changes to the product design, production processes, or location of manufacture shall be the basis for performing another FAI, the scope of the subsequent FAI being at the sole discretion of SEPTA. Changes shall be submitted to SEPTA as specified for configuration management in Section 25, Program Management and Commissioning.

10. Production equipment shall be shipped from the point of manufacture only after an FAI has been offered, passed, and Approved by SEPTA.

11. Retention of Items After FAI:

a. With the exception of the carbody, FAI items shall be retained, and upgraded to the latest Approved design, production and testing configuration, for the duration of the manufacturing phase and stored in a secure area at the Contractor's facilities.

b. However, it is not the intent that entire items be retained for this purpose, such as a whole propulsion inverter or HVAC unit.

c. Retain samples of welds, fit-ups, finishes, and colors, photographs, and FAI documentation, for the duration of the production phase in a secure area at the Contractor's facilities for reference by the Contractor's and SEPTA's representatives. These approved samples shall be tracked on a log by Contractor for SEPTA and made available when requested.

d. These items may be used for production of the last cars following SEPTA inspection and Approval, except for type test units, assemblies, or parts that have undergone destructive testing such as shock and vibration, high-potential testing and accelerated life cycle testing (see Section 15, Test Program).

22.1.3.8.2 Pilot Car FAI

A. An FAI will be performed jointly by SEPTA and the Contractor on a fully assembled Pilot A-car and B-car chosen by SEPTA. SEPTA reserves the right to have access to the

Pilot Car production at any time to enable inspection of areas of the car that will be covered up at time of FAI.

1. The following prerequisites shall be satisfied prior to scheduling a First Article Inspection of the Pilot Cars:

    a. SEPTA Approval of all design review packages, CDR, PDR, and FDR.

    b. SEPTA Approval of all subsystem-level First Article Inspections.

    c. Closure of all action items generated as part of the Pilot Car Production Reviews and the Maintainability and Safety Review.

    d. SEPTA Approval of all Factory Acceptance Test reports for the Pilot Cars.

    e. Closure references established for all design-related hazards in the Hazard Log.

    f. Approval or Conditional Approval of all drawings, including revisions generated as part of the Pilot Car Production Reviews.

    g. Completion of all inspections and buy-back of all open items.

    h. SEPTA Approval of the consumables list, as well as the spare parts list required in the Spare Parts Provisioning Plan (see Section 25, Program Management and Commissioning).

2. The Pilot Car FAI shall establish the quality level of the completed car and define the format and configuration of the Car History Books. It shall evaluate and verify component and system function, accessibility, and maintainability where possible. Perform maintainability demonstrations for FAI components at the car level FAI, as applicable.

3. Photographs and other documentation of these cars shall be gathered during the Pilot Car Production Reviews (Section 25, Program Management and Commissioning) and all FAIs and included in the program quality documentation for reference during the serial production run.

    a. Photographs shall be in high-resolution electronic JPEG format.

    b. Filenames of photographs shall include the date the photograph was taken and include identifying information.

22.1.3.9 Inspection of Work In-Process

A. The Contractor's QA Department shall maintain and direct inspectors to verify that work in its shops is performed in compliance with Contract requirements and Approved design drawings.

    1. Discrepancies in the work shall be recorded, and departments responsible for the work shall be notified of the need for corrections.

2. Rework and corrections shall be inspected for conformance to drawings and SEPTA-Approved rework instructions, as needed.

    a. Reinspection acceptance status shall be indicated by the Contractor's inspectors by stamp or initials on the original of the discrepancy report prior to offering the inspection to SEPTA for consideration.

    b. Responsible manufacturing supervision shall be notified of rework that is rejected.

    c. All corrective actions shall be documented.

    d. An effective feedback mechanism or process shall be implemented to track defects back to their point of origin to prevent recurrences.

22.1.3.10 Hold Point Inspection

A. Establish mandatory hold points in the manufacturing process to provide for critical inspections.

1. Hold point inspections shall be used to ensure significant operations or installations have been properly completed, including items that are about to be covered by succeeding assemblies.

    a. Proceeding to next operation or station will not be allowed until hold point requirements have been found satisfactory.

    b. SEPTA reserves the right to perform inspection of any concealed work that requires inspection prior to the next production step. The need to perform concealed portion inspection shall be established during the inspection of the Pilot Cars.

    c. If work is concealed without inspection, the Contractor will be required to expose the work and ensure inspection requirements have been met to SEPTA satisfaction.

2. Use inspection forms to record the list of discrepancies noted.

    a. Nonconforming products shall not be released from a hold point until discrepancies have been corrected and compliance documented by the Contractor and confirmed by SEPTA.

    b. The inspection forms shall be posted at or near the point of inspection for each car and included with the Car History Book when all discrepancies have been eliminated.

    c. SEPTA reserves the right to add and/or subtract hold point inspections as deemed necessary.

3. Hold point inspections shall include, but not be limited to:

    a. All underfloor equipment, piping, conduit and wiring in place and connected

    b. Car structure complete (no liners installed)

    c. Side doors installed and operating (no liners installed)

    d. Car shell water test (no liners or insulation installed)

    e. Overhead air conditioning apparatus in place and connected (no liners installed)

    f. Floor heat and lighting in place and connected

    g. Cab complete

    h. Floor panel installation

    i. All liners, interior appointments and floor covering installed (no seats)

    j. Complete car water test, including exterior equipment enclosures

    k. Car complete in all respects, ready-to-run in revenue service operation

    l. Painting of the car and components

    m. Truck complete

4. SEPTA will work with the Contractor on the most efficient way to proceed with the hold point inspections, with the general guidelines shown below:

    a. Plan and schedule the hold point inspections with SEPTA within the regular 8-hour workday.

    b. Inspections shall be requested only if there are enough regular work hours remaining to complete the task in that workday. If not, the inspection will be the first task performed the following day.

    c. Ensure that the scheduling of inspections occurs within the established schedule and does not necessitate the need to request overtime or weekend work.

22.1.3.11 Final Inspections

A. The Contractor's QA Program Plan shall identify all final inspections and tests upon which the final release of railcars and equipment will be based.

1. Prior to final inspection, the following shall be completed or provided:

a. Prerequisite inspection and test work, including car watertightness, leveling, and weighing, shall be complete. Watertightness and leveling shall be captured on inspection reports and car weight shall be documented on a computer-generated, dated, weight ticket.

b. The Contractor shall provide the current Configuration Control list and the complete list and status of all deviations, modifications and open engineering changes that affect the car presented, to accurately identify car configuration and ensure car readiness for final inspection.

c. The Software Configuration Item list of all equipment installed.

2. Deviation, modification, and engineering change documentation assigned to the car being inspected shall be accessible at the time of final inspection with any updates, additions, or deletions provided prior to Release for Shipment.

3. Perform final inspection to written procedures, prior to SEPTA's inspection. Discrepancies captured by prior inspection reports shall be corrected before final inspection begins.

4. Present all inspection forms and support documentation for review by SEPTA.

5. Prior to SEPTA commencing the Final Inspection, address all SEPTA's prior concerns to the satisfaction of SEPTA.

6. During final inspection, Contractor shall comply with the following requirements:

a. All systems shall be operational with use of Approved types of special equipment or power supplies.

b. The inspection shall be held in a well-lit environment conducive to performing all appropriate inspection activities.

c. Furnish a qualified supervisor to accompany SEPTA during final inspection to ensure that proper corrective action is taken.

d. Furnish labor and appropriate tools to remove or open and reapply covers and doors if requested by SEPTA.

7. The duration of a SEPTA final inspection may vary dependent upon the level of car readiness presented.

    a. SEPTA reserves the right to terminate the inspection until such time as the Contractor is able to present a product ready for final inspection.

    b. Discrepancies identified during SEPTA's final inspection shall be reworked and satisfactorily closed prior to car release.

8. Products shall not be released for shipment until all final inspections and tests have been completed and the equipment has been demonstrated to be operational to SEPTA's requirements.

    a. Once the car has been deemed complete, all inspection criteria have been met and there is compliance with all other agreed-upon conditions for shipment, SEPTA will issue a "Certificate of In-Plant Inspection and Release for Shipment."

    b. Any items that remain open per agreement between SEPTA and the Contractor shall be included with the signed certificate of release for shipment.

22.1.3.12 Shipping and Receipt Inspection

A. Comply with the following requirements:

1. Implement written procedures to ensure the following:

    a. Completion of manufacture prior to shipment from each manufacturing facility.

    b. That shipments are adequately prepared to preclude damage during shipment.

    c. Receipt inspection to verify that no damage was endured during shipment and during the removal of shipping protection.

2. The procedures shall include the following:

    a. Car shipping preparation instructions.

    b. Inspection procedures for cars scheduled for shipment to the next manufacturing facility or acceptance site.

    c. Receipt inspection instructions to be used when the car arrives at the next manufacturing facility or acceptance site.

3. The results of shipping and receipt inspection shall be included in the Car History Book, which shall be presented for each car, as specified in Section 25,

Program Management and Commissioning. The results of the shipping and receipt inspection shall be Approved by SEPTA prior to release of the car.

22.1.3.13 Retrofit Inspection

A. The Contractor shall provide written procedures to inspect retrofits or changes made to railcars or Spare Parts at the Contractor's acceptance site or elsewhere on SEPTA's property.

1. The Contractor's Quality Control personnel shall verify and document completion status of changes.

2. Records of completed changes and retrofits to railcars and associated inspection shall be made available to SEPTA and recorded in the Car History Book.

3. SEPTA reserves the right to inspect and oversee all work.

22.1.4 Quality Assurance Audits

22.1.4.1 General

A. Establish and maintain procedures for internal and external quality system audits in accordance with requirements of ISO9001 and FTA-PA-27-5194-12.1.

1. The Contractor shall audit its operation so that it assesses compliance with each section of the Quality Manual throughout its organization on a planned periodic basis.

2. The Contractor shall audit its subcontractors to ensure compliance with the Contractor's, SEPTA's, and the subcontractor's own quality and specification requirements.

B. The Contractor and subcontractors shall also be subject to audits performed by SEPTA.

22.1.4.2 Contractor Audits of Subcontractors

A. Comply with the following:

1. Audit subcontractors according to the following schedule:

a. As a condition of the subcontract or purchase order before the start of work. This audit shall be documented and submitted to SEPTA for review and acceptance using the format of a Classification Audit.

b. Within one month before the Contractor's acceptance of the First Article Inspection, or of supplied items and services. This audit shall be documented and submitted to SEPTA for review and acceptance using the format of a Process Audit.

2. Notify SEPTA in advance of any scheduled audit.

3. Contractor audits of the Contractor, manufacturers, subcontractors, and suppliers may be witnessed. Give 30 days' notice to SEPTA of planned Contractor or subcontractor audits.

4. Additional audits of subcontractors may be directed by SEPTA, at its discretion. SEPTA may also conduct its own audit of manufacturers, subcontractors, and suppliers.

5. Submit audit check lists and reports. **(CDRL 22-09, Audit Checklists and Reports)** Use Approved check lists to perform audits.

6. Contractor auditors shall be independent of the operations they will audit.

22.1.4.3 Audits of the Contractor

A. SEPTA will audit the Contractor's QA activities to determine compliance with the Approved QA Program Plan.

1. SEPTA reserves the right to audit the QA programs of all parties invoiced with this Contract.

2. SEPTA may audit the Contractor's QA program at the following times:

a. Before production of the first car shell (this audit shall include the Contractor and major subcontractors).

b. After completion of the first shell before installation of equipment.

c. One month before SEPTA's acceptance of the first married pair.

d. After completion of the first production unit. (This audit shall incorporate a review of the production cars to ensure general conformance with, and resolution of any issues found in, the Pilot Cars. Any structural changes or issues shall be examined in detail).

e. Any time SEPTA determines an audit to be appropriate.

3. SEPTA will notify the Contractor of noncompliance found during audits.

a. The Contractor shall correct noncompliance promptly and request Approval by SEPTA.

b. Noncompliance with any part of the Approved QA Program Plan shall be cause for rejection of Contract work.

c. After corrective action of the noncompliance has been verified, the Contractor will be notified, and Contract work may be resumed.

4. Schedule delays caused by noncompliance with the Approved QA Program Plan shall not justify an extension of time under the Contract.

22.1.4.4 Audit Reports

A. Audit reports shall be submitted as follows:

1. All audit findings and observations will be provided to subcontractors and/or the Contractor at the completion of each audit, with formal report to follow.

2. SEPTA will provide preliminary report draft prior to leaving the facility. Within 15 days following audits, SEPTA will furnish the Contractor with a formal report of each audit. The audit report will describe scope of the audit and procedures followed. The report will identify discrepancies found, corrective action requests, observations noted and date when corrective action for each deficiency is required.

3. The Contractor shall submit a similar report for each manufacturer, subcontractor, and supplier audit it performs.

4. Submit a formal written response to SEPTA within 15 days following the receipt of each audit report. The response shall request Approval for the proposed methods and timetables to achieve compliance with the audit report.

22.2 Contract Deliverable Requirements List (CDRL)

The following contract deliverables have been identified in this section; however, the Contractor is responsible for providing and submitting anything necessary to fulfill the requirements of this contract, including those not identified by CDRL number.

CDRL 22-01, QA Program Plan 22-2
CDRL 22-02, Inspection and Test Plan 22-3
CDRL 22-03, Quality Assurance Manuals 22-3
CDRL 22-04, Subcontractor/Supplier List 22-5
CDRL 22-05, MRB Documentation 22-7
CDRL 22-06, Sampling Plan 22-15
CDRL 22-07, Statistical Quality Control Inspection List 22-16
CDRL 22-08, FAI Packages 22-17
CDRL 22-09, Audit Checklists and Reports 22-26

22.3 CDRL Details

This section lists the expected content for each CDRL required above. The lists provided for each CDRL are an outline only and should not be considered exhaustive, all CDRLs are subject to SEPTA review and approval.

CDRL 22-01 QA Program Plan:

1. The Plan shall include a company policy statement that clearly defines its objectives and its commitment to quality.

2. The Plan shall define the authority of the QA Department, reflecting its independence from the Production function.

3. The Plan shall clearly indicate that QA personnel shall have sufficient authority and organizational freedom to ensure that a nonconforming or discrepant product or service will not be delivered to SEPTA.

4. Include organization charts to show individuals, by name, and not just position, in the Contractor's organization and all subcontractor's organizations involved in the QA function, showing the reporting relationships among all management staff.

5. The Plan shall provide objective technical evidence of the adequacy of the Contractor's QA Program to ensure product compliance.

    a. It shall regulate procedures, methods, and processes to ensure compliance with all Contract requirements.

    b. As a minimum, incorporate written procedures identified in this Section.

    c. Procedures shall define methods to implement and maintain the Contractor's QA Program. Engineering, procurement, manufacturing, and inspection procedures, and test plans shall be developed using the methods and procedures found in the Contractor's QA Manual.

6. The Plan shall include work-specific quality organization and inspection flow charts for the Contractor and all major suppliers at various manufacturing and assembly operations for critical quality functions such as the following:

    a. Receiving inspection and source inspection

    b. In-process and final inspection

    c. Non-conforming material

    d. Material Review Board

    e. Testing product

    f. Contract compliance

    g. Corrective Action and Prevention Recurrence procedures

    h. Problem Solving Process

    i. Software QA requirements, referenced in Section 19, Software Engineering

7. The Plan shall contain or refer to a comprehensive collection of forms for documentation of quality control activities. Forms shall be designed to ensure compliance of materials, processes, personnel, and products to the Approved design drawings and applicable specifications (see TS 22.1.2.16).

8. The Plan shall provide procedures to control reliability and maintainability activities.

CDRL 22-02 Inspection and Test Plan:

1. Update and submit this plan as milestone dates or other significant items change.

2. Show major manufacturing and inspection milestones on a schedule, including planned dates for submittals, and integrate with the Master Program Schedule, (see Section 25, Program Management and Commissioning).

3. Identify Contractor inspection points and SEPTA witness and hold point inspections.

4. This plan shall:

    a. Identify all manufacturing, inspection and testing stages for major components and subsystems as well as the completed car.

    b. Include a car work-flow block diagram of the manufacturing process, showing significant operations and related points for critical inspections, examinations, and tests.

    c. Identify all inspection and test procedures required at the suppliers' or subcontractors' plants, the Contractor's plants, and on SEPTA property prior to acceptance.

5. All inspection or test procedures shall contain the procedure number, location, and Specification reference, if applicable.

6. The Inspection and Test Plan shall identify Contractor and SEPTA hold points. SEPTA hold points will be established when the Inspection and Test Plan is submitted.

7. The Inspection and Test Plan shall identify all First Article Inspections located at the Contractor's plants.

CDRL 22-03 Quality Assurance Manuals:

1. Quality Assurance Manual for the Contractor and each sub-supplier must be submitted and approved by SEPTA before each entity begins physical work.

2. Submit an MRB procedure as part of the Quality Assurance Manual.

CDRL 22-04 Subcontractor/Supplier List:

1. Submit a Subcontractors/Supplier List containing the name, scope of work, address, contact person, and contact information for each subcontracted supplier.

CDRL 22-05 MRB Documentation:

1. Submit all recommendations for "repair" and "use as is" for nonconforming material.

CDRL 22-06 Sampling Plan:

1. The Sampling Plan shall be available at the PDR.
2. Results shall be summarized by part number quarterly.

CDRL 22-07 Statistical Quality Control Inspection List:

1. Submit a list of parts and materials to be inspected by SQC.

CDRL 22-08 FAI Packages:

1. Submit minimum 14 days before the FAI.
2. Include the following detail:
    a. Detailed schedule and agenda
    b. Vendor
    c. Vendor address
    d. Vendor phone number
    e. Vendor contact
    f. Component list with latest drawing list and status
    g. Version level and serialization list when applicable
    h. All material and component certifications
    i. All design, modification, and workmanship open items
    j. The Contractor's Pre FAI report
    k. Contractor's report regarding all contractual business procurement requirements for that vendor.

CDRL 22-09 Audit Checklists and Reports:

1. Audits shall report on the degree of compliance with the Approved QA Program Plan in TS 22.1.2.2, and QA procedures specified in TS 22.1.2.16.

22.4 Referenced Standards

The following standards are referenced in this Section:

ANSI/ASQ Z1.9	Sampling Procedures and Tables for Inspection by Variables for Percent Nonconforming
ISO 9001	Quality Management Systems - Requirements

FTA-PA-27-5194-12.1	Federal Transit Administration Quality Management System Guidelines

SECTION 23
SYSTEM SAFETY AND SECURITY

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23.1 System Safety Program

23.1.1 General

A. Safety shall be of primary importance in the design of the car. The car shall present a safe, hazard-free environment to the public, passengers, guide animals, train crew and maintenance personnel to the greatest extent practical.

1. Comply with all applicable Title 29 OSHA regulations (e.g., 1910, 1926) and respective consensus standards incorporated by reference (1910.6).

2. Conduct a safety program that ensures, to the greatest extent possible, that the cars delivered to SEPTA are operationally safe for passengers, employees, emergency responders, and the general public.

3. The Contractor's System Safety Program shall support SEPTA's Safety and Security Certification Program efforts.

4. The system safety program shall ensure the following:

a. Safety, consistent with system operating requirements, is designed into the system in a timely, cost-effective manner.

b. Hazards are identified, evaluated, and eliminated; or the associated risk is reduced to a level acceptable to SEPTA throughout the entire life cycle of a system.

c. In considering system hazards during the design process, account is taken of human limitations as a design constraint. Design for human engineering shall comply with MIL-STD-1472.

d. Historical safety data, including lessons learned from other systems, are considered and used.

e. Minimum risk is sought in accepting and using new designs, materials, and production and test techniques.

f. Actions taken to eliminate hazards or reduce risk to a level acceptable to SEPTA are documented.

g. Retrofit actions are minimized.

h. Changes in design, configuration, or mission requirements are accomplished in a manner that maintains a risk level acceptable to SEPTA.

i. Consideration is given to safety and ease of disposal of hazardous materials associated with the system, if any.

j. Hazards identified after production are minimized consistent with program restraints.

k. Passage through the car shall be easy and safe.

l. No sharp edges or corners or pinch points shall occur where passengers, crew, or maintenance personnel may come into contact with them.

m. Adequate handholds shall be provided throughout the car.

n. The Operator's cab shall be designed to minimize injury from Operator impact against cab surfaces in a collision by use of smooth surfaces and avoidance of protrusions.

o. Passengers and crew shall not be exposed to tripping hazards, any electrical voltage, toxic materials, abrupt or unexpected accelerations, or similar hazards.

p. Any decals, signage, graphics, and warnings shall comply with Section 14, Interior and Exterior Appointments.

q. Location, illumination levels, colors, graphics, and surface finishes shall be selected to maximize visibility of door thresholds, windscreens, controls, and other objects with which the passengers and crew must interface.

r. Normal and emergency equipment and controls which the passenger or crew may operate shall be clearly identified, and operating procedures shall be presented in both text and graphic formats.

s. Passenger emergency signs shall also be embossed in Braille raised typeface.

t. Exposure of maintenance personnel to lethal or injurious voltages shall be minimized through compartmentalization, interlocks, and similar measures.

u. All equipment enclosures containing hazardous materials, lethal or injurious voltages, or other risks shall be clearly labeled on both the outside and inside of the equipment enclosures.

v. Power capacitors shall self-discharge in accordance with Section 16, Materials and Workmanship.

w. Protection shall be provided against failures, including software failures, which could cause an unsafe condition such that two or more sequential failures will be required for such condition to occur. The first such failure shall not result in an unsafe condition and shall energize an alarm.

23.1.2 Safety Program Manager

A. Designate a Safety Program Manager (SPM), to be Approved, for carrying out the Contractor's System Safety Program, and to serve as a point of contact to SEPTA.

1. The Contractor's SPM shall also serve on the committee established by SEPTA to carry out safety and security certification program activities.

2. Responsibilities of the Contractor's SPM include the following:

    a. Ensuring adequate Contractor resources (technical and financial) are available to support SEPTA's requirements for system safety described in the Specifications.

    b. Supporting the timely delivery of system safety CDRLs and deliverables.

    c. Interfacing with design, manufacturing, testing, and purchasing departments; verifying performance and proposing modifications and corrective actions that address safety issues.

    d. Analyzing safety performance of systems and comparing results with Contractual requirements.

    e. Furnishing technical support for safety and security related issues to design, manufacturing, testing, and purchasing personnel.

    f. Reporting on the status and progress of Contractor system safety program activities during Safety and Security Certification Committee meetings.

    g. Attending all Safety and Security Certification Committee meetings and providing essential input to resolve safety and security critical issues.

    h. Ensuring attendance of other Contractor personnel to Safety and Security Certification Committee meetings to provide technical expertise on an as-needed basis.

3. The Contractor shall seek approval for all software that is used to perform safety analyses. All analyses files and documents shall be submitted with the required documentation or shall be provided to SEPTA upon request.

23.1.3 System Safety Program Plan

A. Submit a System Safety Program Plan. **(CDRL 23-01, System Safety Program Plan (SSPP))**

1. The SSPP shall demonstrate that the Contractor has a clear understanding of the system safety requirements and has an organization in place capable of identifying safety hazards and performing analyses to verify that they have been eliminated or adequately mitigated.

2. The SSPP shall conform to the guidelines and requirements of 49 CFR Part 229 for Federal regulations that prescribe minimum safety standards for locomotives, 49 CFR Part 238 - Subpart B, the latest issue of the American Public Transportation Association Manual for the Development of System

Safety Program Plans for Commuter Railroads, and also of Military Specification MIL-STD-882C - Section 4 and all tasks within Sections 100 and 200 of that document.

3. The SSPP shall identify all hazards related to the car and shall impose design requirements and management controls, in addition to those identified in this Specification, to prevent mishaps by eliminating hazards or reducing risk to levels acceptable to SEPTA. The formats for reports, listings, analyses, and other required submittals shall be jointly determined between SEPTA and the Contractor.

4. The SSPP shall also address the Safety Certification Process and how Safety Certification will be achieved and maintained for the project's duration. If, after Safety Certification is obtained, there is a substantive design change the car builder shall be required to confirm that the certification is still valid by updating any applicable Safety analyses or by providing written confirmation to SEPTA that no change is required.

5. Hazards shall be resolved according to the precedence rules listed in Paragraph 4.4 in MIL-STD-882, with the restriction that hazards with Category I and II severity (as defined in MIL-STD-882) shall be resolved only by Methods 4.4.1 or 4.4.2 of that paragraph, and as mandated by this Specification.

B. The general safety design requirements of Paragraph 4.3 in MIL-STD-882, and the guidelines listed below, shall be incorporated into the design of all car systems affecting safety:

1. Only components with high reliability and which have been proven in conditions similar to the projected service shall be utilized.

2. All devices not guaranteed fail-safe shall be assumed capable of failing in permissive modes.

3. All electronic circuits and software shall be assumed capable of failing in permissive modes.

4. Systems shall be based on closed-circuit principles in which energized circuits result in permissive conditions, while interrupted or de-energized circuits result in restrictive conditions.

5. All vital circuits not wholly within the system apparatus enclosure shall be double-wire and double-break, with the exception of connections to non-vital circuits, which may be single-wire and single-break.

6. Any component or wire becoming grounded shall not cause a permissive condition. Safety circuits shall be kept free of any combination of grounds that will permit a flow of current equal to, or in excess of, 50 percent of the release value of any safety device in the circuit.

7. Circuit impedances, signal encoding, shielding, layout and isolation shall be selected to minimize the effects of interference to the extent that safety is maintained under all conditions.

8. Commands that result in permissive conditions shall be propagated by no less than two independent signals, both of which must be present before the permissive condition can occur. The lack of either signal shall be interpreted as a restrictive command.

9. Systems controlled by variable level signals shall be arranged such that minimum signal levels, or out of range signal levels, results in the most restrictive condition. At least one enabling signal, however, independent from the variable control signal, shall be present before the control signal can modulate the system to a more permissive level.

10. Circuit breakers and fuses shall be guaranteed by the manufacturer to successfully interrupt rated currents. Circuit breakers and fuses shall be applied such that the maximum circuit fault currents cannot exceed the manufacturer's guaranteed operating ranges.

11. Systems that rely on structural integrity for safety shall have sufficient safety factors such that failures are not possible within the life of the car under all possible conditions.

12. Systems subject to wear shall not wear to permissive states within a period no less than three times the overhaul period under the worst-case combination of duty cycle, environment, and all other influences. Such devices shall be clearly indicated as SAFETY CRITICAL in the maintenance manuals.

13. Mechanical systems which apply force to achieve safe states shall not depend upon the application of fluid pressure or electrical energy, unless specifically Approved.

14. All locks, catches, and similar devices affecting safety shall be either self-engaging without application of power, or, if engaged by application of power, shall remain fully and safely engaged in the absence of power.

15. All systems shall function safely under all combinations of supply voltages, fluid pressures, shock, vibration, dirt accumulation, and the SEPTA Railroad Division's environment.

16. All safety-related systems, and devices within those systems, shall be clearly identified as SAFETY CRITICAL in all maintenance manuals, procedures, and training materials.

23.1.4 Failure Induced Hazards

A. All car equipment and systems shall be designed and constructed to revert to safe modes under failure conditions. The Contractor shall employ high quality components, proven systems, redundancy, checking devices, and other techniques to

accomplish this goal. Systems whose failure could result in hazards of Category I or II severity (as defined in MIL-STD-882) shall conform to both of the following design principles:

1. The failure of a single device shall not result in a permissive condition. For certain pneumatic devices, the acceptable permissive conditions created by device failures are described in this Specification; and

2. An undetected failure of any device shall not permit a subsequent device failure to result in a permissive condition.

3. All systems shall conform to the safety design principles by one or both of the following methods:

4. The utilization of fail-safe devices, that is, devices with known, guaranteed by the manufacturer failure modes, such as signal grade relays; and/or

5. Independent channels with independent checking of each. All channels shall indicate a permissive state in order that the controlled system achieves a permissive state. Failure in any channel shall not affect any other channel or force the system into a permissive state. Lack of correspondence between channels shall be alarmed and shall force a restrictive state on the system. As information, checking equipment invariably requires devices conforming to this method.

B. Failures in equipment which result in an indication of danger, whether or not actual danger exists, shall be considered to have occurred in a safe manner. Conversely, a failure, which results in the lack of the ability to recognize an unsafe condition, when in fact an unsafe condition may exist, shall not be considered safe.

23.1.5 Software Safety

A. The Contractor shall submit a Software Safety Program Plan **(CDRL 23-02, Software Safety Program Plan (SWSPP))** which applies to any embedded or external software or firmware which controls or monitors safety-critical functions. The requirements for software safety are in addition to the requirements of Section 19, Software Engineering, Section 24, Cybersecurity, and shall meet or exceed the requirements of 49 CFR 238.105 and IEEE Std 1483.

B. It shall be the responsibility of the Contractor to ensure that software is subjected to these requirements continuously through the evolution of the program, including any software revisions made by the Contractor up to and including the passage of the last vehicle out of warranty.

C. It shall be the responsibility of the Contractor to ensure that sub suppliers comply with all software safety requirements.

D. A Software Configuration Item (SCI) shall be considered safety critical if it contains vital or safety related software functions unless an independent redundant hardware

means is also provided to accomplish the same functions and the hardware/software design has been analyzed and proven to be fail-safe.

E. Features of the software safety program shall include a description of how the following shall be accomplished at each stage of the design and testing process for components, subsystems, systems, cars, consists and trains incorporating software for safety-critical functions.

1. Definition, implementation, and oversight of the software design and verification process

2. Integrity of the documentation

3. Software hazard analysis

4. Software safety reviews

5. Software hazard monitoring

6. Reporting and tracking

7. Software integration with hardware

23.1.6 Sneak Circuit Analysis (SCA)

A. Perform an SCA for safety critical functions to identify inherent design flaws that may cause occurrence of an unwanted function or the inhibition of a desired function by evaluating unexpected current paths, timing, labels, and indicators that may exist in the design.

1. The analysis shall consider the following sneak conditions:

a. Sneak paths: Unexpected paths along which current, energy or logical sequence flows in an unintended direction.

b. Sneak timing: Events occurring in an unexpected or conflicting sequence.

c. Sneak indications: Ambiguous or false displays of system operating conditions that may cause the system or Operator to take an undesired action.

d. Sneak labels: Incorrect or imprecise labeling of system functions (e.g., system inputs, controls, displays and buses) that may cause an Operator to apply an incorrect stimulus to the system.

2. Identify and evaluate all potential unwanted functions or potentially inhibited functions, in the absence of or concurrent with component failure.

3. For each sneak condition identified, redesign the system to eliminate the condition.

4. The SCA shall be performed according to a Capability Level 3 or above SCA process, in accordance with AIAA S-102.2.5.

5. The use of diodes to eliminate sneak paths is prohibited.

6. Submit an SCA Report **(CDRL 23-03 Sneak Circuit Analysis Report)**.

23.1.7 Potentially Hazardous Electromagnetic (EM) Fields

A. Submit an Electromagnetic Field (EMF) Hazard Control Plan. **(CDRL 23-04, Electromagnetic Field (EMF) Hazard Control Plan)**

1. The car shall not produce any health hazard to the public, passengers, guide animals, train crew or maintenance personnel. In this regard, the Contractor shall develop an Electromagnetic Field (EMF) Hazard Control Plan which shall define all efforts from the initial car design phase to control/mitigate any potentially adverse EMF health hazard effects in accordance with EN50155.

2. The methodology used shall be based on sound systems engineering principles and shall include analysis and measurements as necessary. It shall define acceptable worst-case exposure levels and applicable frequency ranges of interest, including conductive, inductive, and radiated emissions based on the car design and application.

3. Analysis and measurement data from similar applications shall be utilized to the maximum extent possible.

4. Recommendations and guidelines of applicable reports, and standard test procedures/limits shall be referenced including those of the EPA, FRA, and IEEE.

23.1.8 Human Error

A. The Contractor shall use MIL-STD-882 and MIL-STD-1472 as guidelines for car design.

B. All systems shall minimize unsafe conditions resulting from human error.

C. No sequence of operations, or the simultaneous activation of any controls, shall result in unsafe conditions. Where conflicting commands, such as simultaneous power and brake, are requested, the more restrictive shall result.

D. Maintenance of safety-related equipment shall be arranged such that the effects of errors are minimized.

Methods such as limitation of adjustment ranges, unalterable software, non-interchangeable parts, and visible wear indicators shall be employed.

23.1.9 System Safety/Hazard Resolution Process

A. The Contractor's approach to system safety shall minimize system risks due to hazards within the constraints of cost, schedule, design requirements, and system effectiveness.

1. The fundamental objective of the system safety process shall be to identify, eliminate or control, and document system hazards throughout the system life cycle.

2. Consideration shall be given to systems, system interfaces, and interrelationships with such factors as facilities, support equipment, operational procedures and environments, and maintenance programs.

3. The system safety process shall be a systematic approach to safety program management, consisting of the following:

    a. Defining the physical and functional characteristics of the system.

    b. Identifying and documenting identified hazards.

    c. Assessing identified hazards to determine severity and probability.

    d. Resolving hazards by implementing corrective action.

    e. Following up to monitor for effectiveness of the hazard resolution effort and to monitor for unexpected results.

B. The above shall be accomplished by applying the following techniques and methodologies.

23.1.10 Preliminary Hazard List

A. Submit a Preliminary Hazard List. (**CDRL 23-05, Preliminary Hazard List (PHL))**

1. The PHL shall be the initial document for the safety analysis and will be developed into the Preliminary Hazard Analysis (PHA) and ultimately the Hazard Tracking Log (HTL).

2. The Contractor shall identify all failure-induced and normal operating (non-failure condition) hazards falling into severity Categories I, II, III and IV (as defined in MIL-STD-882).

3. The following hazards, at a minimum, shall be included in the listings and shall be considered hazards of Category I or II severity:

    a. Emergency brakes fail to apply when requested;

    b. Failure of Emergency Lights;

    c. Service brakes fail to apply when requested;

    d. Propulsion fails to cease when requested;

    e. No-motion detection system indicates no-motion when train is moving;

    f. Door opens spontaneously when not commanded;

g. Door opens on wrong side of car;

h. Door closes on person's limb and indicates door closed and locked to the control system;

i. Door interlocks erroneously indicate door is closed and locked;

j. Excessive currents or overheated equipment cause fire hazard;

k. False uncoupled indication;

l. False coupled indication;

m. Train moves in wrong direction;

n. Slide control does not reapply brakes after slide correction;

o. Cars in train separate when not commanded; and

p. Train regenerates into dead section of catenary.

B. The Contractor shall perform a hazard analysis on all hazards identified in the Hazard Lists. Analyses shall demonstrate that the car conforms to the requirements of this Technical Specification and that all identified hazards are either eliminated or reduced to levels of risk acceptable to SEPTA. All hazard analyses shall be adjusted or amended as required during car design and construction.

C. The analysis methods shall be selected by the Contractor as appropriate for the system under evaluation and the category of hazard severity. Hazards of Category I and II severity shall receive analyses sufficiently rigorous to demonstrate that the hazard cannot occur under any reasonable conditions. The Contractor shall be prepared to demonstrate, by test, the validity of any portion of all analyses of Category I or II severity hazards.

D. Standard failure and safety analysis methods, and published failure rates for components, shall be utilized wherever possible. All electrical circuit failure mode analyses shall include a sneak circuit and dry contact analysis. All methods shall be submitted for review and Approval.

E. Existing hazard analyses of subsystems may be submitted provided the analyzed subsystem is identical in all respects to that proposed, including the operating environment, and the analysis method is sufficiently rigorous.

F. Analyses or tests required by other sections of this Specification, such as structural analyses or fire penetration tests, may also be submitted for consideration by SEPTA where appropriate. Analyses shall examine the car in the married pair and train consist configurations.

G. Use the following hazard identification methods to identify the energy sources, hazardous operations, procedures, and potential accidents that may result in injury to personnel or damage to equipment or facilities:

a. Review the Contract Specifications and design information

b. Review SEPTA procedures and manuals

c. Draw on expertise in the specific areas (such as propulsion, brakes, PTC, etc.)

d. Review lessons learned

e. Analyze similar cars or facilities

f. Analyze available technical data

g. Review energy sources

h. Review the Project Management Plan

2. Alone, any of these methods will identify some hazards, but a logical completion of all or a combination of these steps will result in the development of a more thorough PHL.

3. Once the PHL is completed, use it to help determine what hazards exist in the system or facility. The PHL shall provide input for the PHA.

23.1.11 Preliminary Hazard Analysis

A. Submit a Preliminary Hazard Analysis. (**CDRL 23-06, Preliminary Hazard Analysis (PHA))**

B. The Preliminary Hazard Analysis is built upon the Preliminary Hazard List; however, this analysis shall be more detailed and shall be the basis for the HTL.

1. The term "Preliminary" relates to the stage when the PHA is produced within the project. Prepare a PHA prior to Preliminary Design Review (PDR).

2. The PHA shall provide useful safety input for the decision-making process used in trade-off studies, design criteria, and operational goals.

3. Apply a structured and systematic process to perform the PHA. Details of the methodology shall be provided in the SSPP.

4. Identify previously unidentified hazards associated with the integrated system design, including software and subsystem interfaces.

5. Recommend actions necessary to eliminate identified hazards or mitigate their associated risks.

6. Address all project-developed equipment, commercial equipment, non-developmental items, and software. Areas to consider include system performance, performance degradation, timing errors, design errors or defects, and inadvertent functioning.

23.1.12 Hazard Tracking Log

A. The PHA shall form the basis for the Hazard Tracking Log (HTL), which shall serve as the primary tools used by the Safety and Security Certification Committee to track identified hazards and their recommended closure actions during the program.

1. Submit a Hazard Tracking Log **(CDRL 23-07, Hazard Tracking Log (HTL))** in accordance with MIL-STD-882**.**

a. The HTL, developed and maintained by the Contractor's SPM, shall initially be populated with the hazards identified during the PHA. All subsequent hazards identified shall be documented in the HTL.

b. At a minimum, the HTL shall be updated monthly by the Contractor's SPM. SEPTA may request the Contractor's SPM to submit an updated version of the HTL at any time during the program.

c. The potential hazards identified in the PHA, and later the HTL, shall be organized by types of hazards, by systems, and shall be subdivided into subsystems when the subdividing is beneficial for hazard management.

d. The potential hazards identified in the FMECA, and Operational and Support Hazard Analysis (O&SHA) documents shall also be entered into the HTL for tracking and closure. A separate and unique identifier shall be used in the HTL to track the origin of the potential hazard. If a hazard is caused by multiple causes/factors, each cause should be documented as a separate entry in the HTL.

23.1.13 Failure Modes, Effects and Criticality Analyses

A. Submit a Failure Modes, Effects and Criticality Analysis for all components on the vehicle down to line replaceable unit (LRU) or lowest line replaceable unit (LLRU) level, as applicable, unless otherwise approved. (**CDRL 23-08, Failure Modes, Effects, and Criticality Analyses (FMECA))**

1. The FMECAs developed by the Contractor and subsystem suppliers shall use a MIL-STD-1629 or another standard format. The template shall be submitted for Approval.

2. The FMECA shall be considered a concurrent part of the system design process and shall be started early in the design effort.

3. The FMECA shall include the following information at a minimum:

a. A complete system overview including schematics

b. A complete list of LRUs and LLRUs that will be analyzed

c. Identification of single-point failures, failure effects on both safety and service reliability

4. The analysis shall assume that each single item failure, as its effects are analyzed, is to be considered the only failure in the system.

   a. Where a single item failure is non-detectable, the analysis shall be extended to determine if the effects of a second failure, which in combination with the first undetectable failure, could result in a Catastrophic or Critical failure condition.

   b. The double failures scenario shall be transferred to other safety analysis or Hazard Tracking Log where further assessment on the probability and risk shall be conducted.

5. The FMECA shall consider circuits needed to establish the controlling cab and provide the interface with all other car systems, such as doors, annunciators, couplers, etc. Such circuits shall be carefully designed for safety, reliability and simplicity as they can contain single-point failures that are capable of incapacitating a cab or a consist. The Contractor shall treat them as a subsystem worthy of special attention and, as the design evolves, treat the need to operate from other a car other than the lead cab of the consist as potentially hazardous and as a solution of last resort. Specifically, the FMECA shall consider:

   a. An analysis of potential failures, their operational importance, and how they will be annunciated to the Operator.

   b. Explanation of how each of the identified failures can be overcome by the train crew, i.e., what provisions have been incorporated in the design for reestablishing car operability.

   c. Explanation of how the recommended troubleshooting procedures, test equipment supplied and features of the basic circuit design will direct the attention of maintenance personnel to the point of failure.

6. The FMECA shall be updated throughout car design, development, and commissioning to address design changes and failure mode issues identified throughout the development lifecycle of the car.

7. The FMECA shall consider all operating conditions and scenarios specified in Section 2, Design and Performance Criteria.

23.1.14 Operating and Support Hazard Analysis

A. Perform and submit an Operating and Support Hazard Analysis to identify and assess hazards introduced during system operation, maintenance, and support activities. **(CDRL 23-09, Operating and Support Hazard Analysis (O&SHA))**

B. At a minimum, the analysis shall consider:

1. Hazards associated with personnel and procedures during operations, maintenance, and emergencies.

2. Human interface during the on-car, off-car and facility-level support activities.

   a. Many hazards identified in other safety analyses (PHA, SHA, SSHA, FMECA, FTA) result in an inspection or preventive maintenance task to mitigate the hazard effect of a component malfunction. These activities involve human and equipment interactions during the performance of maintenance tasks, including the use of tools and test equipment, maintenance procedures, facilities, personal protective equipment (PPE), shipping and handling, storage, and disposal. If the risk associated with human interface is not fully addressed in these safety analyses, it shall be further analyzed in the O&SHA.

   b. The human shall be considered an element of the total system in the analysis, receiving inputs, and initiating outputs.

3. During the O&SHA, consider operations and maintenance tasks against the following six human engineering factors:

   a. Task Complexity: The complexity of manual activities involved in operating, maintaining, and supporting the component or subsystem.

   b. System Criticality: Whether a component or subsystem is critical for operations, controlling risks, or is involved in single point failures.

   c. Task Frequency: The frequency with which people need to interact with the component or subsystem.

   d. New Technology: The novelty of the component or subsystem; whether it will require the workforce to gain new knowledge or skills; or will introduce new procedures, work practices, or organizational structures.

   e. Design Scope: The status of design at the time of the screening.

   f. Known Problems: Known issues with similar equipment, or areas of concern to operations or maintenance.

4. The O&SHA shall consider the context in which Operators and maintainers work, including:

   a. Workplace stressors

   b. Communication issue.

   c. Difficulties inherent in task performance arising from equipment design or layout

d. Competing priorities

e. Operator workload.

23.1.15 Fault Tree Analyses

A. Perform and submit Fault Tree Analysis (FTA) to have a quantitative assessment of high-severity or high-risk events. (**CDRL 23-10, Fault Tree Analyses (FTA))**

1. The FTAs shall quantify the probability of each hazard with Category I or II severity, or with Hazard Risk Index 1 or 2 risk as identified in the PHA/ OSHA/HTL.

2. The FTAs shall consider all interfacing items, which in conjunction with the analyzed system, can lead to the occurrence of the identified hazard.

3. FTAs shall integrate all contributing factors from systems and subsystems.

23.1.16 Hazard Assessment

23.1.16.1 Hazard Severity

A. Please refer to MIL-STD-882 for the hazard severity categories to be applied to all identified hazards.

23.1.16.2 Hazard Probability

A. The probability for all identified hazards shall be in accordance with the guidelines specified in MIL-STD-882.

23.1.16.3 Hazard Risk Index

A. The Hazard Risk Index (HRI) Matrix defines risk level derived by considering both the severity and the probability of a hazard. The HRI shall be used to prioritize resources to resolve risks due to hazards and to standardize hazard notification or response actions.

B. The HRI values are shown in MIL-STD-882. The HRI presents hazard analysis data in a format that provides clear, concise information to enable decisions regarding whether hazards should be eliminated, controlled, or accepted. This process provides the basis for logical management decision-making, considering both the severity and probability of a hazard.

23.1.17 General Safety Design Criteria

A. Criteria for system design, for equipment with safety-critical characteristics, and for operational procedures shall ensure that system safety objectives are implemented throughout design development, testing, delivery, operations, and maintenance.

B. Incorporate the following criteria as a minimum:

1. No single-point failure shall result in a hazard with a Hazard Risk Index of 1 or 2. Whenever possible, design all systems to prevent single-point failures from negating the ability of such systems to perform safely as intended.

2. Without a specific waiver, no warning, caution, or other form of written advisory shall be used as the only risk reduction method for a hazard with a Hazard Risk Index of 1 or 2.

3. Car design shall include component interlocks wherever an out-of-sequence operation can result in a hazard with a Hazard Risk Index of 1 or 2.

4. Clearly identify emergency equipment for public use and design to be accessible per NFPA 130, and 49 CFR 37 and 38, as applicable.

5. Design access control and alarm systems to minimize the potential for unauthorized access or inadvertent changes to equipment.

23.1.18 Fail-Safe Design Requirements

A. Design all safety-critical applications to be fail-safe. The Contractor may propose equivalent methods with substantiation for approval. Safety-critical application means failure of the application may result in Catastrophic or Critical hazards.

1. Fail-safe equipment proposed for this Contract shall be proven by in-service experience or made available for type acceptance testing.

2. Fail-safe circuits shall be based on closed-loop principles, e.g., broken wires, damaged or dirty contacts, a relay failing to respond when energized, or a loss of power supply energy shall not result in unsafe conditions.

3. Design all equipment, circuits, material, and designs so that faults and malfunctions are self-revealing, if not in the course of normal operation, then by special means.

4. Self-detecting component or subsystem failures that adversely affect the safe operation of the train shall cause the train to stop or run at a safer, more restricted speed than that permitted with no failure.

5. If an alternative is proposed for a specified subsystem, or for its components, whose function affects the safety of train operation and because of its magnitude and integration parameters precludes absolute fail-safe engineering analysis, the following conditions shall apply:

a. SEPTA will require definitive factory and field tests and documentation of research and development tests, prior to granting approval of the alternative.

b. The acceptance of such an alternative subsystem does not preclude the requirement for further factory tests and field tests to determine that

the alternate subsystem, in actual operation, achieves equivalent level of safety as fail-safe design.

c. If the alternative subsystem fails to achieve the above-mentioned equivalent level of safety, the Contractor shall remedy the design and provide subsystem or component at no additional cost to SEPTA.

23.2 Flammability, Smoke Emission, and Toxicity Testing Requirements

23.2.1 General

A. All combustible materials used in the construction of the car shall meet the requirements of 49 CFR Part 238 and NFPA 130. In addition, conduct a fire hazard analysis of the car in accordance with the guidelines of NFPA 130, Annex E, Fire Hazard Analysis Process, and APTA PR-PS-RP-005-00.

B. All car components, subsystems and systems shall be designed for the prevention of fire and for the protection of the public, employees and emergency response personnel from injury due to fire, smoke, explosion or panic due to fire and for the protection of the system elements from damage by fire or explosion.

C. Design shall provide for equipment to be located outside of the cab and passenger areas whenever practical to isolate potential ignition sources from combustible materials. The floor shall be designed to prevent propagation of an underfloor fire to the car. Fire stops shall be provided at floor and roof penetrations. Enclosures for control and other critical equipment shall be located to provide protection against environmental contamination and mechanical damage.

D. The purpose of the Fire Hazard Analysis (FHA) is to provide a reasonable understanding of the fire performance of car materials and assemblies in the context of actual use and identify hazards.

1. To be complete, the FHA shall be part of a systems approach to reducing/ mitigating risk of personal injuries from other passenger car fire hazards and consider fire containment, fire detection and extinguishment, passenger and crew emergency evacuation, and access by emergency responders.

2. Submit a Fire Hazard Analysis. **(CDRL 23-11, Fire Hazard Analysis (FHA))**

3. Document all hazards identified during the FHA in the Hazard Tracking Log according to the particular subsystem in which the risk is posed and track until closure.

23.2.2 Material Testing Requirements and Matrix

A. Comply with the following:

1. Approved, independent laboratory test results are required indicating successful compliance with the specified flammability, smoke emission, and

toxicity (FST) test procedures and performance criteria for all applicable combustible materials.

a. Combustible materials not required to be tested are specified in TS 23.2.4.

b. Test reports older than five years at the date of Notice-To-Proceed are not acceptable. The Contractor shall re-submit the material for FST testing or shall provide the older test reports and a signed letter from the material manufacturer to confirm that the material composition has not changed, as approved.

c. Conform to these test procedures and performance criteria and ensure conformance by subcontractors and suppliers.

d. FST testing procedures and performance criteria are specified in TS 23.2.6, and TS 23.2.7.

e. Select an industry-accepted test method for determining the heating value and peak heat release rate material properties. The selected test method(s) shall be subject to review and approval.

2. Design the car to minimize its total combustible material content.

a. Assign to each combustible material required to be tested, including those requested for waiver or deviation from the Specifications, an FST Index Number. Include the FST Index Number on all correspondence regarding a specific material in order to track materials throughout the testing and approval process.

b. Submit an FST Matrix. (**CDRL 23-12, Flammability, Smoke Emission, and Toxicity Test Matrix)**

23.2.3 Materials Exempt from Testing Requirements

A. Certain materials and parts will be exempt from FST testing requirements, as approved:

1. Materials used to fabricate miscellaneous, discontinuous small parts that will not contribute materially to fire growth in end-use configuration shall be exempt from FST testing requirements.

2. Exempt parts shall be less than 16 in^2 (103 cm^2) in surface area in end-use configuration and may include, but are not limited to, the following:

a. Knobs

b. Rollers

c. Fasteners

d. Clips

e. Grommets

f. Small electrical parts

3. Perform a fire hazard analysis for exempt parts**.**

4. Combustible operational and safety signage shall not be required to meet FST requirements if the combustible mass of a single sign does not exceed 1.1 lbs. (500 g) and the cumulative area of combustible signage does not exceed 1 ft^2/ft (0.3 m^2/m) of car length.

5. Exempt parts shall not contribute to an unacceptable hazard; otherwise, make the necessary modifications to eliminate, control, or reduce the hazard to an acceptable level.

23.2.4 Materials Requested for Waiver or Deviation

A. The Contractor may request a waiver from material testing requirements or a deviation from the Specifications for materials or parts that do not meet the exemption criteria. Furnish previous FST test reports available for the material.

1. Submit the request for waiver in writing and include the following:

a. FST Index Number

b. Material Supplier

c. Material Description (trade name and specific formulation)

d. Location, including Photographs

e. Material Weight per Location (less any noncombustible material)

f. Material Total Surface Area per Location

g. Reason for Waiver/Deviation Request

h. Contractor's Justification for Waiver/Deviation

2. For materials for which a waiver/deviation is requested, perform fire hazard analysis**.**

3. Materials requested for waiver shall not contribute to an unacceptable hazard; otherwise, make the necessary modification to eliminate the hazard or reduce the hazard to an acceptable level.

23.2.5 Flammability and Smoke Emission Test Procedures and Performance Criteria

A. Test the materials used in cars to demonstrate compliance with the requirements of this Section.

1. Furnish test procedures and results in accordance with the requirements of TS 23.2.3.

2. Follow the test procedures and meet the performance criteria for flammability and smoke emission testing in NFPA 130, Chapter 8, Vehicles, Table 8.4.1, Fire Test Procedures and Performance Criteria for Materials and Assemblies.

23.2.6 Toxicity Test Procedures and Performance Criteria

A. Comply with the following:

1. Materials and products that have highly toxic products of combustion are prohibited.

2. Test combustible materials for toxicity using BSS 7239, or SMP-800C, except those identified as exempt in TS 23.2.4.

3. The tests shall be run in the flaming mode after 240 seconds using the NBS Smoke Density Chamber for sample combustion. The gas sampling may be conducted during the smoke density test. The test report shall indicate the maximum concentration (ppm) for each of the gases listed in BSS 7239 at the specified sampling time.

23.2.7 Floor Assembly Fire Resistance Testing Criteria

A. For specific test requirements and pass/fail criteria, see the floor assembly fire resistance test in the Component Design Qualification Tests section of Section 15, Test Program.

23.2.8 Electrical Fire Safety

A. Except when otherwise approved or where more restrictive requirements are imposed by the Specifications, electrical equipment shall conform to NFPA 130, Section 8.6, Electrical Fire Safety.

23.3 Security Program

23.3.1 General

A. In order to protect all data and maintain system integrity, implement multilevel security provisions, including both physical threats and the cybersecurity threats discussed in Section 24, Cybersecurity:

1. These include data access limitation by password and permission, maintenance of audit controls, and security violation reporting, etc.

2. In addition to network authentication, security shall be administered accordingly at the application, database, module, screen, data field, and transaction level.

3. Passwords shall be used to control access, authenticate valid users, and protect against unauthorized use. Designated SEPTA staff will control password and access rights, authorizations, and any security requirements. The Contractor is responsible for technical aspects of security administration within the application.

23.3.2 System Security Program Plan

A. Submit a System Security Program Plan. (**CDRL 23-13, System Security Program Plan (SSePP))**

1. The SSePP shall demonstrate that the Contractor has a clear understanding of the system security requirements and has an organization in place capable of identifying security threats and vulnerabilities, including both physical threats and the cybersecurity threats discussed in Section 24, Cybersecurity, and performing analyses and tests to verify that they have been eliminated or adequately mitigated.

23.3.3 Threat and Vulnerability Assessment

A. Identify all security risks related to the car and submit a Threat and Vulnerability Assessment. **(CDRL 23-14, Vehicle Threat and Vulnerability Assessment)** Consider all potential system vulnerabilities. The report format shall be similar to that of a hazard analysis, and a template of the proposed report format can be submitted for approval. In particular, consider the following at a minimum:

1. Cab security: Access to cab area shall be equipped with approved locks. The cab door shall be equipped with a security view glass of an approved design to allow the Operator to view the area outside of the operating station before opening the door.

2. Train control display (TOD): Entry into maintenance mode and access to Maintenance Screens shall require additional security consisting of the entry of a valid password.

3. Interior Lockers: Provide all lockers with key locks, using SEPTA's standard crew key, to ensure security. See Section 14, Interior and Exterior Appointments, for details.

4. Data confidentiality: Password protect downloading and viewing of recorded video data, car logs, and other stored passenger or car data with different levels of security including, but not limited to, viewing only, viewing and downloading, etc.

5. Cameras shall be installed in cab and passenger area to enable real-time monitoring. Pantograph cameras and forward-facing cameras shall also be installed. See Section 5, Operator's Cab, and Section 13, Communications for detailed requirements on the Video Surveillance System (VSS).

6. Contractor Representatives:

    a. Identify Contractor representatives and issue appropriate identification to them for display while on SEPTA property.

    b. Contractor's on-site personnel shall undergo background checks for security purposes, and SEPTA's safety training prior to access to SEPTA facilities. They shall adhere to all SEPTA rules and regulations.

7. Cybersecurity. See Section 24, Cybersecurity, for details.

8. Security requirements shall apply, both when the car is in revenue service, and when the car is out-of-service for maintenance or storage.

9. Each security vulnerability found shall be directly corrected or have approved compensating controls.

10. Design and implement security measures such that their effect on reliability, availability, and basic system operation is minimized.

23.4 Safety and Security Certification

23.4.1 Safety and Security Certification Committee

A. Contractor and SEPTA representatives shall form a Safety and Security Certification Committee (SSCC) during the conceptual design phase of the program.

1. The SSCC shall meet regularly, beginning when the Conceptual Design Review (CDR) starts, through to the completion of the project. SEPTA reserves the right to specify the frequency of SSCC meetings to enable appropriate review of the design and safety data generated throughout Contract performance.

2. The SSCC shall review all safety and security related data, analyses, and reports, identify areas needing improvement, and propose actions to ensure the successful completion of the Safety and Security certification.

3. The core members of the SSCC shall be the Contractor Safety Program Manager and Security Program Manager, and SEPTA's assigned Safety and Security Representative.

4. The core members shall be supplemented by appropriate personnel from SEPTA, Contractor, and subcontractors, as required, to facilitate a thorough and accurate review of all data.

5. The Contractor shall require the participation of sub-suppliers, if needed, to ensure clear understanding of the problem component/subsystem and to expedite resolution.

23.4.2 Safety and Security Certification Report

A. Submit a comprehensive Safety and Security Certification of the fleet prior to delivering it to SEPTA, prior to the end of the warranty period for the Pilot Cars and prior to the fleet being placed in revenue service. **(CDRL 23-15, Safety and Security Certification Report)**

1. Conduct the safety and security certification in accordance with the guidelines in FTA MA-90-5006-02-01 and 49 CFR Part 270.

2. The Safety and Security Certification shall ensure that all known hazards have been mitigated to a risk acceptable to SEPTA. List open items from HTL and Vehicle Threat and Vulnerability Assessment and restrictions in operation, if any, and include in the Safety and Security Certification.

3. Update the Safety and Security Certification until all items are closed.

23.4.3 Safety and Security Progress Reports

A. Submit comprehensive Safety and Security Progress Reports on a quarterly basis. **(CDRL 23-16, Safety and Security Progress Reports)**

1. Describe Safety and Security efforts and related project activities appropriate to inform key stakeholders including the PennDOT SSO.

2. Present efforts on Safety and Security as well as Section 21, Reliability, Availability, and Maintainability as an integrated effort.

3. Provide a graphical representation of the status of document closure and hazard mitigation.

4. Include:

a. Brief description of efforts made to manage each open hazard with an HRI of 1 or 2.

b. New entries in the FMECA (after PDR).

c. High level, updated reliability predictions

d. High level, updated maintainability predictions

e. Status of reliability centered maintenance predictions

23.5 Contract Deliverable Requirements List (CDRL)

The following contract deliverables have been identified in this section; however, the Contractor is responsible for providing and submitting anything necessary to fulfill the requirements of this contract, including those not identified by CDRL number.

CDRL 23-01, System Safety Program Plan (SSPP) 23-3
CDRL 23-02, Software Safety Program Plan (SWSPP) 23-6
CDRL 23-03 Sneak Circuit Analysis Report 23-8
CDRL 23-04, Electromagnetic Field (EMF)Hazard Control Plan 23-8
CDRL 23-05, Preliminary Hazard List (PHL) 23-9
CDRL 23-06, Preliminary Hazard Analysis (PHA) 23-11
CDRL 23-07, Hazard Tracking Log (HTL) 23-12
CDRL 23-08, Failure Modes, Effects, and Criticality Analyses (FMECA) 23-12
CDRL 23-09, Operating and Support Hazard Analysis (O&SHA) 23-13
CDRL 23-10, Fault Tree Analyses (FTA) 23-15
CDRL 23-11, Fire Hazard Analysis (FHA) 23-17
CDRL 23-12, Flammability, Smoke Emission, and Toxicity Test Matrix 23-18
CDRL 23-13, System Security Program Plan (SSePP) 23-21
CDRL 23-14, Vehicle Threat and Vulnerability Assessment 23-21
CDRL 23-15, Safety and Security Certification Report 23-23
CDRL 23-16, Safety and Security Progress Reports 23-23

23.6 CDRL Details

This section lists the expected content for each CDRL required above. The lists, and submission frequency, provided for each CDRL are an outline only and should not be considered exhaustive, all CDRLs are subject to SEPTA review and Approval.

CDRL 23-01 System Safety Program Plan (SSPP):

1. The SSPP shall be submitted 30 days prior to CDR and updated throughout the design process.

2. Describe the planned tasks and activities to be used by the Contractor's SPM to implement the required system safety program.

3. Define activities, management controls, and monitoring processes to be used to ensure that safety considerations, compatible with other system requirements, are incorporated into the design of the cars.

4. The SSPP shall comply with the methodologies of MIL-STD-882. It shall contain the following information as a minimum:

    a. Project description, purpose, and scope.

    b. Specific information showing how the Contractor shall verify attainment of system safety requirements during the design, installation, and test phases.

c. A description of organizational relationships and personnel responsible for system safety. The Contractor's SPM shall have direct access to the Contractor's Program Manager.

d. Detailed listing, description, method of analysis, and schedule of specific system safety tasks, which shall be incorporated into the project master schedule.

e. A description of the procedures for the reporting, recording, and resolution of hazards identified during design, installation, and testing.

f. A description of how the Contractor monitors and controls subcontractors' safety activities.

g. Procedures for the Contractor's SPM and other personnel, as required, to participate in all design reviews, review and approve design changes and top-level drawings, and approve all safety-related elements of the Contract.

h. A description of the hazard identification and elimination/control process.

5. A description of the process by which the Contractor will certify the safety of the cars and major systems. The process shall be in accordance with FTA MA-90-5006-02-01.

6. Submit templates for PHA, HTL, FMECA, SHA & SSHA and O&SHA.

CDRL 23-02 Software Safety Program Plan (SWSPP)

1. The SWSPP shall be submitted 30 days prior to CDR and updated throughout the design process.

2. The SWSPP shall apply to any embedded or external software or firmware which controls or monitors safety-critical functions.

3. The requirements for software safety, which shall be in addition to the requirements of Section 16, Materials and Workmanship.

4. Shall comply with 49 CFR Part 238.105 and standard EN50128.

CDRL 23-03 Sneak Circuit Analysis (SCA)

1. The Sneak Circuit Analysis (SCA) shall be submitted 30 days prior to PDR and 30 days prior to FDR.

2. The analysis shall consider sneak paths, sneak timing, sneak indications, and sneak labels.

3. For each sneak condition identified, redesign the system to eliminate the condition.

4. The analysis shall identify and evaluate all potential unwanted functions or potentially inhibited functions, in the absence of or concurrent with component failure.

5. The SCA shall be performed according to a Capability Level 3 or above SCA process, in accordance with AIAA S-102.2.5.

6. The use of diodes to eliminate sneak paths is prohibited.

CDRL 23-04 Electromagnetic Field (EMF) Hazard Control Plan)

1. The EMF Hazard Control Plan shall be submitted 30 days prior to CDR and 30 days prior to FDR.

2. The EMF Hazard Control Plan shall define all efforts from the initial car design phase to control/mitigate any potentially-adverse EMF health hazard effects in accordance with EN50155.

3. It shall define acceptable worst-case exposure levels and applicable frequency ranges of interest, including conductive, inductive and radiated emissions based on the car design and application.

CDRL 23-05 Preliminary Hazard List (PHL):

1. The PHL shall be submitted 30 days prior to PDR.

2. Initial list of hazards developed by the Contractor at the very start of a program to assess the suspected risks, hazards, and potential mitigations. This list will form the basis for the Preliminary Hazard Analysis (PHA).

3. Identify and list hazards or areas of concern related to people, procedures, equipment, and facilities.

CDRL 23-06 Preliminary Hazard Analysis (PHA):

1. The PHA shall be submitted 30 days prior to PDR, after approval of the PHL.

2. Initial risk assessment performed by the Contractor to identify, assess, and make recommendations on the resolution of potential hazards. This analysis will form the basis for the Hazard Tracking Log.

3. The analysis shall include an assessment of the systems and subsystems, operations, processes, equipment, personnel, environment, and materials.

4. Please refer to the MIL-STD-882 for specific Severity and Probability categories but the PHA shall identify, evaluate, and make recommendations for the elimination, control, or acceptance of hazards that could potentially cause the following:

    a. Loss of life or serious injury.

    b. Serious damage to facilities or equipment resulting in monetary loss, from less than $100K to more than $10M.

    c. Hazards that delay revenue service, force a removal of a car from service or result in the evacuation of the car.

d. Detrimental harm to the environment and the surrounding community.

CDRL 23-07 Hazard Tracking Log:

1. The HTL shall be submitted monthly until the end of the project, after approval of the PHA.

2. Develop from the inputs of the PHA. This document shall serve as the primary tool to identify, assess, and make closure recommendations during the hazard resolution process, recognizing that hazard mitigations are the minimum safety requirements that must be met to ensure safety.

CDRL 23-08 Failure Modes, Effects, and Criticality Analyses:

1. The FMECA shall be submitted 30 days prior to PDR and 30 days prior to FDR.

2. Identify potential subsystem failure modes and their subsequent effects on the entire system. The FMECA shall be performed on LRU or LLRU level, as applicable.

3. The FMECAs developed by the Contractor and systems and subsystem suppliers shall use MIL-STD-1629 (in particular Tasks 101 and 102) as a guideline. Submit a template for the FMECA within the SSPP (CDRL 23-1)**.**

4. Information provided in the FMECA shall include the following:

   a. A system overview including schematics

   b. A complete list of subsystem components, interfaces, and software that will be analyzed

   c. Assessment of the effects of the failure on the system (safety and reliability)

   d. Determination of methods to eliminate or control the identified failure

   e. Identification of single-point failures and hazard-level categorization, which should confirm the adequacy of fail-safe design features.

5. As an element of the FMECA submittal, identify all dormant failures that have the potential to lead to a Category I or II failure. Furnish sufficient evidence to SEPTA to justify the acceptability of the dormant failures.

CDRL 23-09 Operating and Support Hazard Analysis (O&SHA):

1. The O&SHA shall be submitted 30 days prior to PDR and 30 days prior to FDR.

2. Identify potential hazards from the normal operations and maintenance of the equipment.

3. At a minimum, the analysis shall identify the following:

a. Activities involving known hazards; the time periods, approximate frequency, and numbers of personnel involved; and the actions required to minimize risk during these activities.

b. Changes needed in functional or design requirements for system hardware, software, facilities, tooling, or support/test equipment to eliminate hazards or mitigate the associated risks for hazards that could not be eliminated.

c. Requirements for engineered features, devices, and equipment to eliminate hazards or reduce risk.

d. Requirements for PPE, to include its limitations.

e. Warnings, cautions, and special emergency procedures.

f. Requirements for packaging, handling, storage, and transportation to eliminate hazards or reduce risk.

g. Requirements for packaging, handling, storage, transportation, and disposal of hazardous materials and hazardous wastes.

h. Training requirements and processes.

i. Effects of commercial-off-the-shelf and non-developmental item hardware and software across interfaces with other system components or subsystems that affect operation or maintenance.

j. Potentially hazardous system modes under Operator control.

k. Related legacy systems, facilities, and processes which may provide background information relevant to operating and supporting hazard analysis.

CDRL 23-10 Fault Tree Analyses (FTA):

1. The FTA shall be submitted 30 days prior to PDR and 30 days prior to FDR.

2. The FTA shall involve the preparation of a logic diagram, which traces the events or combinations of contributing events which have led to an undesirable occurrence (referred to as the "top event"). Each of the contributing event(s) shall be also considered in turn, together with the subsidiary events involved in those failures.

3. The FTA shall be performed for hazards with Catastrophic or Critical failure consequences, or Hazard Risk Index 1 or 2 risks. FTA is not required for hazards caused by systematic errors/failures such as sharp edge, uneven floor, etc.

4. All data used in the FTA shall provide data source and the data source shall be justified.

CDRL 23-11 Fire Hazard Analysis (FHA):

1. The FHA shall be submitted 30 days prior to PDR and 30 days prior to FDR.

2. Assess the fire performance of car materials and assemblies in the context of actual use.

3. Follow the steps outlined in NFPA 130, Annex E, Table E.3, System of Vehicle Fire Hazard Analysis Steps.

4. Approval of the FHA shall be granted only when all identified fire hazards are eliminated, controlled, or reduced to an acceptable level of risk.

CDRL 23-12 Flammability, Smoke Emission, and Toxicity (FST) Test Matrix:

1. The FST Matrix shall be submitted 30 days prior to PDR and 30 days prior to FDR.

2. Verify that combustible materials required for testing meet the flammability and smoke emission performance criteria of NFPA 130 and the toxicity performance criteria of the Specifications.

3. The FST Matrix shall include the following:

   a. FST Index Number

   b. Material Name

   c. Supplier

   d. Function of Material

   e. Combustible Material Weight

   f. Material Total Surface Area

   g. Location of Material

   h. Heating Value (Btu/lb. and Btu/h)

   i. Peak Heat Release Rate (kW/m^2)

   j. Correspondence Letter Number for Submission of Test Results

   k. Toxicity Thresholds as established by BSS 7239 (or SMP 800-C)

   l. Average Heat Release Rate (kw/m^2)

   m. Average Smoke Extinction Rate (m^2/kg)

   n. Date of Test

   o. Test Procedure

   p. Test Facility

   q. Test Facility Report Number

r. Test Result Values

s. Pass/Fail Summary

CDRL 23-13 System Security Program Plan (SSePP):

1. The SSePP shall be submitted 30 days prior to CDR and updated until final Approval of the software is obtained.

2. Describe the planned tasks and activities to be used by the Contractor to implement the required system security program, including the required cybersecurity tasks as specified in Section 24, Cybersecurity.

3. A description of organizational relationships and personnel responsible for system security.

4. Define activities, management controls, and monitoring processes to be used to ensure that security considerations, compatible with other system requirements, are incorporated into the design of the cars.

5. A description of the process by which the Contractor will certify the security of the cars and major systems. The process shall be in accordance with FTA MA-90-5006-02-01.

6. Submit template for Threat and Vulnerability Assessment.

CDRL 23-14 Vehicle Threat and Vulnerability Assessment:

1. The Vehicle Threat and Vulnerability Assessment shall be submitted 30 days prior to PDR and 30 days prior to FDR.

2. Use a systematic method to identify all threats, system vulnerabilities, associated risks, countermeasures applied, resulting in mitigated risk and affected resources.

3. Apply risk-based approach for the analysis by evaluating vulnerability as measured by probability of the threat occurring and the impact of the loss.

4. Analyze the system's capability to detect, report, and stop a security attack attempt.

5. Vulnerabilities to be considered shall include, but are not limited to, the following:

   a. Vandalism

   b. Eavesdropping

   c. Device/user impersonation

   d. Dictionary attacks

   e. Message modification

f. Session hijacking

g. Buffer overflow

h. Denial of service

i. Jamming

j. Virus/worm infection

k. Unauthorized software installation

l. Unauthorized root/administrator access.

6. Develop control measures to bring the security risk to an acceptable level. Control measures could be:

   a. Administrative safeguards

   b. Logical safeguards

   c. Physical safeguards

7. Track the control measure implementation until closure.

8. Make recommendations to SEPTA on how to respond and recover from a security attack.

CDRL 23-15 Safety and Security Certification

1. The Safety and Security Certification CDRL shall be submitted 30 days prior to FDR and updated as required until safety certification is Approved.

   a. Any substantive design change after Safety Certification approval shall then require the car builder to confirm that the certification is still valid by updating any applicable Safety analyses or by providing written confirmation to SEPTA that no change is required.

2. Provide statement and justification that the car is adequately safe and secure for the application, i.e., testing in SEPTA's facility and revenue service.

3. Comply with 49 CFR 270 and FTA MA-90-5006-02-01.

CDRL 23-16 Safety and Security Progress Reports

1. Safety and Security Progress Report CDRLs shall be submitted on a quarterly basis.

2. Describe Safety and Security efforts and related project activities appropriate to inform key stakeholders including the PennDOT SSO.

3. Present efforts on Safety and Security as well as Section 21, Reliability, Availability, and Maintainability as an integrated effort.

4. Provide a graphical representation of the status of document closure and hazard mitigation, including:

    a. Brief description of efforts made to manage each open hazard with an HRI of 1 or 2.

    b. New entries in the FMECA (after PDR).

    c. High level, updated reliability predictions

    d. High level, updated maintainability predictions

    e. Status of reliability centered maintenance predictions

23.7 Referenced Standards

The following standards are referenced in this Section:

49 CFR 37	Transportation Services for Individuals with Disabilities (ADA)
49 CFR 38	American with Disabilities Act (ADA) Accessibility Specifications for Transportation Vehicles
49 CFR 229	Railroad Locomotive Safety Standards
49 CFR 238	Passenger Equipment Safety Standards
49 CFR 238 Subpart B	Safety Planning and General Requirements
49 CFR 238.105	Train Electronic Hardware and Software Safety
49 CFR 270	System Safety Program
AIAA S-102.2.5	Performance-Based Sneak Circuit Analysis (SCA) Requirements
APTA	Manual for the Development of System Safety Program Plans for Commuter Railroads
APTA PR-PS-RP-005-00	Recommended Practice for Fire Safety Analysis of Existing Passenger Rail Equipment
BSS 7239	Test method for toxic gas generation by materials on combustion (Boeing Specification Support Standard)
EN50128	Railway applications – Communication, Signaling and Processing Systems – Software for Railway Control and Protection Systems
EN50155	Railway applications – Rolling Stock – Electronic equipment

FTA MA-90-5006-02-01	Handbook for Transit Safety and Security Certification
IEEE Std 1483	IEEE Standard for Verification of Vital Functions in Processor-Based Systems used in Rail Transit Control
MIL-STD-882	System Safety
MIL-STD-1472	Human Engineering Design Criteria
MIL-STD-1629	Procedures for performing a failure mode, effects, and criticality analysis
NFPA 130	Standard for Fixed Guideway Transit and Passenger Rail Systems
SMP-800C	Toxic gas generation from material combustion (Bombardier)
Title 29 OSHA	Occupational Safety and Health Standards

SECTION 24
CYBERSECURITY

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24.1 Scope

A. This Section provides the cybersecurity requirements for all hardware, software, software services, and firmware to be provided under this Contract, whether resident within an onboard microprocessor controlled system, provided as a part of test or interface equipment (including Portable Test Equipment and Bench Test Equipment), provided as a part of post-downloading data analysis and processing, incorporated within training technology, manuals, or supplied as a part of a software based service (hereinafter referred to as "products" for the purposes of this Section).

24.2 General

A. These requirements apply to all products supplied as a part of this Specification, whether resident within a microprocessor-controlled subsystem, provided as part of test or interface equipment, provided for the purpose of post-download data analysis and processing, incorporated within training technology, manuals, or Bench Test Equipment (BTE).

B. These requirements apply to all products and subsystems that include processors or other programmable components such as Programmable Logic Devices (PLDs).

C. All products supplied as a part of this Contract are subject to these same requirements.

D. The Contractor is required to flow these requirements down to all subcontractors and sub-suppliers, as specified in Section 1, General Topics and Definitions.

E. These requirements represent the minimum set of security requirements and additional security requirements may be called out in other sections of this contract.

24.3 Design and Vulnerability Identification

24.3.1 Risk Management Framework

A. The NIST SP 800-53 Framework shall be used as the underlying risk management framework to identify, detect, protect from, respond to, and recover from security risks associated with the vehicle and products over their lifecycle.

B. This risk management framework shall be used as the basis for all specified security initiatives within this contract (e.g., assessments and testing, application of controls, risk mitigation, etc.).

24.3.2 Asset Management

24.3.2.1 Country of Origin

A. The Contractor shall identify the country (or countries) of origin of all products to be provided under this Contract, and any subcontracts, at any tier.

1. The Contractor shall identify the countries where the development, manufacturing, maintenance, and service for the product are provided or will be provided.

2. The Contractor shall submit a list **(CDRL 24-01, List of Proposed Products and Countries)** of the proposed products identifying the country of origin ("List" hereinafter).

3. The Contractor shall notify SEPTA of changes to the List no less than 90 days prior to the date that the change will be implemented. Any changes shall be subject to SEPTA Approval.

24.3.2.2 Software Bill of Materials / Hardware Bill of Materials

A. The Contractor shall maintain a Software Bill of Materials (SBOM) and Hardware Bill of Materials (HBOM) throughout the design process, with regular updates throughout the warranty period. **(CDRL 24-02, Software Bill of Materials and Hardware Bill of Materials)**

1. Prior to PDR, the Contractor shall submit the SBOM and HBOM format for SEPTA review and Approval.

2. SBOM and HBOM shall be submitted at the following intervals:

   a. At each design review

   b. At FAI

   c. Prior to the delivery of the first vehicle, and

   d. Annually throughout the warranty period.

3. The SBOM shall detail all software components used to provide the required functionality of this technical specification, including all on-board software, and software supplied to support required off-board functionality.

4. Each SBOM entry shall include:

   a. The system name

   b. The part name

   c. The software configuration item name

   d. The software component's name

   e. The version number and

   f. A cryptographic hash of the software.

5. The SBOM shall identify any known vulnerabilities associated with each software component, referencing the Common Vulnerabilities and Exposures (CVE) identifiers where applicable.

6. The SBOM shall be provided in an industry standard format as Approved, such as SPDX, SWID, or CycloneDX.

7. The HBOM shall be a comprehensive list of all hardware components which include microprocessors, programmable logic devices, or other memory and executable code. Each entry shall include the system, the component manufacturer, the component name, model, revision, and any unique identifiers.

8. The HBOM entry shall include supply-chain information including manufacturer location and places of origin for key sub-components.

24.3.2.3 External Information Systems

A. Furnish a list of external laptops and devices that may be used to interface with the Silverliner VI car or associated equipment, including during maintenance, testing, troubleshooting, and back-shop activities. **(CDRL 24-03, List of External Information Systems)**

1. The list shall identify Device Name, OS and MAC addresses and name or category of intended user. This list shall include laptops and devices specified in Section 27, Special Tools and Test Equipment, as well as any laptops and devices owned by the Contractor and its suppliers which may be used to connect to devices supplied as a part of this contract.

2. This list shall be maintained starting upon delivery of the first Pilot Cars to SEPTA and through the end of the warranty period.

3. The first list shall be supplied to SEPTA 30 days prior to scheduled delivery of the first Pilot Cars to SEPTA and be updated prior to the connection of a new device to equipment on-site at SEPTA.

4. Throughout the Warranty period, the Contractor shall Audit the list at least every 30 days using the logs specified in TS 24.4.2.1, to ensure that only listed devices are accessing the car networks.

24.3.3 Software Documentation

A. As part of the IEEE Std 1558-2004 documentation required by Section 19, Software Engineering, describe, at a minimum, the following cybersecurity-related information:

1. The cybersecurity roles and responsibilities applicable to the Contractor and the suppliers.

2. The System Development Life Cycle is used to manage subsystem's software.

3. Detailed Requirements and Design for all software-based security controls referenced in this Section.

4. Test Plan and procedures for testing the proper function of all the security controls referenced in this Section.

5. Test reports for all the security controls referenced in this Section.

B. See Section 19, Software Engineering, for full scope and details regarding the requirements associated with the software documentation.

24.3.4 Vulnerability Assessment and Mitigations

24.3.4.1 Preliminary Vulnerability Assessment

A. The Contractor shall Prepare and submit a preliminary cybersecurity vulnerability assessment report. **(CDRL 24-04, Vehicle Communication and Control System Vulnerability Preliminary Assessment)**.

1. The Assessment shall consider all exploits capable of impacting the security posture of the product. The exploits analyzed shall include, and not be limited to, the following list:

   a. Vandalism

   b. Eavesdropping

   c. Device/user impersonation

   d. Dictionary attacks

   e. Message modification

   f. Session hijacking

   g. Buffer overflow

   h. Denial of service

   i. Jamming (physical layer denial of service)

   j. Virus/worm infection

   k. Unauthorized software installation

   l. Unauthorized root/administrator access

2. For each identified vulnerability, the Contractor shall identify security measures to be implemented in their design to mitigate the identified hazards. The security measures considered for implementation shall include techniques such as:

a. Implementation of secure boot process

b. Use of Trusted Platform Modules (TPM) and/or Hardware Security Modules (HSMs) for secure key storage.

c. Restricting physical access to communication and control subsystem components to all but authorized personnel

d. Use of Access Control Lists (ACL)

e. Use of device and/or user authentication

f. Use of disk and network encryption

g. Use of hardware keys in conjunction with passwords/ passphrases

h. Access logs

i. Intrusion detection/prevention

j. Antivirus

k. Proper isolation of security-critical subsystem functions from other functions

l. Application of secure coding practices

m. Use of secure operating systems

n. Security logging in alignment with SEPTA's Security Information Management (SIM) system

3. The subject preliminary assessment is not required to involve security testing methods such as the independent assessments defined later in this Section, but rather should be seen as a theoretical analysis that shall use the Contractor's and supplier's experience in cybersecurity vulnerability analysis along with the understanding of the intended design of the car, subsystem, or product.

24.3.4.2 Software and Firmware Security Assessment

A. The Contractor shall procure an independent third-party security assessment of software and firmware.

1. The security assessment shall be completed for the following categories of software and firmware:

a. Software specifically developed or modified for this project (Category A software as defined in Section 19, Software Engineering); this requirement applies to all software provided on this project.

b. Software re-used for this project (Category B software as defined in Section 19, Software Engineering); this requirement applies to Software-based subsystems functioning on the Train Control Network (E-TCN) only.

2. The subject security assessment and corresponding requirements specified in this Section shall be implemented as per the following Security Controls from National Institute of Standards and Technology (NIST) SP 800-53 Rev. 5: CA-1, CA-2, CA-5, CA-7, CM-3, RA-1, RA-3, SA-11, SI-2, SI-3, SI-12.

3. The assessment shall be performed by an experienced, independent organization authorized to provide services to the US Government that maintains an active facility security clearance in good standing.

4. The assessment shall be performed by personnel cleared at any level, i.e., confidential, or above, under the facility clearance of the independent organization.

5. Furnish the name of the independent assessment organization. The independent third-party is subject to SEPTA Approval.

6. For all source code that is subject to the independent assessment of software and firmware security, submit documentation confirming that the source code does not include date/time-dependent functions **(CDRL 24-05, Date/Time Dependent Function Confirmation)**.

7. Ensure that the third-party software security assessment provider shall check software and firmware to ensure that critical application security weaknesses (including (Open Web Application Security Project (OWASP's) Top 10 for any web application delivered on this Contract, including but not limited to the TWDT web-based user interface specified under Section 18, Monitoring and Diagnostics, and SysAdmin, Audit, Network and Security (SANS') Top 25 Most Dangerous Software Errors) are addressed.

8. Ensure that the third-party security assessment provider performs the software security assessment using methodologies such as Fuzz, Dynamic, and Static testing. Submit the third party's Software Security Assessment Plan prior to performing the assessment **(CDRL 24-06, Independent Software and Firmware Security Assessment Plan)**.

9. Ensure that the results of each independent software and firmware security assessment are sent directly from the third-party provider to SEPTA and the Contractor **(CDRL 24-07, Independent Software and Firmware Security Assessment Findings Report)**.

10. Submit a response to the third-party's assessment including plans to correct identified vulnerabilities **(CDRL 24-08, Independent Software and Firmware Security Assessment Findings Response and Corrective Action Plan)**.

11. This independent assessment of software and firmware security (including the Contractor's response and Corrective Action Plan) shall be performed during the following time periods, at any time of SEPTA's choosing within these periods:

    a. One assessment after completion of the First Article Inspection and before conditional acceptance of the Pilot Cars.

    b. One assessment after the conditional acceptance of the Pilot Cars, but prior to completion of conditional acceptance of all cars.

12. The Contractor shall be responsible for implementing corrective actions to address vulnerabilities that are identified during an independent assessment of software and firmware security that would prevent the final product from meeting the security requirements defined in this Section.

13. Prior to vehicle acceptance, monitor the NIST National Vulnerability Database (NVD) Common Vulnerabilities and Exposures (CVE) list for all applicable entries based on the SBOM. Any applicable CVE with a Common Vulnerability Scoring System (CVSS) Version 3 severity of medium or higher shall be mitigated prior to vehicle acceptance.

24.3.4.3 Independent Penetration Testing

A. To demonstrate compliance with the specified functional and cybersecurity requirements relating to this Contractor, the Contractor shall procure an independent third-party penetration test and vulnerability assessment.

1. This penetration test shall be performed by a qualified, independent organization. The Contractor shall provide the name of the independent third-party penetration test provider for SEPTA review and approval.

2. The penetration test and corresponding requirements specified in this section shall be implemented in accordance with NIST SP 800-115 and as per Security Controls from NIST SP 800-53 Rev. 5.

3. Submit the independent third-party's test plan and associated procedures **(CDRL 24-09, Independent Penetration Test Plan and Procedures)**. The penetration test shall cover all products included in or incidental to this procurement, as specified in the Specifications.

4. Perform penetration testing on all car and train-to-wayside networks to reveal and report potential network vulnerabilities.

5. Perform penetration testing on all subsystems to reveal and report potential application vulnerabilities.

6. Perform subsystem penetration testing from the car-level connection point(s).

7. Perform penetration testing from both inside the car networks and from SEPTA wayside connections.

8. Ensure that the results of each independent hashing.

9. Penetration tests are sent directly from the third-party provider to SEPTA and the Contractor **(CDRL 24-10, Independent Penetration Test Findings Report)**.

10. Submit a response to the third-party penetration test, including a Corrective Action Plan to correct identified vulnerabilities **(CDRL 24-11, Independent Penetration Test Findings Response and Corrective Action Plan)**.

11. This independent penetration test shall be performed during the following time periods, at any time of SEPTA's choosing within these periods:

    a. One penetration test after the completion of the First Article Inspection and before conditional acceptance of the Pilot Cars.

    b. One penetration test after the conditional acceptance of the Pilot Cars, but prior to completion of conditional acceptance of all cars.

12. The Contractor shall be responsible for implementing corrective actions to address any vulnerabilities that are identified during the penetration test that would prevent the final product from meeting the security requirements defined in this Section.

24.4 Car Protection

A. Protect the availability, confidentiality and integrity of the data processed and generated by the Silverliner VI car.

1. Appropriate security controls shall be implemented for all aspects of the Silverliner VI vehicle design that are susceptible to security risks, adhering to a minimum of NIST 800-53.

2. These controls shall encompass a broad range of security measures and practices to ensure the protection of the Silverliner VI cars and associated software and services.

3. In addition to implementing security controls based on NIST 800-53, appropriate security controls shall be implemented for all aspects of the Silverliner VI cars and associated software and services which are susceptible to security risks, following industry-specific guidance where available.

4. This guidance may include TS/CLC 50701 for Rail, Cloud Security Alliance for cloud-based assets, CIS for system hardening/benchmarking, OWASP for software security hardening, and other applicable standards and best practices.

24.4.1 Processes and Procedures

24.4.1.1 Awareness and Training

A. All personnel performing work related to the development, operation, or maintenance of the product supplied as a part of this technical specification shall undergo adequate security training.

B. The Contractor shall demonstrate that the cybersecurity stakeholders assigned to this project, from the Contractor and the suppliers, have received sufficient awareness and training regarding the Cybersecurity program required by this Technical Specification, and implemented by the Contractor.

C. The training shall cover the specific roles and responsibilities in delivering the equipment and services, and effectively mitigating the associated security risks. The Contractor shall ensure that all personnel are equipped with the necessary knowledge and skills to uphold the highest standards of security throughout the equipment's lifecycle.

1. The Contractor and each subsystem supplier shall furnish a Cybersecurity Awareness and Training Plan, which can be embedded in a Cybersecurity Management Plan, in which each organization documents its plan for addressing Cybersecurity Awareness and Training related to the products to be delivered on this project.

2. The Contractor and each subsystem supplier shall furnish a Cybersecurity Awareness and Training Report, which shall show and attest that all relevant stakeholders have received Cybersecurity Awareness and Training related to the products delivered on this project. The report shall include the roster of who completed the training.

24.4.1.2 Secure Software Coding Practices

A. The Contractor shall ensure that security vulnerabilities are identified and removed prior to the delivery of the source code. The Contractor shall integrate specific software security activities into their software development life cycle(s), follow the latest version of the NIST Special Publication (SP) 800-218, Secure Software Development Framework (SSDF) Version 1.1: Recommendations for Mitigating the Risk of Software Vulnerabilities), and other techniques as recommended and required as a part of the activities related to the independent assessment of software and firmware security.

1. These activities shall be described in the Contractor's and each supplier's Software Project Management Plan (SPMP), as specified in Section 19, Software Engineering.

2. These activities are subject to audit during software Quality Assurance audits, as specified in Section 19, Software Engineering.

24.4.1.3 NIST Checklist(s)

A. Where applicable, all software included within this procurement shall be configured in alignment with the NIST National Checklist Program.

1. This requirement shall be applied to all software components where NIST National Checklists are applicable. A NIST National Checklist is to be considered applicable if the Software component's name provided to SEPTA is listed in column "Name (Version) " of the NIST National Checklist repository (see Item 3).

2. The repository for NIST National Checklist can be found at https://nvd.nist.gov/ncp/repository.

3. The Contractor and each supplier shall submit:

a. **CDRL 24-12, Identification of Subsystem, Associated Software, and Applicable NIST Checklist(s)**

b. **CDRL 24-13, Completed NIST Checklist(s)**

24.4.1.4 Obsolescence

A. The subsystems shall be designed without the use of proprietary protocols, to ensure the ability to incorporate future security improvements. All protocols shall be documented in the Interface Control Documents specified in Section 17, Network and Trainline Control.

24.4.1.5 Vehicle Baseline Configuration

A. Develop, document, and maintain a baseline configuration for all the technology and subsystems loaded onto the car **(CDRL 24-14, Vehicle Baseline Configuration)**.

1. The baseline configuration can be developed either manually, or automatically through use of an Intrusion Detection System (see TS 24.5).

2. The baseline configuration shall illustrate, at a minimum, the following information:

a. Network map

b. Data flows

c. Communication and protocols (including authentication and encryption)

d. Device name

e. Device IP address

f. Firmware version(s)

g. Firewall and ACL rules

24.4.1.6 Configuration Control

A. The Software Configuration Control Plan (SCCP) specified in Section 19, Software Engineering, shall be used for tracking potential security obsolescence in software used in onboard subsystems, Portable Test Units (PTU) and Bench Test Equipment (BTE).

24.4.2 Protection Design and Technology

24.4.2.1 Logging and Auditing

A. The Contractor shall provide logging capabilities that include security relevant messages for all devices supplied as a part of this Contract.

B. Logging capabilities provided by the Contractor shall be configurable by SEPTA and support security auditing requirements.

C. The product shall cover the following events, at a minimum (as appropriate to their function):

1. Information requests and device responses

2. Successful and unsuccessful authentication and access attempts

3. Account changes

4. Privileged uses

D. Security log files shall be stored in the VMDS specified in Section 18, Monitoring and Diagnostics.

E. The systems shall transfer security log files from the car to SEPTA's wayside central Security Information Management (SIM) system via the Train-to-Wayside Data Transfer (TWDT) specified in Section 18, Monitoring and Diagnostics. Details of SEPTA's SIM will be provided by SEPTA during the design review phase.

F. Time stamp audit trails and log files in Coordinated Universal Time (UTC).

G. Provide security protection of log files, both stored in VMDS, and stored on the wayside, with confidentiality and integrity.

H. Security log files shall be read-only for all user accounts, including administrator accounts, and furnish a method to validate log integrity.

I. Security log files shall contain timestamped events to allow audits and investigations similar to "syslogs", as defined by RFC 5424 (Syslog Protocol March 2009 Abstract).

J. Events in the security log files shall comply with the Log Management requirements specified under NIST SP 800-92.

K. Submit a list of all log management activities that the product is capable of generating and the format of those logs. This list shall identify which of those logs are enabled by default **(CDRL 24-15, Product Logging Management Capabilities)**.

24.4.2.2 Principle of Least Functionality/Privilege

A. The Contractor and suppliers shall implement the principle of least functionality and the principle of least privilege, as defined in NIST SP 800-53 Rev. 5 specified in TS 24.4, on each subsystem making up the car.

1. Configure each component of the product to operate using the principle of least functionality so that each subsystem shall be given only those permissions needed for it to perform its intended function. For instance, the event recorder shall perform only within the limits of the function that it is intended to achieve, the recording function, and shall not include any function that would be used to address train control or monitoring functions.

2. All subsystems shall employ the principle of least privilege to allow access where a user account permission hierarchy is provided, to enable each user account access only to the requisite capabilities.

3. Provide a centralized user account management tool to allow fleetwide modifications, additions, and deletions of user accounts in a secure manner demonstrated to be compliant to the recommendations of the National Institute of Standards (NIST).

    a. If a vehicle is not in communication with the tool when an update to user accounts is issued, the update shall be scheduled to happen automatically when the vehicle next connects to the tool.

    b. The tool shall furnish feedback as to the update progress to all applicable vehicles, so as to allow an administrator to verify that all vehicles received the update.

4. All user logins shall be authenticated and authorized by the end device prior to allowing access to the network, with further authentication and authorization provided by each end device. Login credentials only validated on local PTU software are prohibited.

24.4.2.3 Network Protocols

A. Submit information on all communications (e.g., protocols) required between SEPTA's network security zones whether inbound or outbound and identify each. (**CDRL 24-16**)

24.4.2.4 Physical Security

A. Employ physical security solutions to protect the car against cybersecurity threats. See TS 24.4.3, for details.

24.4.2.5 Network Segmentation

A. Employ an architectural approach that divides the car network into multiple segments or subnets.

1. A secure network architecture and segmentation strategy shall be implemented to isolate critical systems and components from less critical ones, preventing unauthorized access, limiting lateral movement within the onboard networks, and mitigating potential attacks.

2. Secure communication channels shall be established between trainset components to protect sensitive data and ensure secure interaction between systems.

3. Provide a method to restrict communications traffic between different network security zones. Furnish documentation on methods and equipment used to restrict communications traffic.

B. See Section 17, Network and Trainline Control, for details.

24.4.2.6 Subsystems Identification Management

A. Design the car network assuming that the subsystems' authenticity cannot be trusted.

1. Provide means to authenticate all onboard and external subsystems onto the car networks. See TS 24.4.3, for details.

2. Employ strong maintenance password requirements on subsystems and network equipment. See TS 24.4.3, for details.

24.4.2.7 Network Ports Configuration

A. Configure the network ports to limit access to the data transiting into the car.

1. Disable unused ports on the onboard network (e.g., switch, router) and subsystems.

2. Implement a method to disable maintenance ports when not in use (e.g., PTU).

3. Apply ingress/egress rate limiting on end-device ports as appropriate. Ingress/egress rate limiting is only required on end-device ports if not suitably protected by ingress/egress rate limiting on network switches.

24.4.2.8 Subsystems Configuration

A. Ensure that subsystem maintenance and configuration features (e.g., web servers) not intended to be used by SEPTA have been disabled following delivery of the car to SEPTA.

24.4.2.9 Subsystems Resilience

A. Design subsystems with denial-of-service protection, as defined in NIST SP 800-53 Rev. 5 specified in Section 24.4, Car Protection.

24.4.3 Authentication and Access Control

24.4.3.1 Passwords and Authentication

A. Deliver a product that adheres to standard authentication protocols.

1. Document and submit the levels, methods, and capabilities for authentication and authorization of passwords **(CDRL 24-16, Authentication and Password Management)**.

2. Propose an authentication method (e.g., password based, IP-based, Certificate based authentication) subject to review and Approval by SEPTA for the following types of connections:

a. Wired connections:

(1) Local connection: Temporary connection between external equipment and a car subsystem (e.g., PTU connected to a car subsystem)

(2) Network connections between car subsystems and car networks

(3) Network connections between external equipment and car networks (e.g., PTU connected through Ethernet Universal Service Port)

b. Wireless connections (TWDT): See Section 18, Monitoring and Diagnostics, for details.

3. Encryption and authentication schemes that are used shall be Approved for active use (e.g., not superseded or deprecated) by their respective governing bodies. Identify the most applicable cryptography standard and submit to SEPTA for Approval. Obsolete protocols and security algorithms (e.g., WEP) are prohibited.

4. Protect all passwords, including, but not limited to the following methods:

a. Passwords shall not be stored in clear text.

b. Passwords shall not be hardcoded into software or scripts.

c. Passwords shall not be logged.

d. Passwords shall use both salting and peppering mechanisms to make the hash version of the password, as referenced in Item e below, more secure.

e. Passwords shall be stored in a one-way hashed format in compliance with NIST requirements from IA-5 (Authenticator Management) in NIST SP 800-53 Rev.5, and from industry hash standards; deprecated hashing protocols are prohibited (e.g., SHA1). Identify the most applicable industry hash standard and submit to SEPTA for Approval.

f. Any communication that involves the transmittal of passwords or session tokens over a network (e.g., a PTU login or file transfer) shall use an end-to-end encrypted connection (e.g., HTTPS, FTPS, SFTP).

g. All factory passwords that may be publicly available shall be replaced by a password that meets the above requirements prior to delivery of the product to SEPTA.

5. The network segmentation scheme, subnet assignments, and assignment of IP addresses to each device on the car and train networks is subject to Approval by SEPTA.

6. Static IP Address Assignment shall be used to configure the IP scheme of each subsystem connected to the onboard network. When the same device type is used in multiple locations, IP Address Assignment shall not require manual configuration upon equipment replacement, with static IP assignment based on inputs, configuration memory which remains with the car, or other approved methods. When not feasible, the use of Dynamic IP address assignment, such as Dynamic Host Configuration Protocol (DHCP), may be proposed provided that it comes with appropriate security feature (e.g., DHCP snooping) in place.

7. Provide SEPTA with a password reset procedure to ensure that SEPTA can continue to access a subsystem, when given physical access to a device, if passwords are lost. This action shall be logged and auditable. The procedure is subject to SEPTA's Approval.

24.4.3.2 Access to Cabinets and Enclosures

A. Secure equipment connected to the car network with cabinets, enclosures, and covers that provide a high level of physical security.

1. Use tamper resistant locking hardware on equipment not otherwise protected by lock and key. See Section 14, Interior and Exterior Appointment, for details.

2. If it is not possible to enclose a system that hosts one or more car network interface(s) in a locked cabinet (e.g., Conductor Control Panel, Train Operator's Display (TOD)), the applicable subsystem shall be mounted on the car such that the subsystem’s network interface(s) cannot be physically accessed without having to disassemble environmental parts that use tamper evident / tamper proof locking hardware.

24.4.3.3 Access to Network Equipment

A. Provide means to protect access to the onboard network equipment from unauthorized personnel.

1. Install monitored / alarmed physical barriers on network equipment that hosts one or more Ethernet Ports.

2. Remove or disable, through software, physical disconnection, or engineered barriers, all services and ports in the product not required for vehicle operation, maintenance, or troubleshooting.

   a. This will include communication ports and physical input/output ports (e.g., USB, docking ports, video ports, UART ports, and serial ports).

   b. All ports shall be configurable by SEPTA to allow for enabling/disabling, with logging and remote reporting of status and changes to status.

3. Submit documentation of disabled ports, connectors, and interfaces **(CDRL 24-17, Product Disabled Services)**.

4. Submit summary documentation of the product's security features and security-focused instructions **(CDRL 24-18, Product Security Features and Instructions)** on maintenance, support, port enabling/disabling, and reconfiguration of the product's default settings.

5. Disclose the existence of all known methods for bypassing computer authentication contained in the product. Submit written documentation that any potential development bypasses have been permanently deleted from the final product delivered to SEPTA **(CDRL 24-19, Product Development Bypass Disclosure and Removal)**.

6. Ensure that the re-enabling of any disabled or unused capability generates a security log event.

7. SEPTA prohibits the use of flash drives and other removable media when communicating with any subsystem located on the car.

24.4.3.4 Remote Access

A. Ensure that remote access to the onboard subsystems is documented and managed.

1. Document and submit all remote access entry pathways **(CDRL 24-20, Remote Access Entry Pathways)** and ensure that they can be enabled or disabled by SEPTA. Use Virtual Private Network (VPN) connections as directed by SEPTA during design review.

2. In particular, wireless communications between an onboard subsystem and wayside shall be achieved over a VPN connection, as defined in NIST SP 800-77. These connections are subject to SEPTA Approval.

24.4.3.5 Access Permissions Management

A. Design the cars to limit access as necessary between specific locations (e.g., security zones, business networks, and demilitarized zones (DMZs)) on the network and submit documentation of the car's configuration as delivered. (**CDRL 24-16)**

1. The software shall deny access by default and allow access by specific permissions.

2. Provide, for each subsystem relying on a human interface device (e.g., TOD, PTU, TWDT), user accounts with configurable access and permissions associated with one or more defined user role(s).

    a. Provide, for the subject systems, a mechanism for changing users' roles (e.g., group) or associations and for defining access and security permissions, user accounts, and applications with associated roles.

    b. Configure these options, as specified by SEPTA.

    c. Provide access permissions management on the provided wayside platform.

    d. Provide a means to issue credentials to SEPTA-managed computers. This shall include the ability to issue PTU credentials to SEPTA-managed computers.

    e. Document and submit the subject mechanisms to SEPTA **(CDRL 24-21, Access Control User and Roles Proposed Options)**.

3. Submit recommended methods for SEPTA to prevent unauthorized changes to the Basic Input/Output System (BIOS), bootloaders, and other firmware **(CDRL 24-22, Recommended Methods Against Unauthorized Changes to BIOS and Firmware)**. If it is not technically feasible to protect the BIOS to reduce the risk of unauthorized changes, document this and provide mitigation recommendations when complying with CDRL 24-22.

24.4.3.6 Unauthorized Logging Device

A. Verify and submit documentation for the product, attesting that unauthorized logging devices (e.g., key loggers, cameras, and microphones) are not installed on the car following its delivery to SEPTA **(CDRL 24-23, Unauthorized Logging Device Removal Statement)**.

24.4.4 Data Security

24.4.4.1 Cryptography and Encryption

A. Cryptography/Encryption: Encryption shall be used as a security control to maintain confidentiality, verify authenticity or integrity, and provide non-repudiation

throughout end-devices through all communication links operating via the onboard networks.

B. The use of encryption shall consider all relevant aspects, including but not limited to:

1. Key Management: Procedures and controls for key generation, distribution, storage, and revocation shall be implemented.

2. Protection of Cryptographic Keys: Measures shall be taken to protect cryptographic keys from unauthorized access, loss, theft, or compromise.

3. Recovery of Encrypted Information: Procedures shall be implemented to enable the recovery of encrypted information in the event of key loss or compromise. Processes for key recovery shall be established.

4. Compliance with Industry Standards: Encryption algorithms and protocols employed must adhere to industry standards for strong security and integrity. Compliance with relevant standards, such as FIPS (Federal Information Processing Standards), shall be ensured to maintain the highest level of encryption security.

24.4.4.2 Communication with Wayside

A. Provide means of securing data exchanged between the car and wayside.

1. Protect the confidentiality and integrity of the data exchanged between the car and wayside using a method of encryption subject to SEPTA Approval.

2. Strong encryption algorithms and secure communication protocols, meeting industry standards for security and integrity (e.g., FIPS compliant), shall be employed for all wireless networks used.

3. Propose and implement a method for protecting the authenticity of the data exchanged between the car and wayside.

4. Wireless access points, cellular devices, and routers shall be securely configured, and regular firmware updates shall be performed to mitigate potential vulnerabilities.

5. Wayside communication devices shall be configured with secure settings, including the disabling of unnecessary services and features that may introduce vulnerabilities.

6. Access control mechanisms, such as strong authentication and SIM card security measures, shall be employed to prevent unauthorized use of cellular devices and/or SIM cards.

7. See section addressing the TWDT subsystem from Section 18, Monitoring and Diagnostics, for additional details.

24.4.4.3 Software and Firmware Integrity

A. Provide a secure process for validating software and firmware integrity at all stages of deployment.

1. A comprehensive process for software/system updates, patching and maintenance shall be implemented to ensure the integrity and authenticity of updates installed on the vehicle components.

2. The Contractor shall establish a robust system for verifying the source and integrity of updates before installation, including the use of digital signatures from authorized entities on all software and firmware releases.

3. This verification process shall guarantee that updates are legitimate and have not been tampered with, maintaining the overall security and reliability of the equipment and software supplied with this contract.

4. Each end-device shall implement verification of digital signature on software and firmware packages.

5. The version and checksum for every software, firmware, and parameter file instance loaded on the car shall be made available on the network by its corresponding end-device at a frequency subject to SEPTA's Approval.

6. The version and checksum for every software, firmware, and parameter file instance loaded on the car shall be displayed on the TOD to facilitate a manual check, as specified in Section 18, Monitoring and Diagnostics, and to facilitate the manual portion of the software update process as specified in Section 19, Software Engineering. The version and checksum shall be checked against an approved baseline configured by SEPTA, and the TOD display shall clearly highlight exceptions without the need for manual comparison by a maintainer.

   The version and checksum for every software, firmware, and parameter file loaded on the car shall also be checked for anomalies by the intrusion detection system specified under TS 24.5.1, when possible. For other cases, the Contractor shall propose for Approval a methodology for checking for anomalies.

24.5 Incident Detection and Response

Provide continuous monitoring and detection capabilities to detect anomalies and suspicious activity occurring on the car network.

24.5.1 Intrusion Detection System

A. Deliver an intrusion detection system (IDS) based on anomaly-based detection methodology and the network-based and network behavior analysis technologies defined in NIST SP 800-94.

B. SEPTA anticipates refining the specific requirements and functionality of the IDS during the design development phase. The Contractor is required to collaborate in this refinement process.

1. The IDS shall include on-board hardware and software operating on each car that shall monitor each on-board network for anomalies. Separate instances of the IDS shall be implemented on each network, unless otherwise Approved.

2. All on-board networks incorporating communication between Software Configuration Items supplied by different vendors, as well as all communication between separate network security zones, shall be monitored.

3. The IDS shall be capable of capturing, at a minimum, the following security threat scenarios:

    a. Malicious reconnaissance activity in preparation for potential future attacks

    b. Unauthorized device connected (physically or remotely) to the target networks

    c. Denial of service attacks on to the target networks

    d. Unintended loss of communication from one or more subsystems connected to the target networks

    e. Unauthorized software updates on devices connected to the target networks

    f. Password cracking attempts against network devices

    g. Unknown / undefined network traffic on the target networks

4. The IDS shall be capable of detecting, at a minimum, the following types of anomalies:

    a. Payload anomalies

    b. Application layer anomalies

c. Protocol anomalies: Media Access Control (MAC) Spoofing, IP Spoofing, Duplicate IP, Unknown IP, etc.

d. Malware detection

e. Bandwidth Anomaly

f. Abnormal Connection Rate detection

5. The IDS shall be capable of providing the following functions and features:

a. Asset and Hosts Discovery

b. Network map generation

c. Anomaly detection

d. Events recording and logging at the subsystem level and car level

e. Events Notification (e.g., email, text, web, etc.)

f. Transfer of events to wayside using the TWDT

g. Web based Graphical User Interface with event reporting capabilities at the car, fleet, network, and subsystem level for threats and anomalies detected on the onboard networks shall be provided, to be operated on SEPTA provided virtual servers hosted in SEPTA data centers or cloud environments. The Contractor shall support the integration of the wayside components of the IDS solution into SEPTA's environment.

h. Maintenance and configuration of the proposed intrusion detection system. All maintenance and configuration features shall be user-accessible to allow for SEPTA to make necessary changes and updates.

6. The IDS shall meet the following requirements if proposed as a hardware-based product:

a. The proposed hardware shall meet the requirements of this Technical Specification for onboard hardware (including requirements identified in Section 2, Design and Performance Criteria) and be certified for use in the rail vehicle environment, including meeting the requirements of EN 50155:2021.

b. The proposed hardware shall use d-coded M12 connectors for all 100 Mbps Ethernet connections, and X-coded M12 connectors for all Gigabit Ethernet connections.

7. The IDS shall meet the following requirements if proposed as a software-only product:

    a. The software shall be designed to operate within its designated hosting environment without degradation of performance to the hosting environment.

    b. The software solution shall be compatible with the operating system of its designed hosting environment.

8. The IDS shall be capable of analysis of all protocols utilized on the car.

9. It shall be possible to update the IDS through the software update process specified in Section 19, Software Engineering.

10. If the Contractor decides to subcontract the development of the IDS to a third-party, the proposed vendor shall be submitted to SEPTA for review and approval.

11. Regular audits of the IDS shall be conducted to ensure its effectiveness throughout the warranty period.

12. The IDS shall implement advanced technologies and techniques to detect both known and emerging threats.

13. The Contractor shall submit its design for on-board monitoring and intrusion detection and associated wayside system **(CDRL 24-24, On-Board Intrusion Detection System Design)**.

24.5.2 Incident Response

A. The contractor shall provide procedures and controls for SEPTA to implement that enables the continuity of vehicle operation during adverse conditions, including cyber-attack.

B. In situations where the security controls implemented may not be sufficient to secure information during adverse conditions, alternative controls shall be implemented to maintain an acceptable level of security coverage until normal operating conditions are restored.

C. Any security incidents or breaches shall be promptly reported to SEPTA, providing comprehensive details and remediation actions.

24.6 Contract Deliverable Requirements List (CDRL)

The following contract deliverables have been identified in this section; however, the Contractor is responsible for providing and submitting anything necessary to fulfill the requirements of this contract, including those not identified by CDRL number.

CDRL 24-01, List of Proposed Products and Countries 24-2

CDRL 24-02, Software Bill of Materials and Hardware Bill of Materials 24-2
CDRL 24-03, List of External Information Systems 24-3
CDRL 24-04, Vehicle Communication and Control System Vulnerability Preliminary Assessment 24-4
CDRL 24-05, Date/Time Dependent Function Confirmation 24-6
CDRL 24-06, Independent Software and Firmware Security Assessment Plan 24-6
CDRL 24-07, Independent Software and Firmware Security Assessment Findings Report . 24-6
CDRL 24-08, Independent Software and Firmware Security Assessment Findings Response and Corrective Action Plan 24-6
CDRL 24-09, Independent Penetration Test Plan and Procedures 24-7
CDRL 24-10, Independent Penetration Test Findings Report 24-8
CDRL 24-11, Independent Penetration Test Findings Response and Corrective Action Plan 24-8
CDRL 24-12, Identification of Subsystem, Associated Software, and Applicable NIST Checklist(s) 24-10
CDRL 24-13, Completed NIST Checklist(s) 24-10
CDRL 24-14, Vehicle Baseline Configuration 24-10
CDRL 24-15, Product Logging Management Capabilities 24-12
CDRL 24-16, Authentication and Password Management 24-14
CDRL 24-17, Product Disabled Services 24-16
CDRL 24-18, Product Security Features and Instructions 24-16
CDRL 24-19, Product Development Bypass Disclosure and Removal 24-16
CDRL 24-20, Remote Access Entry Pathways 24-16
CDRL 24-21, Access Control User and Roles Proposed Options 24-17
CDRL 24-22, Recommended Methods Against Unauthorized Changes to BIOS and Firmware 24-17
CDRL 24-23, Unauthorized Logging Device Removal Statement 24-17
CDRL 24-24, On-Board Intrusion Detection System Design 24-22

24.7 CDRL Details

This section lists the expected content for each CDRL required above. The lists provided for each CDRL are an outline only and should not be considered exhaustive, all CDRLs are subject to SEPTA review and Approval.

CDRL 24-01 List of Proposed Products and Countries:

1. Submit the list in MS Excel format and in PDF format (signed copy from the Contractor).

2. The hardware portion of the List shall be based off of the Illustrated Parts Catalog specified by Section 26, Manuals and Training.

3. The software portion of the List shall be based off of the Software Summary Table specified by Section 25, Program Management and Commissioning.

4. Submit the list at PDR and at FDR.

CDRL 24-02 Software Bill of Materials and Hardware Bill of Materials

1. Submit the Software Bill of Materials (SBOM) and Hardware Bill of Materials (HBOM) in the approved format.

    a. At each design review

    b. At FAI

    c. Prior to the delivery of the first vehicle, and

    d. Annually throughout the warranty period.

CDRL 24-03 List of External Information Systems:

1. Submit the list in MS Excel format and in PDF format (signed copy from the Contractor).

2. Include in the list the information specified in TS 24.3.1.2.

3. Submit the first list 30 days after delivery of the first Pilot Cars to SEPTA and then whenever a new laptop or device is added to the list.

CDRL 24-04 Vehicle Communication and Control System Vulnerability Preliminary Assessment:

1. Submit the report in MS Word format and in PDF format (signed copy from the Contractor).

2. The preliminary cybersecurity vulnerability assessment report shall identify the following:

    a. All potential subsystem vulnerabilities

    b. All exploitation techniques from the MITRE Adversarial Tactics, Techniques, and Common Knowledge (ATT&CK) framework applicable to this project

    c. Countermeasures considered for mitigating identified vulnerabilities.

3. The format of the Vulnerability Preliminary Assessment shall be similar to that of a Hazard Analysis, consistent with the format specified in Section 23, System Safety and Security, but independent of the Hazard Analysis specified in Section 23. Submit a representative sample of the proposed assessment format for Approval prior to submitting the assessment itself.

4. Submit the report at PDR.

CDRL 24-05 Date/Time Dependent Function Confirmation:

1. Submit the confirmation in the form of an attestation stating that the source code product(s) subject to the confirmation is(are) free of Date/Time Dependent code.

2. Submit one attestation per vendor subject to this confirmation. One attestation may address more than one source code product if applicable.

3. Submit the confirmation in a PDF signed by both the applicable vendor and the Contractor.

4. Submit the confirmation at PDR and FDR.

CDRL 24-06 Independent Software and Firmware Security Assessment Plan:

1. Submit one plan per vendor subject to the Independent Software and Firmware Security Assessment.

2. Identify the list of source code product(s) to be tested in the plan and for each of them, document the following:

    a. List of vulnerabilities the source code product will be tested against to

    b. Testing method (e.g., Fuzz Testing, Static Testing, Dynamic Testing), tools and setup

    c. Testing schedule/duration

    d. Testing planned location

    e. Party responsible for the test

3. Submit the plan in MS Word format and in PDF

4. Submit the plan 90 days prior to the event

CDRL 24-07 Independent Software and Firmware Security Assessment Findings Report:

1. The independent organization in charge of the assessment shall:

    a. Submit one report per vendor subject to the Independent Software and Firmware Security Assessment

    b. Include the results and findings from the activities planned in **CDRL 24-06**

    c. Submit the report in MS Word format and in PDF signed by the independent organization in charge of the assessment

    d. Submit the report within 30 days following the completion of the event

CDRL 24-08 Independent Software and Firmware Security Assessment Findings Response and Corrective Action Plan:

1. Submit, as applicable, one plan per vendor subject to the corrective action effort

2. Identify the list of source code product(s) to be corrected in the plan and for each of them, document, at a minimum, the following:

    a. List of vulnerabilities and findings to be adressed

    b. High level description of the activities planned to correct the vulnerabilities

    c. Estimated timeline for delivery of the corrected product to SEPTA.

3. Submit the plan in MS Word format and in PDF signed by both the applicable vendor and the Contractor

4. Submit the corrective action plan within 30 days following the submission of the Independent Software and Firmware Security Assessment Findings Report **(CDRL 24-07)**

CDRL 24-09 Independent Penetration Test Plan and Procedures:

1. Submit one Penetration Test Plan to cover all the Penetration Testing events specified in the Specifications.

2. The Penetration Test Plan shall describe at a high level the requirements of the Penetration Testing events and document, at a minimum, the following:

    a. List of vulnerabilities the Penetration Testing event will cover

    b. Testing approach (e.g., Wireless access, Physical access)

    c. Testing phases (e.g., Black box, Grey box, White box) and corresponding scope

    d. Testing tools

    e. Testing schedule/duration

    f. Testing planned location

    g. Party Responsible for the test

3. Submit the Penetration Test Plan 90 days prior to the completion of the First Article Inspection.

4. Submit one Penetration Test Procedure for each Penetration Testing event specified in the Specifications.

5. Each Penetration Test Procedure shall specify the specific test items applicable to its corresponding Penetration Test and shall document, for each phase of the testing event (e.g., Black Box, Grey Box, White box), at a minimum, the following:

    a. List of items to be shared from SEPTA to the Independent Penetration Test Organization

b. List of systems and network equipment targeted during the test

c. Detailed description of the attack approach and supporting tools

d. Pass/Fail criteria

6. Submit each Penetration Test Procedure 90 days prior to the event.

CDRL 24-10 Independent Penetration Test Findings Report

1. The independent organization in charge of the Penetration Test shall:

   a. Submit one Penetration Test Findings Report as a result of each Penetration Testing event specified in the Specifications

   b. Include the results and findings from the testing activities planned and specified in **CDRL 24-8**.

   c. Submit the report in MS Word format and in PDF signed by the independent organization in charge of the Penetration Test

   d. Submit each Penetration Test Findings report within 30 days following the completion of the event

CDRL 24-11 Independent Penetration Test Findings Response and Corrective Action Plan:

1. Submit, as applicable, one corrective action plan as a result of each Penetration Testing event specified in the Specifications.

2. Identify the list of vendors and systems subject to the corrective action effort in the plan and for each of them, document, at a minimum, the following:

   a. List of vulnerabilities and findings to be adressed

   b. High level description of the activities planned to correct the vulnerabilities

   c. Estimated timeline for delivery of the corrected product to SEPTA.

3. Submit the plan in MS Word format and in PDF signed by both the applicable vendor and the Contractor.

4. Submit the corrective action plan within 30 days following the submission of the corresponding Penetration Test Findings Report to SEPTA.

CDRL 24-12 Identification of Subsystem, Associated Software, and Applicable NIST Checklist(s):

1. Submit the list in MS Excel format.

2. The list shall include one column for each of the following:

   a. Vendor Name

b. Subsystem Name

c. Subsystem Software Name and Version

d. Corresponding Security NIST Checklist Name

e. Security NIST Checklist Implementation Status (Open/Closed).

3. Submit the list at PDR and at FDR.

CDRL 24-13 Completed NIST Checklist(s):

1. Submit the completed version of the list specified under **CDRL 24-11**.

2. Submit the list in MS Excel format and in PDF signed by the applicable vendor(s) and the Contractor.

3. Submit the list at FDR.

CDRL 24-14 Vehicle Baseline Configuration:

1. Submit the Vehicle Baseline Configuration in MS Excel format, with two tabs, as follows:

   a. "Network Map and Data Flow" tab shall be a diagram illustrating the network and connected devices. Include the following in the diagram:

      i. Car Network

         (1). Switches (L2)

         (2). Routers (L3)

         (3). End Devices

         (4). VLANs and subnets

         (5). Trunk Ports

      ii. Interface with Wayside Equipment

      iii. Network Security Zones

      iv. Interface with SEPTA corporate Network

   b. "Communication" tab shall be a table documenting the following information:

      i. Source System Name

      ii. Destination System Name

      iii. Source IP Address

iv. Destination IP Address

v. Protocol Name

vi. Protocol Priority

vii. Unicast/Multicast

viii. Port Number

2. Submit the list at PDR, FDR and upon delivery of first Pilot Cars to SEPTA.

CDRL 24-15 Product Logging Management Capabilities:

1. Submit the subject CDRL in MS Excel format.

2. Include one tab illustrating how all the security logs generated by the car systems will flow within the car and how they will flow between the car and the wayside.

3. Include one tab for each subsystem capable to generate a security log. Each tab shall be named according to the subsystem name and the security log information included in each tab shall include the following information:

   a. Security Event ID

   b. Security Event Name

   c. Security Event Description

   d. Trigger/Reset Conditions

4. Submit at PDR and FDR.

CDRL 24-16 Authentication and Password Management:

1. Submit this CDRL in a MS Word document.

2. This document shall describe the Authentication methods specified under TS 24.4.3.1.

3. This document shall describe any communication that involves the transmittal or management of passwords and how each password will be managed by the corresponding vendors and the Contractor.

4. The information shall be documented in a textual format; use of supporting diagram when applicable, is recommended.

5. Submit this CDRL at CDR and PDR.

CDRL 24-17 Product Disabled Services:

1. Submit this CDRL for each vendor delivering an electronic device to SEPTA on this project.
2. Submit this CDRL in an MS Excel format. The document shall include:
    a. Vendor Name
    b. System Name
    c. Service/Port Name (e.g., Web Server, File Server, Ethernet, USB…etc…)
    d. Service/Port Number/Protocol
    e. Service Status (Enabled/Disabled).
3. Submit at FDR.

CDRL 24-18 Product Security Features and Instructions:

1. Submit this CDRL for each vendor delivering an electronic device to SEPTA.
2. Submit this CDRL in a MS Word document.
3. Include the information specified under TS 24.4.3.3.
4. The information shall be documented in a textual format along with supporting diagram, when applicable.
5. Submit at FDR.

CDRL 24-19 Product Development Bypass Disclosure and Removal:

1. Submit this CDRL for each vendor delivering an electronic device to SEPTA.
2. Submit as a MS Word document and as PDF signed by both the applicable vendor and the Contractor.
3. If no bypass ever existed in the product delivered to SEPTA, the document shall include an attestation stating that the product(s) delivered to SEPTA does not host any method to bypass computer authentication contained in the product.
4. If one or more bypass methods existed during the development but has been removed by the vendor upon delivery to SEPTA, the document shall include a high-level description of the subject bypass method(s).
5. If one or more bypass methods still exists upon the delivery to SEPTA, the document shall include a detailed description of the subject bypass method(s) along with a step-by-step procedure for how to exploit it(them).

6. Submit the disclosure at qualification test and again upon delivery of the first Pilot Cars to SEPTA.

CDRL 24-20 Remote Access Entry Pathways:

1. Submit this CDRL as a MS Word document and PDF signed by each applicable vendor and the Contractor.

2. Describe any methods or functionality offered to any authorized user to access the car subsystems or network from a geographical distance through any form of network connection.

3. The information shall be documented in a textual format along with supporting diagram, when applicable.

4. Submit at FDR.

CDRL 24-21 Access Control User and Roles Proposed Options:

1. Submit this CDRL as a MS Word document and PDF signed by each applicable vendor and the Contractor.

2. Describe the information and instructions specified under TS 24.4.3.5.

3. The information shall be documented in a textual format along with any applicable supporting diagrams and screenshots.

4. Submit at FDR.

CDRL 24-22 Recommended Methods Against Unauthorized Changes to BIOS and Firmware:

1. Submit this CDRL as a MS Word document and PDF signed by the Contractor.

2. Describe information and instructions specified under TS 24.4.3.5.

3. Submit at Qualification Test.

CDRL 24-23 Unauthorized Logging Device Removal Statement:

1. Submit the statement in the form of an attestation stating that the car does not host any unauthorized logging device at the time of its delivery to SEPTA.

2. Submit the confirmation in a PDF signed by the Contractor.

3. Submit the confirmation upon delivery of the corresponding car to SEPTA.

CDRL 24-24 On-Board Intrusion Detection System Design

1. Submit this CDRL in a MS Word document.

2. Include the information specified under TS 24.4.3.3.

3. The information shall be documented in a textual format along with supporting diagram, when applicable.

4. Submit at CDR, PDR, and FDR.

24.8 Referenced Standards

The following standards are referenced in this Section:

EN 50155:2021	Railway applications – Rolling stock – Electronic equipment
IEEE Std 1558-2004	Standard for Software Documentation for Rail Equipment and Systems
NIST SP 800-53 Rev. 5	Security and Privacy Controls for Federal Information Systems and Organizations
NIST SP 800-218	Secure Software Development Framework (SSDF) Version 1.1: Recommendations for Mitigating the Risk of Software Vulnerabilities
NIST SP 800-77 Rev. 1	Guide to IPsec VPNs
NIST SP 800-94	Guide to Intrusion Detection and Prevention Systems (IDPS), February 2007
NIST SP 800-92	Guide to Computer Security Log Management, September 2006
NIST SP 800-115	Technical Guide to Information Security Testing and Assessment, September 2008
RFC 5424	The Syslog Protocol
TS/CLC 50701	Railway applications - Cybersecurity

SECTION 25
PROGRAM MANAGEMENT AND COMMISSIONING

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25.1 General

A. This Section specifies the requirements for management systems and processes. The management systems and processes shall be sufficiently comprehensive to enable the Contractor to meet the requirements of the Specifications and to enable SEPTA to monitor the progress of the contractual effort.

25.1.1 Contractor's Program Manager

A. Designate a Program Manager and establish an organization to provide effective management of this procurement program.

1. The Program Manager shall have responsibility for all aspects of the program during all phases.

2. All supporting departments shall report to the Program Manager for functional management of the project, including but not limited to engineering, production, warranty, site support, quality, contracts, shipping, field support, and materials control personnel. The list of the supporting departments will be presented in the relevant organizational chart.

25.1.2 Subcontractor Management

A. The Contractor is wholly responsible for the performance of all subcontractors and equipment suppliers as well as the components and parts used during the execution of this project.

1. All Specification requirements of the Contractor shall also be requirements of each subcontractor engaged by the Contractor, including the Contract requirements for correction of deficiencies.

2. Ensure that all subcontractors and any major equipment suppliers receive a complete copy of the Specifications, including modifications that are created during the execution of this Contract. Submit a copy of the Contractor's transmittal letter to each subcontractor and supplier to demonstrate compliance with this requirement.

25.2 Communications Protocol

A. Comply with the following:

1. All official correspondence shall be on 8.5 x 11-inch (216 x 279 mm) standard size page, addressed to SEPTA's Program Manager, and submitted electronically as specified in TS 25.2.2. E-mails, memos, and faxes are not considered official correspondence, but will be registered in the document control system.

2. Response to official correspondence shall be 30 days or less.

3. All oral and written communications shall be in English, as specified in Section 1, General Topics and Definitions.

4. All deliverables, including software products, shall be delivered in English, as specified in Section 1, General Topics and Definitions.

5. Document details of the communications protocol as specified in TS 25.3.

25.2.1 Document Management System

A. The Contractor and SEPTA shall use an internet-based document management system (DMS) for distributing and storing project correspondence and project submittals.

1. SEPTA will select the DMS and will provide the Contractor with the necessary access rights.

2. The DMS will be password protected with individual account access; the Contractor shall provide contact information necessary for SEPTA to provide access rights.

3. Specific DMS protocols, such as information required to be in letter templates, shall be determined jointly during the project kick-off meeting, and modified as needed during the course of the Contract.

25.2.2 Soft Copy Correspondence

A. Submit complete copies of every letter, attachment, drawing, design review package, or other project submittal through the DMS for the official record file. These documents shall include the original source computer files (e.g., MS Excel), searchable PDFs, and PDF scans of signature pages.

1. Letters shall be on letterhead and signed. Digital signatures are acceptable.

2. SEPTA will submit its letters and attachments to the Contractor in a similar fashion to that specified above.

25.2.3 Meetings

A. Comply with the following:

1. Official program meetings shall include an agenda and an attendance sheet, both to be provided to SEPTA at a minimum 72 hours prior to the meeting in order to sufficiently prepare and to suggest changes or additions.

2. Any documents or presentations to be discussed at the meeting shall be provided to SEPTA at a minimum 72 hours prior to the meeting in order to sufficiently prepare.

3. Minutes will be taken by SEPTA and reviewed and agreed to by both (all) parties at the conclusion of each meeting. Meeting minutes are defined as

conclusions, statements, or agreements resulting from the meeting. Meeting minutes are not transcriptions of conversations.

4. A responsible party and a due date will be established for all action items.

5. SEPTA will transmit the meeting minutes and action items by project letter, for tracking and reference purposes, following the meeting; request revisions within 10 days of receipt of the minutes, or else the minutes shall be considered to be final.

6. When SEPTA agrees that a meeting can be designated as a "working session," minutes and action items are not required. SEPTA will provide its formal comments against any subsequent design submittal.

25.2.4 Video Conferencing

A. At SEPTA's discretion, meetings may be conducted through the use of video conferencing. Conferencing shall be through Microsoft Teams or as Approved. Contractor grants SEPTA permission to record and retain project meetings.

25.2.5 Software

A. SEPTA uses the Microsoft Office suite of software tools as well as Adobe Acrobat. Submit all electronic files in Microsoft Office and Adobe compatible PDF file formats, or as individually Approved (e.g., STEP files).

25.2.6 Travel

A. Unless otherwise approved, the Contractor shall provide a minimum of 70 days notice for any in-person meeting, test, inspection, or other project activity that takes place outside the SEPTA service area in order for SEPTA staff to obtain the necessary travel approvals.

25.3 Program Management Plan

A. Submit and maintain a program management plan (PMP). **(CDRL 25-01, Program Management Plan (PMP))**

1. The PMP shall be responsive to all Contract, regulatory requirements, and Federal Transit Administration requirements, and shall include the following elements, as a minimum:

a. Organization Chart: Depicting the functional and project reporting paths for all supporting departments, all key personnel engaged with this project, including primary subsuppliers.

b. Staffing Plan: Defining the responsibilities and required qualifications of all key personnel, including experience and duration associated with the proposed position. Include staffing requirements for on-site support (commissioning and warranty) from key subcontractors.

c. Management Approach: Describing methods, procedures, and communication protocols used to control program schedule, technical performance (including testing and warranty), program changes, subcontracts or purchase orders, material procurement, field service support, manuals, training, and the overall quality management plan, including subsupplier quality management for the program.

d. Engineering Plan:

(1) Organization of the engineering department, with identification of the subgroups as organized by function or system.

(2) Critical path/workflow plan for completion of all engineering functions.

(3) The schedule for completion of major design activities including all stages of design reviews, mockup review, finalization of engineering, test plan development, carshell stress and structural performance analysis, proof of design testing and delivery of all required engineering documentation.

(4) Oversight of vendor engineering functions and integration of supplier engineering into the Contractor's design.

(5) Manufacturing engineering plan, including assembly station work scope, parts flow and estimated labor hours/station staffing plan. A comprehensive manufacturing engineering plan shall be submitted for review.

(6) Carshell engineering plan, including design, finite elements analysis, quasi-static and dynamic testing, measurement of critical dimensions, acceptance and shipment, and inspection/repair procedures.

(7) Completed car weight control plan.

(8) A mockup review plan, describing all mockups to be developed by the Contractor, the locations where the mockups will be built and reviewed, and the schedule for completion and review of the mockups.

(9) FRA Test and Approval plan, addressing what documentation will be used at what stage in the program to ensure full approval of the new vehicles by the FRA.

e. Supply Chain Management Plan: Detailed plan describing how the Contractor will manage materials throughout the program phases to ensure that production, commissioning, warranty, and SEPTA spares activities will always have a sufficient supply of parts.

f. Facilities Plan: A description of the facilities resources needed to complete the project, including but not limited to engineering, fabrication, assembly, test, storage, and transportation resources. Include a discussion of the management plan established to ensure availability of required facility resources throughout the program life cycle.

g. Risk Mitigation Plan: Covering technical, schedule, facilities, and financial aspects of the program.

2. The PMP shall be updated every three months during the life cycle of the program, from Notice To Proceed (NTP) through close-out when the last payment is made, unless SEPTA agrees that no update is needed at each interval if no changes were made to the PMP.

25.4 Staffing Requirements

A. The following program team members working in support of this project shall be subject to prior Approval. Furnish detailed position descriptions for each of the program team members, defining their roles and reporting structure. Submit these descriptions, and all resumes for program team members, as part of the Contractor's Program Management Plan for Approval. Contractor key personnel changes in program team members shall be subject to Approval.

1. Key Personnel 100%-dedicated to this program:

a. Program Manager

b. Lead Project Engineer(s)

c. Lead Systems Engineer

d. System Integrator

e. Network Integrator

f. Safety Program Manager

g. Field Service Manager

h. Warranty Manager

2. Personnel supporting this program:

a. Warranty and Reliability Engineer(s)

b. Materials Manager

c. Quality Engineer

d. Industrial Design Engineer (or subcontractor)

e. Resident Engineer

f. Scheduler

g. Production Manager (final assembly)

h. Commissioning and Deliverables Manager

i. Design Engineers (Structural, Mechanical, and Electrical)

j. Warranty Engineers (Lead, Mechanical, and Electrical)

k. QC Inspectors (Warranty/field modifications)

l. Test Engineer (plant and field)

m. Industrial/Methods Engineer

n. Training and Manuals Manager

o. Contracts Department Manager

B. The Contractor will be required to remove key personnel from the program due to poor performance or otherwise unacceptable conduct at SEPTA's request.

25.4.1 Computer and Network Integrator Requirements

A. Comply with the following:

1. Retain the services of an experienced computer network engineering and integration resource to act as Computer and Network Systems Integrator.

a. The Integrator shall be responsible for systems engineering, integration, and testing for all network and trainline communication.

b. The resume for the Network Systems Integrator and, if a third party is selected, the company profile and previous related work experience, shall be provided for Approval.

25.5 Schedules and Project Control

25.5.1 Program Phases

A. The car procurement program will be divided into the major phases detailed in Table 25-1:

Table 25-1, Program Phases	
1	NTP
2	Kick-Off
3	Conceptual Design
4	Preliminary Design

5	Final Design
6	Qualification Testing and First Article Inspections
7	Pilot Car Production
8	Pilot Car Qualification Testing and FAI
9	Delivery of Production Cars
10	Post-Delivery/Warranty

25.5.2 Master Program Schedule

A. Submit and maintain a Master Program Schedule (MPS) based on the Critical Path Method. **(CDRL 25-02, Master Program Schedule)** A structured format shall be used.

1. Prepare the schedule using Oracle's Primavera P6 Professional Project Management software (P6), or as Approved, and submit its native (editable) format and a PDF copy.

2. The program schedule shall identify all Contractual milestones and activities including the following:

   a. All deliverables per CDRL and car deliveries.

   b. Milestones for completion of program phases.

   c. Significant subsystem development milestones including subsystem development:

      (1) All design reviews.

      (2) Appropriate qualification testing and First Article Inspection (FAI).

      (3) Delivery of major and critical materials and components for assembly of the Pilot Cars.

      (4) Final assembly, factory test, delivery, and final acceptance of the Pilot Cars.

   d. Development and delivery details regarding Special Tools, Training, Manuals, and Spare Parts.

3. The program schedule shall identify:

   a. The earliest possible and latest possible dates for accomplishing each milestone.

   b. The shortest and longest permissible time span between each dependent milestone.

   c. Critical and minor paths that are essential for accomplishment of program objectives.

4. The schedule shall indicate interaction with project activities of suppliers providing car components and subsystems.

5. Include a detailed production schedule within the MPS. This detailed schedule shall identify the following for each subsystem, as a minimum:

    a. Receipt of necessary materials

    b. Production

    c. Design qualification test (DQT) by car or married pair number

    d. Pre-shipment factory acceptance test by car or married pair number

    e. Predelivery inspection

    f. Delivery of the cars

    g. Each production and on-site acceptance testing stage

    h. Acceptance schedules by car or married pair number

6. The MPS shall be cost loaded per justification for progress payments.

7. The MPS shall be resource loaded for non-engineering tasks for Contractor equipment and labor allocations through use of native fields. Use of static/non-native field methods on a case-by-case basis is subject to Approval. Resource loading is not required for tasks performed by Subcontractors.

8. The MPS shall include appropriate schedule calendars applied to work tasks, e.g., plant closures, SEPTA contractual test availability limits.

9. The MPS shall be designed to also present summary-level schedules that illustrate actual progress apart from low-level details to allow easy creation of a management-level report.

10. The MPS shall include all tests required by the Specifications. These items in the MPS shall be filterable to enable a schedule of all tests to be easily created. Furnish information regarding the location of the test and the categories of SEPTA personnel (if any) that are required to support or witness the test.

11. Update the preliminary MPS submittal, submitted with the Contractor's Technical proposal, for review at the project kick-off meeting.

    a. This submittal shall be subject to Approval, and shall become the baseline schedule for the program, once Approved.

    b. The Contractor shall not adjust the baseline milestone dates of any task following SEPTA's formal Approval of the MPS submittal.

c. Submit monthly revisions to the schedule in advance of the regular monthly progress review meetings; the reporting date of the monthly progress review shall be the data date of the schedule.

d. Update the MPS to reflect actual completion dates and revised completion dates, corrections, and task additions; report the baseline and current schedule of each task.

e. Maintain identification and traceability of tasks through revisions or adjustments so that affected schedule activities are identified and marked as associated with a specific change.

f. Accompany each MPS update, or a less frequent interval as Approved, with a Schedule Risk Assessment to identify, monitor, and plan responses (e.g., avoid, mitigate) to schedule risks and opportunities. The Schedule Risk Assessment shall use an Approved quantitative risk analysis approach.

12. Follow criteria to align with SEPTA Project Controls requirements:

a. Activity numbers shall not exceed twenty alphanumeric characters.

b. Activity descriptions shall not exceed sixty characters and shall indicate definable items of work.

c. Each activity in the MPS shall be assigned a responsibility code; activities assigned to SEPTA shall be assigned the responsibility code "SE."

d. Each activity in the MPS shall be assigned an area code identifying the location of the Work being performed, where applicable.

e. Each activity in the MPS shall be assigned a phase code identifying the phase, as described in TS 25.5.1, of the work being performed, if applicable.

f. Each activity in the Schedule shall be assigned a subcontractor code identifying the Contractor’s subcontractor performing the Work described by that activity, if applicable.

g. Contract interim milestone dates and the Contract Completion Date shall be input as finish constraint dates and shall agree with such dates specified in the Contract. Other constraint dates are unacceptable unless Approved.

h. The use of lag time in activity relationships should be kept to a minimum and must be Approved. The use of negative lag time in activity relationships is forbidden.

13. Accompany each MPS submission after NTP with a written MPS data narrative and revision log discussing:

a. Calendars used in the MPS

b. Out of sequence logic revision for Approval

c. Non-contract constraint dates and lags for Approval

d. Addition and deletion of activities

e. Addition and deletion of relationships including relationship types and lags

f. Changes to activity descriptions

g. Changes to activity original durations

h. Changes to relationship types and lag codes

i. Changes to contract milestone dates and approved constraint dates

j. All other revisions.

25.5.3 Project Kick-off Meeting

A. A project kick-off meeting shall take place no later than 30 days after NTP. The objective of the meeting is to develop a joint understanding of the project plan, schedule, and risks.

1. The meeting will be held at SEPTA's Headquarters (1234 Market Street) in Philadelphia.

2. The meeting is anticipated to require up to five working days, and shall accomplish the following as a minimum:

a. Introduce SEPTA and Contractor key personnel and suppliers.

b. Establish formal channels of, and procedures for, communication; define drawing tree and car production numbering schemes, etc.

c. Identify technical and schedule risks.

d. Complete a detailed review of the Master Program Schedule; provide an initial Schedule Risk Assessment.

e. Complete a detailed review of commercial and technical provisions of the Contract to enable SEPTA to more completely understand how the Contractor will comply with the requirements.

f. Present the contractors approach to the integration and interface of all contractual requirements.

g. Present a list of components (e.g., video screens) that do not meet a minimum design life of 20 years, for possible Approval.

h. Provide the detailed agenda for this meeting seven days after NTP.

25.5.4 Specification Review Meeting

A. Within 30 days after NTP, conduct a Specification Review Meeting at SEPTA's Headquarters (1234 Market Street). During this meeting the Contractor's Project Manager and technical specialists, major subcontractors, and suppliers will populate the Specification Compliance Matrix (SCM). **(CDRL 25-03, Specification Compliance Matrix (SCM))**

1. Include the following in the SCM at a minimum:

a. A comprehensive list of Specification requirements extracted from the Specifications.

b. As it becomes available during the design phase, list all Documentation the Contractor submitted to demonstrate compliance with each Specification requirement, such as reports, analyses, system descriptions, manuals, drawings, inspection and test procedures, and test reports. The document name and approval status shall be indicated in separate columns.

c. An indication for each requirement when it is compliant.

2. Use the SCM to document the Contractor's compliance with each Specification requirement in spreadsheet format. Populate and submit the SCM for Approval.

3. All approved changes to the original contract requirements shall be indicated with the associated Specification Change Technical Request Number (SCTR).

4. Update the SCM on a regular basis and submit monthly or at another Approved interval.

25.5.5 Monthly Progress Review Meetings

A. Program progress reviews shall be held on a monthly basis unless otherwise directed by SEPTA. As directed by SEPTA, the reviews shall be held at either the Contractor's facility, SEPTA's facilities, or via video conference. In addition to any other pertinent discussion topics, the Contractor's monthly progress update report shall be reviewed at each meeting.

25.5.5.1 Monthly Progress Update Reports

A. Submit monthly progress update reports. **(CDRL 25-04, Monthly Progress Update Reports)**

1. The monthly progress reports shall contain detailed information on the following subjects in narrative form:

    a. Work completed as of the reporting date. For manufacturing activities, this info shall be supplemented by various photos)

    b. Work in progress as of the reporting date

    c. Major problems/risks (e.g., delays incurred or anticipated) and remedial action plans

    d. Status of outstanding action items

    e. Progress against the Approved MPS

        (1) Summary progress towards phase completion

        (2) Progress against the critical path

        (3) Activities that may become critical within the next 30-day period

    f. Engineering Change Proposal (ECP) status

    g. Organizational changes

    h. Subcontractor program progress.

    i. Updated Buy America status.

    j. Updated Staffing Plan (see TS 25.3)

    k. Updated Management Approach (see TS 25.3)

    l. Updated Supply Chain Management Plan (see TS 25.3)

    m. Updated Facilities Plan (see TS 25.3)

    n. Updated Status of Quality Assurance audits (see Section 22, Quality Assurance)

    o. Updated status of Software Quality Assurance audits (see Section 19, Software Engineering)

    p. Updated weight report showing actual and estimated values for all major assemblies. The report shall include breakdowns, car total, imbalances, and axle loading.

2. The progress report shall detail the status of all configuration changes made to each car following Pilot Car FAI.

a. Identify and describe existing and proposed Engineering Change Proposals (ECPs), Production Modification Instructions (PMI), and Field Modification Instructions (FMI), and furnish an implementation status.

b. Clearly describe the schedule for implementation, the effectiveness of each change, and the schedule for incorporation into the normal production process using process traveler and drawing revision documents.

3. Whenever the work progress falls behind the approved MPS, submit information including a comparison to the previous MPS update's status, the reason(s) for the schedule slippages a detailed explanation of the work-around or recovery plan to be followed to regain acceptable progress. Include the work-around or recovery plan in the monthly progress update report. Integrate the response with the Schedule Risk Assessment to identify if monitored risks are realized or if there are unidentified risks.

4. Include additional tabular data, e.g., Risk Register, as Approved.

5. Submit the progress report no later than 10 calendar days after the end of the previous month and at least two business days before any meeting.

25.5.6 Weekly Project Management Meetings

A. Weekly meetings will be scheduled between SEPTA and Contractor Project Managers to discuss program issues. These meetings may be held via video conferencing or in person, as mutually agreed.

B. The agenda for the weekly meeting shall be provided at a minimum 24 hrs in advance.

25.5.7 Phase Completion Meetings

A. Periodic phase completion meetings will be scheduled to measure progress towards completing each program phase. If Approved, some of these meetings may be combined with the Monthly Progress Review meetings.

1. The meetings will be held at SEPTA's Headquarters (1234 Market Street) in Philadelphia.

2. These meetings shall generally be separate from the regular monthly progress review, and may include additional internal and external program stakeholders associated with SEPTA and the Contractor.

3. Program progress will be measured against the completion of items in the MPS. Successful completion of all scheduled activities shall be required before the program moves to the next phase of the life cycle.

4. The Contractor may allow some design activities to proceed, on a case-by-case basis, to the next engineering phase at the sole risk of the carbuilder in order to avoid potential schedule delays.

5. Failure to meet goals can result in delays in the program, withholding of payments, and suspension of deliveries.

6. If a phase review meeting is not successful, the Contractor and SEPTA shall create a joint focus team to expedite any remedial action required to move the program to phase completion.

25.6 Systems Engineering

25.6.1 General

A. Treat the married pair, in its design and manufacture, as a single system rather than as an assembly of independently engineered and manufactured elements.

1. The Systems Engineering function shall be responsible for the successful life-cycle engineering of the married pair, from design through manufacturing, and for integration and testing of all car subsystems, data networks, and software.

2. The Systems Engineer shall review and approve with signature all specifications, drawings, test procedures, and reports.

3. Systems Engineering shall participate in every design review and FAI.

25.6.2 System Integration

A. The Contractor, as part of its responsibility for system design of the entire married pair and all of its equipment, shall be responsible to SEPTA for proper interrelation, function, and system integration of all phases of all subsystems, their interrelation with all other parts of the system, and their interrelation with the wayside and shop facilities.

1. Provide complete systems integration services during the design, manufacturing, and testing phases of the Contract.

2. In concert with the Systems Engineer, coordinate all electrical and mechanical interfaces between the different subsystems, the married pair system and the wayside and shop, and electrical interference control.

3. The system integration services shall include, but not be limited to:

a. Data network integration, including hardware and protocols (Section 17, Network and Trainline Control)

b. Diagnostic subsystem integration (Section 18, Monitoring and Diagnostics)

c. Propulsion and brake subsystem interface and integration (Section 10, Propulsion and High Voltage System, and Section 12, Friction Brake)

d. ATC/PTC System, (Section 20, Automatic Train Control – Positive Train Control)

e. Communications subsystems (Section 13, Communications)

f. Other car subsystem interface and integration

g. Married pair, and train interface

h. Car-to-wayside interface, including EMI/EMC (Section 2, Design and Performance Criteria, and Section 18, Monitoring and Diagnostics)

i. Car-to-shop facilities' interface

j. System Safety Plan

k. Cybersecurity

l. Manuals

m. Reliability and Maintainability

n. Reliability-based maintenance plan

o. Train hardware and software safety

p. Inspection, testing, and maintenance plan (Section 15, Test Program)

q. Training and qualification program

r. Pre-revenue service acceptance testing plan.

25.6.3 Systems Engineering and Integration Testing Plans

A. Submit a Systems Engineering Plan (**CDRL 25-05, Systems Engineering Plan)**. that describes the organization and process by which the Contractor proposes to:

1. Transform Specification requirements into a description of system and subsystem configuration and performance parameters through the use of an iterative process of definition analysis, design, test, and evaluation.

2. Integrate related technical parameters and ensure compatibility of physical, functional, and program interfaces in a manner that optimizes the car design.

3. Incorporate reliability, maintainability, safety, quality assurance testing, and human factors into the total engineering effort.

4. Include design considerations that simplify future overhaul, refurbishment, and technology transfers.

B. As part of the Systems Engineering Plan, submit an integration testing plan **(CDRL 25-06, Systems Integration Testing Plan and Matrix (SITPM)**.

1. The SITPM shall be updated and expanded to include specific test references prior to CDR, PDR, FDR, and Pilot Car FAI meetings.

2. A final revision shall be submitted and Approved prior to SEPTA's acceptance of the Pilot Cars following on-site qualification testing. At that time, the lead Systems Engineer shall certify the successful completion of the integration and testing plan.

3. The SITPM shall clearly identify and describe all of the testing required to thoroughly test each interface within the cars.

4. Successful integration testing of all married-pair subsystems may require testing that is not fully defined in the Specifications. It is the Contractor's responsibility to complete all interface testing to demonstrate a thorough integration of all subsystems.

25.6.4 Interface Control Document

A. Comply with the following:

1. The Contractor and each supplier shall develop and submit a complete set of Interface Control Documents (ICD), in accordance with IEEE 1558, that fully define the mechanical, electrical, and software interfaces for each component **(CDRL 25-07, Interface Control Document)**.

   a. The Contractor shall develop an overall car ICD that integrates ICDs provided by all subsuppliers and for all components, and clearly delineates the responsibility for developing the referenced component level Interface Control Documents.

   b. Each interface or protocol between two or more components shall be tracked through an ICD.

   c. Conflict resolution within the married-pair and train systems shall be documented in the ICD.

2. The Contractor shall furnish Network Interface Control Documents. **(CDRL 25-08, Network Interface Control Document))**

   a. All networks shall be based on the 7-layer Open Systems Interconnection (OSI) model. Full documentation of each layer for each network shall be provided.

   b. Clearly identify (for each component) all signals transmitted over data networks, including the following information for each signal:

      (1) Signal name

      (2) Signal description

      (3) Detailed explanation of signal function, source, and timing characteristics

(4) System or systems concerned

(5) Network path, including sender, receiver, and any intermediate nodes

(6) Data format

(7) Frequency and duration of transmission

(8) Type of transmission service, e.g., broadcast, acknowledged, etc.

(9) Protocols

c. Furnish detailed descriptions of all data frame types transmitted over data networks. Interface documentation for all data networks, wired and wireless, shall be furnished with a level of detail sufficient to permit suppliers, other than the original equipment supplier, to provide compatible and interoperable equipment.

d. All networks, including networks between components within a subsystem, shall be documented through these data Network Interface Control Documents.

e. For additional details, see Section 17, Network and Trainline Control.

3. Develop an ICD that documents how a configurable set of data from the as-built onboard systems can be sent to a future onboard system.

4. Develop a separate ICD that documents data that can be sent to a future vehicle management system (future replacement for VMIS). This ICD shall be a one-way ICD, in the sense that only data to be transferred from the car shall be documented.

25.6.5 System Description

A. Submit **(CDRL 25-09, System Description)**

1. It shall describe and graphically depict the married pair as a system, and the overall train as a system of systems.

2. It shall show all component subsystems, with the internal and external interfaces and networks.

3. All terminology shall be consistent with the Specifications and with the Subsystem Functional Descriptions (SSFDs) for all subsystems.

4. It shall identify by title and document number all subsystem SSFDs, all network description documents, and all interface definition documents.

5. It shall describe the partitioning of requirements between subsystems and shall describe the allocation of any derived requirements to the individual subsystems.

6. It shall provide a consolidated Operator-Vehicle Interface Description.

    a. Provide a consolidated functional requirements specification for vehicle controls, monitoring and diagnostics and reporting, with a focus on information relating to the Operator – vehicle interface.

    b. This document shall describe the vehicle behavior, power up sequence, operating modes and mode transitions, the shutdown sequence as well as other sequences and procedures.

7. All approved changes to the original contract requirements shall be indicated with the associated Specification Change Technical Request Number (SCTR). See TS 25.8.1 for further details.

25.6.6 Subsystem Descriptions

A. Submit a Subsystem Description (SSFD) for each subsystem **(CDRL 25-10, Subsystem Description)**

1. Each SSFD shall include a context diagram showing the specific subsystem in relation to other subsystems and all external interfaces shall be identified and described. All names and other terminology used must match that in the Specifications, the SFD, and all software documentation.

2. A decomposition diagram is required showing the components of the subsystem including hardware, software, and networks. This diagram shall also use terminology consistent with other documentation and shall show all internal interfaces between components and external interfaces to other subsystems.

3. Each Software Configuration Item (SCI), including Commercially Available (CA) items, shall be described in a separately numbered section giving the name of the Software Item, the general functions it will provide, the hardware it is associated with, and the internal interfaces within the subsystem.

4. A Software Summary Table (SST) shall be included with a row for each software item in the system. Columns shall give the software item name and ID, SRS name and ID, SDD name and ID, and the section number within the SSFD where it is described.

5. For programmable logic components such as FPGAs, CPLDs, and other similar devices, all specific hardware and programmed functions and the interfaces shall be defined in a separately numbered section of the SSFD and each item shall be included in the SST or a separate similar table.

6. The final design shall then be documented in the schematics or in an appropriate output of the software tool used to program the device.

7. Each hardware item including printed circuit boards and enclosures shall be described individually.

8. All approved changes to the original contract requirements shall be indicated with the associated Specification Change Technical Request Number (SCTR).

25.7 Configuration Management

25.7.1 General

A. Prepare configuration records for each car produced, as specified or as Approved, and maintain accurate and current configuration records.

1. The configuration records shall be contained in a controlled release document, which shall be available to SEPTA throughout the period of warranty.

2. Ensure that subsuppliers' equipment incorporated in the car design complies with all requirements specified in this Section.

3. SEPTA's car numbers shall be used as the primary equipment reference on all documents and deliverables.

25.7.2 Configuration Management Plan

A. Prepare and submit **(CDRL 25-11, Configuration Management Plan)** This plan shall identify how the Contractor intends to meet the configuration management requirements.

25.7.3 Change Control

A. Comply with the following:

1. The Specifications identify the procurement baseline for the cars. Changes to the procurement baseline shall be controlled by the processing of ECPs.

2. Submit ECPs created prior to the acceptance of the Pilot Cars, or ECPs that are cut into production and do not impact accepted cars.

3. Submit any ECP that impacts accepted cars (e.g., FMIs).

a. The ECP shall include details for ensuring the integration and functionality of each car following the change. In particular, the Contractor shall ensure software integration and functionality.

b. All Field Modification Instructions (FMIs) shall require inspection by SEPTA prior to being considered complete, unless the inspection is waived. This requirement does not relieve the carbuilder of responsibility to inspect all work performed.

4. ECPs shall be reviewed by the Contractor's organization responsible for configuration control for total impact evaluation prior to recommendation and submittal to SEPTA for review and Approval.

    a. ECPs shall be reviewed and approved by the Contractor's Systems Engineering department.

    b. Engineering changes shall affect all cars, unless specifically Approved otherwise.

5. Each configuration change made to a subsystem after Approval of an FAI shall be submitted to SEPTA for Approval.

    a. Submit ECPs with complete documentation, sufficient for a thorough review of the impact of the change on the configuration and performance of the car.

    b. The Contractor must receive Approval from SEPTA prior to implementation of any such change. Any work completed prior to official Approval will be considered noncompliant and shall be re-worked at Contractor's expense.

25.7.4 Configuration Records

A. The Contractor's configuration records shall be prepared to acceptable commercial standards, as specified or as Approved.

1. They shall define the Approved configuration of equipment under development, test, or production, or in operational use, and shall include supporting engineering data (e.g., test procedures, wiring diagrams, etc.). Such items shall be identified to the lowest level required to ensure repeatable performance, quality, and reliability.

2. The configuration records shall portray the relationship between all items. Hardware configurations not used on this Contract, and manufacturing status, shall not be included in the configuration records.

3. The Contractor's configuration records and documentation shall indicate:

    a. The composition of each part number at each level in terms of subordinate part numbers

    b. All next higher assembly part numbers for each part

    c. The specification document, specification control drawings, or source control drawing numbers associated with each subcontractor, supplier, or Contractor part numbers.

4. The Contractor's configuration records and documentation shall identify engineering changes and retain the record of superseded configuration

requirements affecting items that have been formally released for test or production.

5. Employ a system of identifying numbers for specifications, drawings, software, test procedures, test reports, and associated documents that shall ensure that differing parts, assemblies, and installations are uniquely identifiable.

    a. The part number used by the Contractor and its subcontractors shall identify a specific item having a specific configuration.

    b. All items down to the lowest level of repair or replacement that are identified by the same part number shall have the same physical and functional characteristics, shall be equivalent in performance and durability, and shall be interchangeable without alteration to themselves or associated items, other than normal field adjustments. An item shall not be considered interchangeable if it requires selection for fit or performance.

    c. Old and new configuration items that require segregation shall be identified either by a new drawing number or a dash number added to the original drawing.

6. Permanently mark all hardware components to the lowest level of repair and replacement with part number identification.

    a. The hardware identification marking shall at all times coincide with the officially released engineering data.

    b. Nameplates on major equipment items shall provide space for a minimum of 20 characters for SEPTA to add later.

    c. Serialization is required on each item of equipment delivered unless otherwise directed by SEPTA. Individual serial numbers shall be assigned in a numerical sequence established for the type or model series of the equipment being supplied, unless Approved otherwise.

7. Maintain a serialization and configuration record for each car. Submit two copies as part of the Car History Book.

8. Revisions and alterations to items on the car shall be documented in a manner Approved by SEPTA and maintained through the warranty period.

25.7.4.1 Serial Numbers

A. Provide serial numbers of equipment in the relevant Car History Books.

1. Serial numbers shall not exceed 10 digits except where Approved. The revision or alteration version of each item with a serial number shall be noted as part of, or immediately adjacent to, the serial number in a manner as Approved.

2. Duplicate serial numbers shall not be used within a type or model series.

3. Serial numbers are required for:

    a. Carbody

    b. Wheels

    c. Axles

    d. Truck frames

    e. Truck bolsters

    f. Journal bearings

    g. Air conditioning condensers

    h. Air conditioning evaporators

    i. Air conditioning compressors

    j. Air conditioning motors

    k. Couplers

    l. Drawbars

    m. Door operators

    n. Door controls

    o. Traction motors

    p. Traction motor rotors

    q. Gear units

    r. Batteries

    s. Pantographs

    t. Transformers

    u. Line filters

    v. Converters

    w. Inverters

    x. Propulsion control units

y. Brake resistors

z. Brake calipers

aa. Brake actuators

bb. Brake Control Units

cc. Air compressors

dd. Communication control panels

ee. Radios

ff. VMDS units

gg. Passenger information displays

hh. Destination signage

ii. ATC unit

jj. PTC unit

kk. Motors in any of the above-listed apparatus and equipment

ll. Printed circuit boards

mm. Any other items of equipment that are customarily numbered serially.

4. Submit a description of the serial numbers for each of the items listed above as part of the Configuration Management Plan.

   a. The description may identify a block of numbers from which the serial numbers will be drawn, or as a minimum, the number of characters in the serial number and whether numerals, letters, or a combination thereof will be used.

   b. Existing serialization programs of the Contractor or subcontractors will be considered acceptable, subject to Approval.

   c. Serial numbers used by the Contractor and subcontractors shall not duplicate serial numbers assigned to like products, equipment, or parts delivered to SEPTA under separate, ongoing, or previously completed contracts or subcontracts.

5. Submit for Approval a list of items not to be serialized.

25.7.4.2 QR Codes

A. Permanently affix QR codes identifying each part number and serial number to each serially numbered component below the stamped or engraved serial number.

1. The location of QR codes shall be chosen to provide ease of reading without requiring the removal the component from the car.

2. The medium used for the QR code shall be subject to Approval.

3. As a minimum, the QR code itself shall contain the manufacturer's part number, serial number, and a 9-digit allocation for SEPTA's stock number.

4. The Contractor is encouraged to recommend further information to be contained in the QR code.

5. All equipment assemblies and spare parts shall be QR-coded to facilitate electronic scan recording of maintenance actions.

25.7.4.3 Materials Management System

A. SEPTA's Materials Management System is VMIS.

1. Submit all part numbers, serial numbers, configuration data, etc. in a format that can be directly imported into the VMIS system.

2. SEPTA will provide a detailed description of the VMIS tool and interface protocol upon request.

25.8 Deviations and Waivers

25.8.1 Requests for Technical Changes to the Specifications

A. Submit deviation requests individually and formally in a Specification Change Technical Request (SCTR) form.

B. The SCR information shall include:

1. Existing specification language

2. Proposed specification language

3. Justification

4. Program impact(s): cost, schedule, weight, safety

5. Any and all supporting information required for SEPTA to fully evaluate the request.

C. Each request shall be subject to Approval prior to implementation.

25.8.2 Waiver for Proven Equipment

A. If the component or subsystem in question is identical in design to equipment extensively and recently deployed in other North American passenger railroad

applications, it may not be necessary to conduct design qualification tests on that equipment.

1. If the Contractor believes that conducting design qualification tests on a specific item is not necessary, a formal waiver request shall be submitted for Approval. The waiver request shall contain the following data:

    a. Identification of the equipment, including model number and revision level

    b. Methodology used by the equipment supplier to identify and maintain the equipment's configuration

    c. Identification of current locations of equipment applications, quantities of equipment at each location, and date of installation

    d. Equipment owner's contact name, address, and telephone number

    e. Description of all differences between the other application and the requirements of the Specifications

    f. Certified test results for the relevant design qualification tests that have previously been conducted on the equipment.

2. Based on the data submitted, SEPTA will determine if the testing requirements will be waived. Specific requirements for each set of equipment will be considered individually.

25.9 Safety Certification

A. Provide all resources and specialized staffing necessary to complete the system safety certification activities as detailed in the SEPTA Safety and Security Certification Plan (latest revision), and in Section 23, System Safety and Security.

1. The Contractor shall be an active member of the Safety Committee for this procurement, and shall be responsible for providing all data necessary to obtain SEPTA's safety certification.

2. SEPTA's safety certification process will start immediately following NTP and must be completed prior to Pilot Car acceptance.

25.10 Pilot Car Production

25.10.1 Pilot Cars

A. The Pilot Cars shall be the first three married pairs completed, and shall be the first cars delivered to SEPTA's site for acceptance testing.

1. SEPTA will examine and provide contractual disposition to each assembled and completed part of the work before similar work is undertaken on the remaining cars of that type.

2. The remaining cars are considered production cars and shall be constructed and assembled in accordance with the Pilot Cars. No changes shall be made unless authorized in writing in accordance with the configuration control requirements of the Specifications.

3. The intent of this section is that all cars shall be of the same configuration. This provision is not intended to discourage the incorporation of design improvements during the construction of the cars, as "effective point" changes, with SEPTA's concurrence.

25.10.2 Pilot Car Production Reviews

A. During the production of the Pilot Cars, hold regular (e.g., monthly) Pilot Car Production meetings.

1. The purpose of these meetings is to review each installation during the production of each Pilot Car with all internal stakeholders and SEPTA representatives to confirm the installation meets the Contractor's production standards and SEPTA's Specifications.

2. In addition, these meetings will enable the revision of SEPTA's book of quality standards to establish specific quality inspection criteria for all production cars where the criteria are not expressly stated in the Specifications.

3. Meetings shall be conducted on the cars such that each installation can be reviewed in situ.

4. Contractor attendees shall include at a minimum:

a. Contractor:

(1) Production Engineer

(2) Quality Control Manager

(3) Quality Assurance Engineer

(4) Systems Engineer

(5) Supplier representatives, as required

(6) Design Engineering

(7) Industrial Designer.

5. The Contractor shall empower its production and design engineers to create red-lines to drawings, as required, based on the outcomes of these meetings.

6. These meetings are considered formal program meetings. All meeting minutes and action items shall be recorded and distributed.

7. SEPTA may validate the incorporation of any changes resulting from Pilot Car production reviews by performing additional reviews on later cars. Support these validation reviews in the same manner as the Pilot Car production reviews.

25.10.3 Maintainability and Safety Review

A. Following the production of the first set of Pilot Cars, and prior to the Pilot Car FAI, host a Maintainability and Safety Review meeting to allow a thorough review of the completed cars by SEPTA's maintenance, safety, and training personnel.

1. Execute the Pilot Car Maintainability Demonstration Plan specified in Section 21, Reliability, Availability, and Maintainability, as part of this Maintainability and Safety review.

2. Submit for Approval the list of consumables, with associated frequency of replacement/reapplication, as part of this review.

3. Be prepared to make necessary configuration changes and adjustments to installations based on the outcomes of this review.

4. Successful completion of this review and associated action items is required prior to scheduling the Pilot Car FAI (see Section 22, Quality Assurance).

25.11 Sample Car Inspection

A. The Contractor shall participate in and assist SEPTA during the sample car inspection by the FRA. For this activity, the contractor shall be prepared to demonstrate the following, at a minimum:

1. Review of the latest revision of the safety appliance arrangements drawings showing dimensions and locations with respect to top of rail and coupler centers as outlined in 49 CFR Section 231.14- Passenger-train cars without end platforms.

2. Review of all signage installed on the car for service

3. Emergency lighting duration test.

4. Door Operation

5. Removal of a typical emergency window for escape and for access into the vehicle

6. Operation of the Passenger Emergency Intercom (PEI)

7. Confirm the dimensions for the ADA restroom (not equipped on the Silverliner VI, but added to list for completeness as this was listed by FRA)

8. Wheelchair lift test if so equipped

9. Physical Inspection of the vehicle

10. Review relevant testing data

11. Anything missing from this list that is required of FRA Freight sample car inspection that is relevant to passenger vehicles , or is requested by the FRA representative at the time of the inspection.

B. The individual assigned to perform the sample car inspection shall review in advance the current MP&E Sample Car Inspection Procedure Guidelines, pertinent regulations covering the type of car or locomotive to be inspected, and (if possible) the current Association of American Railroads (AAR) Manual of Standards and Recommended Practices or the American Public Transit Association (APTA) Standards applicable to the car to be inspected. Inspectors should have the necessary equipment to perform the inspection (i.e., appropriate regulations and standards, gauges, camera, ruler, measuring devices, and the checklist)

C. Equipment shall be inspected according to:

1. 49 CFR Part 215 Freight Car Safety Standards

2. 49 CFR Part 223 Safety Glazing Standards

3. 49 CFR Part 224 Reflectorization

4. 49 CFR Part 229 Locomotive Safety Standards

5. 49 CFR Part 231 Safety Appliance Standards

6. 49 CFR Part 232 Power Brake Systems

7. 49 CFR Part 238 Passenger Car Equipment Safety Standards

8. 49 CFR Part 239 Passenger Train Emergency Preparedness

D. Equipment shall be inspected from a standpoint of Operational Safety including those not covered by regulations. Photographs will be taken of conditions detrimental or potentially detrimental to safety.

E. Inspector shall be able to inspect the brake system and examine the location of pertinent brake components which must be observed during the performance of required brake inspections by railroad inspectors. The brake must be designed so that a railroad inspector can observe from a safe position, either the piston travel, an accurate indicator which shows piston travel, or any other means by which the brake system is actuated. The design shall not require the railroad inspector to be placed on, under, or between components of the equipment to observe the brake actuation or release during a required train air brake inspection.

F. FRA Form F6180.4, Special Inspection of Safety Appliance Equipment, will be completed for each type of equipment inspected.

G. The Hand Brake entry should include the manufacturer and model number. The Handhold and Ladder Tread entries should show clear, usable length. The Power Brake block should show the type of brake applied.

H. Provide copies of the golden shoe test report, along with any other brake test reports, slewing reports, etc., to the inspector upon request.

I. The inspector shall not advise the carbuilder that all FRA requirements are met but may generally advise the carbuilder of findings.

J. Carbuilder shall support any additional inspections the inspector wishes to perform as part of the sample car inspection.

K. Carbuilder shall notify SEPTA 45 days prior to the perceived date the first married pair will be ready for the sample car inspection.

L. SEPTA will be responsible for contacting the FRA to confirm availability to establish inspection date.

25.12 Shipping Authorization

A. The Contractor must receive written authorization from SEPTA prior to shipping car shells from their point of manufacture to the final assembly site, and prior to shipping completed cars to SEPTA.

1. Prior to authorizing shipment, SEPTA will review all documentation, including all open items lists, non-conformance reports, and car history books.

2. Payments will be withheld for any carshell or completed car shipped without specific Approval.

3. Neither a pre-shipment inspection nor a release for shipment shall be considered by the Contractor to constitute acceptance of a car or other material.

25.13 Car Commissioning Process

A. The process of commissioning includes qualification and routine testing, serial production car delivery, testing, inspection, and acceptance, and fleet warranty support.

1. Assign an on-site Commissioning Manager to lead all related activities.

2. The Commissioning Manager shall report directly to the Program Manager and shall have full responsibility for all Contractor and subsupplier activities in the commissioning phase of the program.

3. The Contractor shall provide office space at SEPTA's commissioning site for up to five staff throughout the commissioning process.

25.13.1 Inspections and Testing

A. Comply with the following requirements:

1. Inspection: Give the Commissioning Manager the necessary authority and resources to ensure that cars and subsystem equipment are presented to SEPTA for inspection in accordance with Section 22, Quality Assurance, and agreed protocols.

2. Testing:

a. Perform testing in compliance with Section 15, Test Program, and the Approved Test Plan.

b. The Contractor's Commissioning Manager shall be responsible for scheduling all tests and for ensuring that all necessary test documentation is submitted to SEPTA at the required time.

c. The Commissioning Manager shall ensure that adequate and competent resources are available to conduct all required testing according to schedule.

d. SEPTA reserves the right to perform, at its own expense, operating tests of each car, married pair, and in trains of up to six cars. The Contractor shall assign a competent representative to witness such operating tests.

3. Defects:

a. Each defect disclosed by such tests in apparatus, materials, or workmanship shall be corrected at the Contractor's expense.

b. The Contractor shall bear all expenses and costs incurred in the removal of cars from the designated delivery point for correction of defects.

c. If a car is delivered to SEPTA that has previously been rejected, the Contractor shall bear all expenses for testing that must be repeated. The Contractor shall further be held responsible for any impacts on SEPTA's daily operations this rejected car may cause, either by occupying needed space or by requiring resources needed for commissioning of other cars.

25.13.2 Warranty Support

A. The Contractor's Commissioning Manager shall be available at SEPTA site throughout the warranty period and shall make available within 3 hours sufficient technical resources for warranty actions necessary to return cars to revenue service without unreasonable delay.

1. Submit a warranty plan. **(CDRL 25-12, Warranty Plan)**

25.14 Spare Parts Management

A. The Contractor is responsible for the delivery of all spare parts under this Contract.

1. Ensure that all spare parts delivered to SEPTA are maintained to the latest configuration at all times throughout the warranty period.

2. Parts that have a limited shelf life (e.g., elastomeric products) shall be replaced accordingly so that the required amount of parts are available at all times.

3. Parts that may require special storage conditions (e.g. batteries) shall be handled accordingly by the contractor.

4. All data received from the Contractor shall be in a format that can be directly imported into SEPTA's Materials Management system (VMIS).

5. The Contractor shall furnish spare parts for all apparatus and components of the cars in the quantities and configuration listed in the price proposal. Deliver all assemblies as called out in the delivery schedule. All items shall be identical with corresponding items as provided on the cars, and any changes to parts made on the cars before or during the warranty period shall be made by the Contractor on applicable spare parts at no cost to SEPTA. Where appropriate, all parts shall be packaged for long term and protected storage.

6. The Contractor shall supply a quantity of consumable type spare parts other than lubricants required to support operation of the base quantity of cars for a period of twelve months from delivery of each car. These parts shall be based upon the consumable parts identified in the maintenance manuals such as HVAC filters, compressed air system filters, brake shoes and pads, windshield wiper blades, interior lamps and exterior bulbs, including indicator LEDs and the like, required to support all daily, periodic, preventative, and any other type of scheduled maintenance.

7. The Contractor shall supply three married pairs' worth of spare trucks that are entirely identical to, and fully interchangeable with, the other trucks of the same type provided under this Contract. Deliver the spare trucks in assembled form, ready for installation under a car. These spare trucks are separate from the ones required in Exhibit III of the Contract.

8. Spare parts from different subsystems shall not be crated or stored together when delivered to SEPTA.

9. Submit the following CDRLs for spare parts:

   a. **CDRL 25-13, Spare Parts Provisioning Plan**

   b. **CDRL 25-14, Recommended Spare Parts List**

   c. **CDRL 25-15, Spare Parts Control Numbering System**

25.15 Design Documentation and Other Deliverables

25.15.1 Contract Deliverable Requirements

A. Comply with the following requirements:

1. See Section 1, General Topics and Definitions, for general requirements for Contract deliverables.

2. Specific requirements for each deliverable are contained in the referenced Specification section. CDRLs are noted in the body of each section as CDRLs and specified in detail in the CDRL Detail section at the end of each Specification section. Table 25-2 contains a consolidated listing of the CDRLs identified at the end of each section.

3. Each deliverable submitted shall be identified on the first page of the document by the applicable CDRL number. In addition, include the relevant CDRL number or Specification section number in the subject line of the transmittal letter.

4. Each document shall include a list of applicable acronyms near the beginning of the document.

5. Where a CDRL is applicable to multiple parties (e.g., suppliers), use a sub-number for tracking purposes, and show each in the tracking report.

6. When data contained in a CDRL item has changed, submit a new CDRL.

7. Proper revision level numbering, a revision log, and tracked changes indications shall be provided with each updated document.

8. Whenever the estimated completion date of a CDRL shown on a schedule has passed, furnish a revised completion date to SEPTA.

9. Multiple documents may address a single CDRL, while some documents may address multiple CDRLs.

25.15.2 Drawings

25.15.2.1 General Requirements

A. Submit a method of drawing organization and naming convention (see also TS 25.5.3).

1. Submit a Drawing List and update for each project phase. **(CDRL 25-16, Drawing List)**

2. Provide either 2D or 3D drawings, or both, for each submittal as specified by SEPTA. SEPTA's intent is for design reviews to primarily use 3D drawings, with 2D drawings used as part of final drawing packages and for documentation intended for use while away from a desktop computer (e.g., troubleshooting manuals).

3. Comply with the following requirements for drawings:

    a. Submit drawings in a SEPTA-Approved file format. Where solid models (3D) are approved for formal submittal, they shall be in SOLIDWORKS and STEP format and in a fully query-capable format such as Adobe PDF 3D, with other model viewer formats only if a freely licensed viewer is available and identified by the Contractor.

    b. SEPTA anticipates that the top-level car assembly drawings will be in a 3D format, with 3D parts drawings. Where 3D drawings are submitted, corresponding 2D drawings shall also be submitted if determined necessary by SEPTA, as generated in an Approved CAD format from the 3D model.

    c. Information on drawings shall be in black on a white background.

    d. Dimensions on drawings shall be in U.S. Customary Units with International System of Units following in parentheses.

    e. Drawing file names, titles and wording on drawings shall be in English. English translations shall appear adjacent to, and dominate, the original wording/units.

    f. Terminology used in drawings and correspondence shall be conventional to the transit and railroad industries within the United States.

    g. Include a drawing key to permit rapid identification of elements portrayed.

    h. Electrical drawings shall include the state of the circuitry.

    i. Drawings containing weldments shall provide a clear reference to the Welding Procedure Specification (WPS) used to make the welds. The WPS references shall be included adjacent to each weld symbol on the drawing. Welding symbols shall be per AWS, or as Approved.

    j. The selected projection for drawings shall be consistent for all drawings.

    k. No more than five sizes of drawings shall be used, with 36 by 72 inches (914 by 1829 mm) being the largest drawing size permissible.

4. Submit for Approval, detailed drawings of all assemblies, subassemblies, equipment, apparatus, and each car type, including mechanical and electrical details.

    a. Submit sufficient drawings to convey concept, design, dimensions, maintenance access, operation, overall assembly aspects, and interfaces.

    b. Detailed parts drawings need not be furnished unless required by SEPTA to enable its review of another drawing.

c. Arrangements and details of all apparatus, including apparatus within equipment boxes, shall be submitted for review; outline drawings are not sufficient.

d. Electrical drawings include schematics, wire lists, device tables, train-wide circuits, and device locators. Complete and editable schematic files are required for every circuit board used in the cars, in a Special Tool, in a portable test unit (PTU), or in a bench test equipment (BTE) assembly.

e. Each drawing shall include the following:

(1) A complete Bill of Materials, supplier name, and supplier part number on the field of the drawing or on a separate sheet of the same drawing, describing all parts and subassemblies, including subcontractor-furnished items that form a part of the assembly, subassembly, or piece depicted.

(2) Every assembly drawing shall include the weight of the assembly.

(3) Drawings shall reference the drawing number of the next higher subassembly or assembly. This requirement does not apply to standard hardware, electrical, or electronic components.

(4) Whenever a material or process is identified on a drawing by the Contractor's own specification number, the drawing shall also include the commercial equivalent. If there is no commercial equivalent, furnish copies of its specification.

f. Approval of a drawing does not relieve the Contractor of the obligation to meet the requirements of the Contract. Approval of a drawing that contains a deviation from, or violation of, the Specifications does not constitute authority for that deviation or violation. Such deviations must be specifically requested and granted.

25.15.2.2 Drawing Revisions

A. Submit revisions to drawings affecting submitted drawings as they are issued.

1. No more than five drawing change orders shall remain unincorporated on a drawing at any time.

2. Drawings on which changes have been made, even though fewer than five in number, shall be revised to incorporate those changes at no less than the following project phase. After FAI, updates shall be provided at no less than two-month intervals so that on-site inspectors have updated information.

3. The revision block shall give details of the changes made by that revision, or a summary of the changes and the numbers of drawing change orders may be used instead of detailed descriptions. In the latter case, the drawing change

orders shall have been submitted no later than at the time of submittal of the revised drawing and shall give details of the change made by the revision.

25.15.2.3 Arrangement Drawings

A. Prior to beginning final design of the cars, submit complete and comprehensive arrangement drawings of the cars. **(CDRL 25-17, Arrangement Drawings)**

1. Arrangement drawings shall be included on the Drawing List.

2. Arrangement drawings for each car type shall include:

a. Floor plan with square footage for calculation values of passengers at AW1, 2 and 3 levels

b. Reflected ceiling plan

c. Underfloor equipment arrangement

d. Details for all major components and equipment including overall dimensions, orientation, center of gravity, weight, points of normal support, method of support during mounting and removal, and including sufficient information to evaluate access space requirements for maintenance, inspection, and repair.

e. Inside longitudinal sections of both sides of the car

f. Exterior side elevations of both sides of the car

g. Elevation views of both ends of the car

h. Location and space requirements for ventilation intake and exhaust openings and cable entrances.

i. Sufficient transverse half-sections or full sections through the car to show all variations in cross-section such as at windows, doors, and door pockets. The cross-sections shall also show underfloor equipment.

j. Truck assembly

3. After Approval, revise arrangement drawings upon SEPTA request.

25.15.2.4 Dynamic Outline Drawing

A. Submit, prior to beginning the final design of the cars, a complete dynamic outline of the proposed car. **(CDRL 25-18, Dynamic Outline Drawing)**

1. Include these drawings on the Drawing List.

2. Include the following:

    a. All projecting appurtenances.

    b. All possible motions that fall within the limiting dynamic outline given in Appendix A Contract Drawings, Dynamic Outline.

    c. Supporting assumptions, tolerances, and calculations.

25.15.2.5 "As-Built" Drawings

A. Prior to the acceptance of the last married pair, submit an updated drawing list and a complete set of "as-built" drawings for the fleet in a SEPTA-Approved format. **(CDRL 25-19, As-Built Drawings)**.

1. Submit complete and Approved sets of every as-built drawing and 3D model used in the manufacturing and construction of the cars and for all other items of material and equipment provided.

2. Submit two complete sets of the drawings on external solid state drive, with a minimum 15-year design life unless otherwise Approved (including any special font files) and two complete sets of the drawings as hard copy drawings plotted on vellum.

3. Each electronic drawing shall be capable of being opened and have editing capabilities using the software selected. The drawings shall be completely updated via the Contractor's configuration management system until the end of the warranty including any extensions.

4. The drawing sets shall contain a copy of every drawing used by the Contractor, every subcontractor, and every supplier in this procurement, regardless of previous submission. This shall include all "off-the-car" material and equipment furnished under this Contract, all diagnostic tools, and all special tools.

5. Include circuit board level detail, installation, and connection drawings. Include general arrangement drawings, color schedules, and clearance drawings. Prepare drawings in accordance with ASME Y14 drawing standards using third angle projections. First angle projection will be allowed provided all views are labeled including the front, top, bottom, and side views.

6. Incorporate every engineering change, deviation, Material Review Board (MRB) repair, or similar variance affecting form, fit, or function into the affected drawing whenever such variance applies to five or more cars.

7. Those variances applying to fewer than five cars may either be incorporated in the affected drawings or, as an alternative, be supplied separately, with a list of applicable variances included in each relevant Car History Book, cross-referenced to the affected drawings.

25.15.2.6 Use of Terminology of Existing Cars

A. To facilitate understanding and maintenance of the cars, each component or device that corresponds closely in function to a counterpart on SEPTA's Silverliner V cars shall be designated by the same name and symbol used for that counterpart in the drawings, schematics, and manuals that describe SEPTA's existing cars.

B. SEPTA will provide sample documentation (e.g., manuals, schematics, and other drawings) demonstrating names and symbols used for components and devices on the existing cars at or before the kick-off meetings.

25.16 Design Reviews

25.16.1 General

A. Three phases of formal design review meetings shall be held, at Approved location(s), to evaluate and summarize progress of design. These periodic in-progress reviews shall be conducted to evaluate the progress and technical adequacy of the design and compatibility with the requirements of the Contract.

1. Develop an outline for a complete design review submittal package based on the specified requirements for all design reviews, and as Approved.

    a. For each design review phase, furnish the complete outline document, with the Table of Contents showing which sections of the submittal are required for that phase of design review.

    b. Subsequent design reviews shall update prior submittals while adding to the overall content.

    c. All prior design documents shall be resubmitted for completeness of the package, even if previously approved and not updated.

    d. Updated revision levels shall be provided accordingly. Updates shall also be indicated using the "track-changes" features of the Microsoft Office software, with a "changes accepted" revision also submitted for clarity.

    e. The Final Design Review Package shall be independent, in that it documents all elements of the design reviews, without need to refer to other prior submittals.

2. Key system suppliers shall attend the design review meetings (the Contractor may request an exception for Conceptual Design Review only)

3. Review meetings shall include the presentation and review of the system function and design, the and functionality of BTEs and PTUs, including any related custom software. Design review document package submittals shall include adequate information to support the review of the BTE and PTUs.

4. Systems engineering, safety certification, maintainability and reliability shall be reviewed in detail at each meeting. Failure to provide such information may

result in a delay of the applicable design review meeting until such information is furnished.

5. Prior to each review, submit a review package that includes the system functional description, drawings, technical data, analyses, CDRLs, and other supporting information required for the review. These review packages shall be received no later than 30 days before the scheduled design review.

6. After each review, update the design review package to address prior written comments and comments from the design review meeting itself. This package will be the basis of Approval of the design review.

7. Informal working sessions may be scheduled between design phases at SEPTA's discretion in order to facilitate discussion of design updates and reduce interim submittal letters. Such working sessions may be held virtually where appropriate.

25.16.2 Conceptual Design Review

A. The purpose of the Conceptual Design Review (CDR) is for the Contractor to seek SEPTA's early agreement on the approach to the design of the cars and their subsystems.

1. The CDR shall be based on, and consistent with the Specifications and the Contractor's Final Proposal Revision, and shall provide such additional details as necessary to fully present the design approach, to eliminate ambiguities, and to narrow alternatives as subsystem subcontractors are selected.

2. The CDR may be accomplished progressively on a subsystem-by-subsystem basis, and separate CDR sessions may be scheduled.

3. Schedule subcontractor participation to support the Contractor's presentation of the design concepts and be available for detailed questions from SEPTA.

4. The CDR process shall commence no later than 90 days after Contract award.

5. Submit CDR package (or packages). **(CDRL 25-20, CDR Package(s)**

a. Include the following as a minimum:

(1) A narrative description of each major subsystem as proposed by the Contractor and subsupplier(s). This may be an elaboration, confirmation, or clarification of information submitted during pre-award discussions or as part of the Best and Final Offer.

(2) A dynamic outline and calculations for the car and its structure, including worst-case conditions of wear and failure.

(3) Updated car arrangement drawings.

(4) Identification of all interfaces between the major systems and subsystems.

(5) A narrative description of each BTE and PTU. Where PTUs consist of laptops with custom software, furnish a description of the various custom software applications, including minimum system requirements to operate the software, and comparison of the functionality with regard to the VMDS capability.

(6) Status review of all CDRLs scheduled for delivery during this phase as detailed on the MPS.

25.16.3 Preliminary Design Review

A. Conduct a formal Preliminary Design Review (PDR) to summarize progress made with the selected design approach, evaluate its adequacy, and access its compliance with the Specifications.

1. The PDR shall represent approximately 60% completion of the total engineering effort required for the cars to be provided.

2. Submit PDR package (or packages) **(CDRL 25-21, PDR Package(s))**

a. Include the following as a minimum:

(1) Interior layout

(2) Underfloor layout

(3) Detailed functional descriptions of car subsystems and major components and the Overall SFD and SFD for each system.

(4) Detailed interface descriptions and drawings, including mounting arrangements, installation methods, and definitions of all electrical connections with voltage, current, waveform, and impedance levels.

(5) Software plans and documentation required in Section 19, Software Engineering.

(6) List of trainlines and proposed coupler pin arrangement.

(7) Heat load calculations for the heating, ventilating, and cooling (HVAC) subsystem, including psychometric charts for each control condition.

(8) Data verifying that the propulsion equipment and friction brake equipment meet the specified performance and thermal duty cycle.

(9) Propulsion motor characteristics showing speed, voltage, and tractive effort versus motor current.

(10) Preliminary Hazard Analysis (PHA) (Section 23, System Safety and Security).

(11) List of special tools required for each subsystem.

(12) Detailed functional descriptions of the BTEs and PTUs, including detailed descriptions of the software design and configuration control methods, and compliance with VMDS capability.

(13) List of all person/machine interfaces in the Operator's cab area.

(14) Roll center location (height) and list of carbody motion limits in relation to the track as follows: vertical, lateral, longitudinal, and roll (degrees).

(15) Suspension characteristics including damping constant of each shock absorber, natural frequency, and spring rate of primary and secondary suspension.

(16) Details of the passenger door system.

(17) Specifications for seating.

(18) Side window and windshield specifications.

(19) Status review of all CDRLs scheduled for delivery during this phase as detailed on the MPS.

(20) List of all repairable line replaceable units (LRUs) and LLRUs.

(21) Preliminary car structural design.

25.16.4 Final Design Review

A. The Final Design Review (FDR) shall be conducted incrementally as the final design of each subsystem is completed and the production drawings are ready for release.

1. The FDR shall confirm that the design of the subsystem under review satisfies the Contract requirements, including compatibility of car interfaces with other subsystems on the car, other cars in SEPTA's fleet, and SEPTA's wayside systems.

2. During the review, demonstrate that all design-related safety hazards have been mitigated. Submit all FMECA and fault tree data and obtain Approval prior to FDR.

3. Submit FDR package (or packages). **(CDRL 25-22, FDR Package(s))**:

a. Latest revisions of the drawings and documentation submitted for the PDR, including the SFD and the SSFDs for each subsystem.

b. Assembly drawings down to LLRU.

c. Software documentation as required by Section 19, Software Engineering.

d. Electrical schematic drawings, down to the individual signal or wire level, for each electrical circuit.

e. Pneumatic schematics or flow schematics for each fluid circuit, showing control and check valves, test point orifices, and other circuit details.

f. Final brake failure mode analysis.

g. Component data sheets upon request by SEPTA.

h. Assembly drawings for all BTEs and PTUs, other than laptops or other commercially-available PTUs.

i. Status review of all CDRLs scheduled for delivery during this phase as detailed on the MPS.

j. List of all repairable LRUs and LLRUs.

k. Final car structural design

l. A single exterior arrangement drawing that shows, at a minimum the following dimensional details:

   (1) Car length

   (2) Door width

   (3) Door height

   (4) Window height

   (5) Exterior equipment locations.

m. A single interior arrangement drawing that shows, at a minimum the following dimensional details:

   (1) Aisle width

   (2) Seat dimensions

   (3) Seating offset

   (4) Interior equipment locations.

25.16.5 Design Verification Review

A. Conduct a series of Design Verification Reviews (DVR) to serve as a tangible baseline to demonstrate the evolution of the car design to SEPTA internal and external stakeholders. Conduct these reviews utilizing 3D models and renderings in conjunction with the mock-ups and virtual reality scenarios specified in TS 25.17.

B. The DVR process will begin at or before PDR and carry forward through the project's design review and initial manufacturing phases. The DVRs shall be used to validate SEPTA Approval of the design and design progress, and accomplish the following:

1. Demonstrate the mock-up car design features for concept visualization and stakeholder buy-in.

2. Demonstrate the form-fit-finish of aesthetic design elements.

3. Demonstrate proposed equipment locations and configurations.

4. Verify that the overall equipment location scheme meets accessibility and maintainability requirements, including removal and replacement of equipment.

5. Provide a mechanism for the Contractor to translate 3D CAD concepts into physical reality to evaluate design decisions and assess manufacturability considerations.

6. Serve as a practical laboratory to evaluate alternate design options for integrating car structural elements and carborne equipment with the routing of power, control, and pneumatic lines.

7. Provide an overall tool for SEPTA and the Contractor to come to agreement on design, configuration, and appearance matters.

25.17 Engineering Mock-Ups, Models, and Materials

25.17.1 Cab and Interior Soft Mock-up and Virtual Reality Scenarios

A. At or before PDR, construct a full-scale mock-up of the full-width Operator's cab and half of the car interior including high and low level doors, The purpose of this mock-up is to facilitate the ongoing design review process.

B. Fabricate the mock-up using wood or similar Approved, durable, but easily modifiable material, to provide dimensional stability throughout the initial design development and review iterations. **(CDRL 25-23, Cab and Interior Soft Mock-ups)**

1. The mock-up shall indicate proposed locations and arrangements of all controls, indications, panels, windows, cab seating, cab bulkheads, cab doors, low-level passenger door and trap door, if applicable, and observer seat and instruments, and other equipment.

2. The mock-up shall be used to convey the layout of the cab in the detail illustrated in drawings, and as such, shall show the current status of the design.

3. The mock-up shall include representative access panels and volumetric representations of major subassemblies for evaluation of equipment removal and replacement.

4. As part of the mock-up review, it shall be possible to easily relocate controls and equipment representations to assess alternative layouts and ergonomic arrangements.

5. Present samples of pushbuttons, switches, displays, master controller, and other Operator interfaces for inspection during mock-up review.

6. The full-width cab portion of the mock-up should be separable from the passenger area mockup to allow review at a separate location.

7. The passenger portion of the mock-up shall at a minimum include seats, screens, lighting, luggage racks, signage, door partitions, stanchions, bike racks, mobility-aid parking, etc., to convey the interior arrangement plans.

8. After initial Approval, the soft mock-up shall remain intact, and shall be kept up-to-date to reflect design and configuration changes, until the full-scale A-car mock-up is completed.

9. At a date determined by SEPTA, the mock-up shall be removed by the contractor at the contractor's expense.

10. As part of each design review phase, provide virtual reality scenarios. Virtual reality scenarios shall be updated to reflect Approved design and configuration changes, until the final design has been completed. Provide the following at a minimum **(CDRL 25-24, Virtual Reality Scenarios)** :

    a. View of the interior and exterior of the vehicle under various lighting conditions (e.g. bright sunlight, night, etc.) to help SEPTA stakeholders and the public understand the final appearance of the car.

    b. Access and maintainability of major subassemblies.

    c. Cab layout, controls, and sounds (alerts and annunciators).

    d. All specified seating configurations for evaluation.

    e. Sample passenger information messages, visual and audible

    f. All necessary hardware, software, and licenses necessary for at least two people using the virtual reality scenarios simultaneously.

25.17.2 Full Scale A-Car Design Mock-Up

A. At or before FDR, construct a pre-production detailed mock-up of the A-car. The purpose of this car is to facilitate the ongoing design review process, to provide a potential test platform to facilitate developmental system integration testing.

B. At an agreed time during pilot car production, the mock-up car shall be shipped to SEPTA for use in public relations events and staff orientation events. **(CDRL 25-25, Full Scale A-Car Design Mock-up)** .

1. Construct the full scale mock-up car using actual production methods and materials to the extent practicable to replicate accurately the complete A-car, unless otherwise noted. Exceptions to using actual production materials and construction methods will be considered but shall be submitted with justification.

2. The mock-up shall be designed to be transportable from Contractor to SEPTA sites.

3. The mock-up shall be finished and complete on both the exterior (including livery, decals, and underfloor equipment installation) and interior to represent the final car configuration.

4. During the design phase of the program, configure the underfloor equipment arrangement to demonstrate differences in the A and B-car equipment arrangement in an Approved manner.

5. Also incorporate selected modifications to the base A-car configuration to demonstrate unique B-car features if applicable. The selected B-car modifications shall be subject to SEPTA review and Approval.

6. Also incorporate selected modifications to the base A-car configuration to demonstrate unique airport car features and demonstrate the conversion from airport to standard layout, and reverse . The selected airport car modifications shall be subject to SEPTA review and Approval.

7. The mock-up shall be used to demonstrate the low level to high level door conversion in its original, and future state. Should there be differences in the conversion of the low level doors, for example at the cab end, all scenarios shall be demonstrated.

8. The mock-up may initially use temporary items to demonstrate proposed design evolution concepts, such as special shop trucks or stands to facilitate underfloor review, but the final mock-up configuration shall be populated with the exact equipment and components employed on the cars except as otherwise Approved or specified in this Section.

9. Provide renderings of the car for public distribution**.**

10. At a date determined by SEPTA, the mock-up shall be removed by the Contractor at the Contractor's expense.

25.17.3 Married Pair Models

A. Construct and submit to SEPTA scale models of the exterior of a married pair.

1. The exterior shall display the styling, the current representation of decorative treatments for, and application of SEPTA's identification.

2. The interior layout and trucks are not required to be fully detailed.

3. Deliver one 10-foot (3 m) long model and four 4-foot (1.2 m) long models. All models shall be delivered with Approved carrying, shipping, and display cases.

4. The models shall become SEPTA property.

25.17.4 Prototype Seating

A. Provide seats in accordance with Section 14, Interior and Exterior Appointments.

1. Because of the difficulty of depicting the shape and comfort of a seat in drawings, submit for inspection (prior to production), a production prototype of each seat type to supplement the seat drawings and convey all aspects of the seat design. **(CDRL 25-26, Seat Production Prototypes (by seat type))**

a. Submit drawings and prototype seat assemblies prior to production of the seats.

b. Prototypes shall be as close to production quality and comfort, and use production grade materials as practicably possible.

2. Show seat drawings on the drawing list, and include as part of the drawing submittal requirements. Deliver prototype seats to the attention of the Program Manager, at SEPTA.

3. Upon Approval, and if in good condition, the prototype assemblies may be subsequently installed on a car.

25.17.5 Decorative Material Samples

A. Submit samples of each decorative material. **(CDRL 25-27, Decorative Material Samples)**

1. Materials include plastics, upholstery, paint chips, floor coverings, and other decorative materials.

25.18 Car History Books

A. Submit a Car History Book for each car **(CDRL 25-28, Car History Books)**.

1. Each Car History Book shall travel with the applicable carshell or completed car when shipped.

2. Car History Books shall be readily available for inspection by SEPTA's representatives upon request.

3. Keep the Car History Books up-to-date and record all changes, repairs, retrofits, and additions made to each car until conditional acceptance of the car.

4. After SEPTA acceptance of car, provide all FMI documentation to SEPTA for addition into the car history books.

25.19 Contract Deliverable Requirements List (CDRL)

The following contract deliverables have been identified in this section; however, the Contractor is responsible for providing and submitting anything necessary to fulfill the requirements of this contract, including those not identified by CDRL number.

CDRL 25-01, Program Management Plan (PMP) 25-3
CDRL 25-02, Master Program Schedule 25-7
CDRL 25-03, Specification Compliance Matrix (SCM) 25-11
CDRL 25-04, Monthly Progress Update Reports 25-11
CDRL 25-05, Systems Engineering Plan 25-15
CDRL 25-06, Systems Integration Testing Plan and Matrix (SITPM) 25-15
CDRL 25-07, Interface Control Document 25-16
CDRL 25-08, Network Interface Control Document 25-16
CDRL 25-09, System Description 25-17
CDRL 25-10, Subsystem Description 25-18
CDRL 25-11, Configuration Management Plan 25-19
CDRL 25-12, Warranty Plan 25-30
CDRL 25-13, Spare Parts Provisioning Plan 25-31
CDRL 25-14, Recommended Spare Parts List 25-31
CDRL 25-15, Spare Parts Control Numbering System 25-31
CDRL 25-16, Drawing List 25-32
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25.20 CDRL Detail

This section lists the expected content for each CDRL required above. The lists provided for each CDRL are an outline only and should not be considered exhaustive, all CDRLs are subject to SEPTA review and Approval.

CDRL 25-01 Program Management Plan (PMP)

1. The PMP shall comply with the guidelines and use the standard formatting given in the Project Management Institute's Project Management Body of Knowledge.
2. At a minimum it shall include the following, per the requirements of TS 25.3:
    a. Organization Chart
    b. Staffing Plan
    c. Management Approach
    d. Engineering Plan
    e. Car Weight Control Plan
    f. Mockup Plan
    g. FRA Test and Approval Plan
    h. Supply Chain Management Plan
    i. Facilities Plan
    j. Risk Mitigation Plan
3. The PMP shall be updated every three months from NTP through to project closeout.

CDRL 25-02 Master Program Schedule (MPS):

1. The schedule shall be developed through a critical path method (CPM) in Oracle's Primavera P6 Professional Project Management software (P6) or as Approved.
    a. MPS shall be provided in native (editable) format and in PDF.

CDRL 25-03 Specification Compliance Matrix (SCM)

1. Within 30 days after NTP, conduct a Specification Review Meeting with SEPTA and major system suppliers or contractors and populate the Specification compliance Matrix.
2. Update the SCM during design phases, testing, and manufacturing and add the submitted Documentation that fulfills each specification requirement.

3. Submit monthly or at another Approved interval.

CDRL 25-04 Monthly Progress Update Reports:

1. Information in the report shall be shown in CDRL and MPS sequence, to the extent possible. For the list of submittals in CDRL number sequence, show the transmittal date, transmittal number, and status.

2. The progress assessment shall clearly show the state of the program relative to Approved schedules and shall identify the critical path(s) to project completion.

3. A printout of the schedules shall show progress to date (in Gantt chart format) showing all activities, activity durations, remaining durations, early starts, early finishes, late starts, late finishes, predecessors, and successors.

CDRL 25-05 Systems Engineering Plan:

1. The plan shall be developed consistent with the processes and principles contained in INCOSE's Engineering Handbook: A Guide for System Life Cycle Processes.

CDRL 25-06 Systems Integration Testing Plan and Matrix (SITPM):

1. A reporting matrix shall graphically depict the interfaces between subsystems and identify the test(s) required to confirm interface integrity.

CDRL 25-07 Interface Control Document

1. Develop an ICD that documents how a configurable set of data from the as-built onboard systems can be sent to a future onboard system

2. Develop a separate ICD that documents data that can be sent to a future vehicle management system (future replacement for VMIS). This ICD shall be a one-way ICD, in the sense that only data to be transferred from the car shall be documented

CDRL 25-08 Network Interface Control Document

CDRL 25-09 System Functional Description (SFD)

CDRL 25-10 Subsystem Functional Description (SSFD)

CDRL 25-11 Configuration Management Plan

1. The plan shall be produced in accordance with IEEE 828

2. Include a description of the serial numbers for each of the items listed in TS 25.7.4.2

CDRL 25-12 Warranty Plan

1. The plan shall identify the proposed approach to providing warranty support, addressing such issues as personnel, locations, response time, inspections, warranty

spares, and how warranty days out of service will be captured and applied to the end of the warranty period.

CDRL 25-13 Spare Parts Provisioning Plan

1. Provide the list and quantity of spare parts that will be provided.
2. Identify storage space requirements, including both geometric and environmental (temperature, humidity, etc.) requirements, for all spare parts.
3. Provide a shipment plan for all spare parts, with parts grouped by subsystem as specified.

CDRL 25-14 Recommended Spare Parts List

1. Submit an electronically controlled recording medium such as a database or spreadsheet where all parts and materials are listed by name, Contractor part number, supplier part number, revisions levels, and quantities. A full record of deliveries and extractions from stock shall also be recorded within the medium as parts and materials are delivered or used.

CDRL 25-15 Spare Parts Control Numbering System

1. Ensure conformance with SEPTA's VMIS.
2. Document how the control numbering system correlates to the subsystem with which the spare parts are associated.

CDRL 25-16 Drawing List

1. Submit in a SEPTA-Approved electronic format.
2. Identify all drawings used in the assembly of the married pair, from the completed married pair down to the lowest line replaceable unit (LLRU), in a logical manner by subsystem and level of assembly.
3. Indicate those drawings to be submitted for Approval and those to be submitted for information or reference only.
4. Identify the number of sheets per drawing, the current revision number of the drawing, the Contractor's transmittal number, transmittal date, and the current Approval status for each drawing.
5. As part of the initial drawing list submittal, describe the primary drawing numbering system, including the significance of characters.

CDRL 25-17 Arrangement Drawings

1. Arrangement drawings shall be dimensioned, and all key points shall be located by dimensions from the longitudinal centerline, the pulling face of the F-end coupler, and the top of rail.

2. Arrangement drawings shall be to a scale of 1:25 or larger, except for cross-sections, which shall be to a scale of 1:10 or larger.

CDRL 25-18 Dynamic Outline Drawing

CDRL 25-19 As-Built Drawings

1. Each drawing shall look exactly as intended when opened with a standard software.

2. Whenever possible, the drawing creator shall not use any exotic or special fonts in place of standard easily translatable text styles. If any special fonts are used, the font files shall be supplied on each external solid state drive.

3. The quantity of drawing "layers" shall be kept to a reasonable minimum. Each drawing shall be drawn to a full 1 to 1 scale whenever possible. Dimensions should always be at the proper scale after "exploding" block entities.

4. Each drawing shall have a maximum size of 3 feet 8 inches wide and 2 feet 10 inches high.

5. Every drawing shall have a SEPTA title block containing the notation "SEPTA SLVI Car," drawing title (including subsystem identification), drawing number, Contractor’s name, revision number, and dates of all revisions listing the changes made in each revision.

6. Include a Bill of Materials for each drawing number that contains the part number identification for each individual part, drawing number for individual parts where drawings have been assigned, drawing number showing the next higher assembly, and weight for each part.

7. Organize the drawing sets in a logical drawing tree system based on the physical configuration of the cars. This shall include both fully dimensioned manufacturing part drawings as well as dimensioned assembly drawings for all parts, subassemblies, assemblies, and arrangements.

8. Electrical schematic drawings shall indicate all wire numbers, references to other drawings of any and all manufacturers to which connections are made, nominal voltages, currents and frequencies, significant resistance values, and the rating of all loads. Devices shall be labeled in agreement with the identification appearing on the actual device, and their locations on the cars shall be shown. Pneumatic schematic drawings shall be prepared in a similar fashion.

CDRL 25-20 CDR Package(s)

CDRL 25-21 PDR Package(s)

CDRL 25-22 FDR Packages

CDRL 25-23 Cab and Interior Soft Mock-ups

CDRL 25-24 Virtual Reality Scenarios

CDRL 25-25 Full Scale A-Car Design Mock-up

CDRL 25-26 Seat Production Prototypes [by seat type]

CDRL 25-27 Decorative Material Samples

1. Submit during the design development process.
2. Submit 4 samples of each decorative material.
3. In addition, deliver two complete sets of all such materials with the first married pair.
    a. Sample sets shall include source information for purchase of replacement materials by SEPTA.
    b. The information shall include stock numbers, paint manufacturer's color mixture identification numbers, and the like for all decorative material items.

CDRL 25-28 Car History Books

1. Submit the books in an Approved electronic format.
2. Include the following information for each car of the pair:
    a. Car numbers (Contractor's number and SEPTA's number), type, and class.
    b. Completed shipping authorization forms for carshell and completed car.
    c. Carshell information:
        i. All inspection records
        ii. All non-conformance reports
        iii. All repairs or modifications
        iv. List of open issues
        v. Mill reports or other material certifications for each material in the carshell. These data may be submitted on a "per lot" basis, if a cross-reference is included in the Car History Book.

d. Truck information:

   i. Retain copies of all truck and truck equipment manufacturing and test records.

   ii. Include material certifications and test records for all trucks and truck-mounted equipment in the Car History Books, including:

      (1). Wheel, journal bearing, and gearbox quill mounting records, which includes heat numbers, manufacturer name, and manufacturing dates for wheels, axles, and journal bearings, and results of all inspections and tests.

      (2). Copies of the manufacturer's test reports certifying that the materials used in the manufacture of all wheels and axles have been sampled, tested, and inspected in accordance with AAR M-101 and M-107. These data may be submitted on a "per lot" basis if a cross-reference is included in the Car History Book.

e. Factory Acceptance Test Reports, including car weight report.

f. All non-conformance reports created as part of the final assembly process.

g. Serial numbers of all serially-numbered apparatus fitted on the cars.

h. Configuration records, including the revision number and revision date of all assemblies/subassemblies and major components, and a list of accepted deviations and unincorporated changes. This includes all FMIs, PMIs, etc., as applicable at the time of shipment from the Contractor's final assembly site. List all adjustment points and initial setting.

i. List of workmanship defects noted and the disposition of each, including MRB repairs.

j. Other equipment or material certifications, as specified in the Specifications.

25.21 Referenced Standards

The following standards are referenced in this Section:

49 CFR 215	Railroad Freight Car Safety Standards
49 CFR 223	Safety Glazing Standards – Locomotives, Passenger Cars and Cabooses
49 CFR 224	Reflectorization of Rail Freight Rolling Stock
49 CFR 229	Railroad Locomotive Safety Standards
49 CFR 231	Railroad Safety Appliance Standards

49 CFR 231.14	Passenger-Train Cars Without End Platforms
49 CFR 232	Brake System Safety Standards for Freight and Other Non-Passenger Trains and Equipment; End-of-Train Devices
AAR M-101	AAR Manual of Standards and Recommended Practices (MSRP), Section G—Wheels and Axles, Standard M-101, Axles, Carbon Steel, Heat Treated
AAR M-107	AAR Manual of Standards and Recommended Practices (MSRP), Section G—Wheels and Axles, Standard M107/M-208, Wheels, Carbon Steel
ASME Y14	Drawing Standards
IEEE 1558	IEEE Standard for Software Documentation for Rail Equipment and Systems
PMI PMBOK	PMI Project Management Body of Knowledge (PMBOK)

Table 25-2, Contract Deliverable Requirements List (CDRL)

CDRL No.	Title	Due Date
SECTION 2 - DESIGN AND PERFORMANCE CRITERIA		
2-01	Energy Efficiency Report	Initial, CDR, PDR, Pilot Test
2-02	Vehicle Clearance Diagrams	CDR, PDR, FDR
2-03	Car Weight Report	CDR, PDR, FDR
2-04	Catenary Power Supply Analysis and Measurement Report	PDR
2-05	EMC Control and Test Plan	CDR
2-06	Spectrum Analysis of Pilot Cars	Pilot Test
2-07	Electromagnetic Compatibility (EMC) Design Report	FDR
2-08	Vehicle Performance	CDR
2-09	Duty Cycle Simulations	Initial, CDR, PDR
2-10	Dynamic Brake Fade Point	CDR, PDR, FDR
2-11	Train Rescue	FDR
2-12	Key Usage Matrix	PDR
SECTION 3 - CARBODY		
3-01	Carbody Equipment and Apparatus Details	CDR, FDR, and Delivery
3-02	Material Specifications	CDR, PDR, FDR
3-03	Exterior Finish Samples	120 days after NTP, FDR
3-04	Articulated Alternative to Collision Posts	PDR, FDR
3-05	Roof Equipment Drainage Provisions	CDR, PDR, and FDR
3-06	Emergency Roof Access Zone Design	CDR, PDR, and FDR
3-07	Emergency Roof Access Procedure	FDR
3-08	Equipment Boxes and Apparatus Support	CDR, PDR, and FDR
3-09	Jacking Pad Locations	CDR, PDR, and FDR
3-10	Snowplow Pilot Complete Approved Package	CDR, PDR, and FDR

Table 25-2, Contract Deliverable Requirements List (CDRL)		
CDRL No.	**Title**	**Due Date**
3-11	Carbody Stress Analyses and Test Plans	120 days after NTP, CDR, PDR, FDR
3-12	Carbody FEA Model and Model Report	PDR and FDR
3-13	Carbody Preliminary Stress Analysis Report	PDR
3-14	Carbody Stress Analysis Report	FDR
3-15	Carbody Validation of Stress Analysis Report	FAI
3-16	Natural Frequency Analysis	PDR and FDR
SECTION 4 - COUPLER AND DRAFT GEAR		
4-01	Coupler System Design Package	CDR, PDR, and FDR
4-02	Coupler Load Analysis	PDR and FDR
4-03	Coupler System Curving Analysis	PDR and FDR
4-04	Drawbar System Design Package	CDR, PDR, and FDR
SECTION 5 - OPERATOR'S CAB		
5-01	Cab Design Details	CDR, PDR, FDR
5-02	Interior General Arrangement Drawings	CDR, PDR, FDR
5-03	Final Console Arrangement	FDR
5-04	Sample Operator's Seat	PDR
5-05	Horn Installation Details	PDR, FDR
5-06	Master Controller Details	PDR
5-07	Cab End Drop Sash Window Drawing	PDR, FDR
SECTION 6 - PASSENGER DOORS		
6-01	Accessibility and Maintainability	PDR, FDR
6-02	System Functional Description	CDR, PDR, FDR
6-03	Exterior Side Door Design	CDR, PDR, FDR
6-04	Body End Door Design	CDR, PDR, FDR
6-05	Door Control System	CDR, PDR, FDR
6-06	Door Control Switch and Indicator Arrangement	CDR, PDR, FDR
6-07	Configuration of High-Level and Low-Level Boarding Doors	CDR, PDR, FDR
6-08	Exterior Crew Switches	CDR, PDR, FDR
6-09	Adjustable Parameters for Door Control System	PDR, FDR
5-10	Door Actuator and Motors Details	PDR, FDR
6-11	Door Interlock and Bypass Details	PDR, FDR
6-12	Door Status Indicator Details	PDR, FDR
6-13	Door Obstruction Sensing System Details	Carbuilder to Propose
6-14	Door Control Unit Documentation	PDR, FDR
6-15	Emergency Door Release	PDR, FDR
SECTION 7 - HEATING, VENTILATION, AND AIR CONDITIONING (HVAC)		
7-01	HVAC Load Calculations	CDR, PDR, FDR
7-02	Major Component Details	CDR, PDR, FDR
7-03	HVAC Unit Mounting Arrangement	CDR, PDR, FDR
7-04	Microprocessor Control	PDR, FDR
7-05	Fresh Air Damper Control/Adjustment and Fresh Air Supply	CDR, PDR, FDR
7-06	Computational Fluid Dynamics (CFD) Model and Analysis	PDR, FDR
7-07	Fresh Air Water/Snow Elimination and Filter Replacement	CDR, PDR, FDR

Table 25-2, Contract Deliverable Requirements List (CDRL)		
CDRL No.	**Title**	**Due Date**
7-08	Static Sidewall Heaters	CDR, PDR, FDR
7-09	Cab Heater Design	CDR, PDR, FDR
7-10	Threshold Heater Design	CDR, PDR, FDR
7-11	Control Box Electrical Component Arrangement and Accessibility	PDR, FDR
7-12	PTU Functionality and Screens	PDR, FDR
SECTION 8 - LIGHTING		
8-01	Lighting Interior General Arrangement	PDR
8-02	LED Driver End of Life Function Description	PDR
8-03	Cab Lighting Arrangement	CDR
8-04	Exterior Lighting Equipment Arrangement	PDR
8-05	Emergency Lighting Arrangement and Control	PDR
8-06	Passenger Lighting Controller System Function Description	PDR
SECTION 9 - AUXILIARY POWER		
9-01	Auxiliary Power Supply Load Analysis	CDR, PDR, FDR
9-02	Functional Description of the Auxiliary Power Supply Equipment	CDR, PDR, FDR
9-03	Layover Mode Functional Description	PDR, FDR
9-04	DC and AC Load Shedding	CDR, PDR, FDR
9-05	Auxiliary Power Inverter Design Details	PDR, FDR
9-06	API Protection Strategy, Isolation, and Grounding Scheme	PDR, FDR
9-07	Low Voltage Power Supply Load Analysis	PDR, FDR
9-08	Design Details for the LVPS	PDR, FDR
9-09	LVPS Protective Features	PDR, FDR
9-10	Low Voltage Distribution	CDR, PDR, FDR
9-11	Storage Battery Sizing	CDR, PDR, FDR
9-12	Storage Battery Enclosure	CDR, PDR, FDR
9-13	Circuit Breakers and Fuses	CDR, PDR, FDR
9-14	Shop Power Receptacle	CDR, PDR, FDR
SECTION 10 - PROPULSION AND HIGH VOLTAGE SYSTEM		
10-01	Propulsion System Functional Description	CDR, PDR, FDR
10-12	Interference Current Monitoring Unit	CDR, PDR, FDR
10-02	Electrical Protection	CDR, PDR, FDR
10-03	Fault Indications	CDR, PDR, FDR
10-04	Traction motors	CDR, PDR, FDR
10-05	Gear Units	CDR, PDR, FDR
10-06	Pantograph	CDR, PDR, FDR
10-07	High Voltage Wiring	CDR, PDR, FDR
10-08	Primary Current Fault Protection	CDR, PDR, FDR
10-09	Main Transformer	CDR, PDR, FDR
10-10	Ground Return System	CDR, PDR, FDR
10-11	Energy Measurement System	CDR, PDR, FDR
SECTION 11 - TRUCKS		
11-01	Truck System Design Description	CDR, PDR, FDR
11-02	Truck-to-Carbody Connection Analysis Report	PDR

Table 25-2, Contract Deliverable Requirements List (CDRL)		
CDRL No.	**Title**	**Due Date**
11-03	Truck Structural Validation Plan	120 after NTP, CDR, PDR, FDR
11-04	Truck Stress Analysis Plan	CDR
11-05	FEA Model Input Package	CDR
11-06	Truck Stress Analysis Report	PDR, FDR
11-07	FEA Model Output (Results) Package	PDR, FDR
11-08	Truck Stress Test – Laboratory, Plan	FDR
11-09	Truck Stress Test – Laboratory, Report	FAI
11-10	Truck FEA Structural Model Validation Plan	FDR
11-11	Truck FEA Structural Model Validation Report	FAI
11-12	Truck Stress and Load Test – On-Track, Dynamic Plan	FDR
11-13	Truck Stress and Load Test – On-Track, Dynamic Report	FAI
11-14	Fatigue Assessment Validation Report	Pilot Test
11-15	Manufacturing Validation Report	CDR
11-16	Truck Clearance Diagrams	CDR, PDR, FDR
11-17	Coil Spring Design Stress Calculation Report	PDR
11-18	Axle Stress Calculation Report	PDR
11-19	Wheel Stress Analysis Report	PDR
11-20	Journal Bearing Life Analysis Report	PDR
11-21	Vehicle Dynamic Performance Qualification Plan	120 days after NTP, CDR, PDR, FDR
11-22	Vehicle Dynamic Simulation Plan	CDR
11-23	Vehicle Dynamic Simulation Report	PDR
11-24	Vehicle Dynamic Model Validation Plan	PDR
11-25	Vehicle Dynamic Model Validation Report	Pilot Test
SECTION 12 - FRICTION BRAKE		
12-01	Brake System Component and Design Description	CDR, PDR, FDR
12-02	Brake System Piping Diagram	CDR, PDR, FDR
12-03	Brake System Wiring Diagram	CDR, PDR, FDR
12-04	Layout for Brake System	PDR and FDR
12-05	Brake Calculation	CDR, PDR, FDR, and FAI
12-07	Foundation Brake Equipment Design Description	CDR, PDR, FDR, and FAI
12-08	Friction Brake Self-Test and Test-on-Demand Capability	CDR, PDR, FDR
12-09	Friction Brake Diagnostic System	CDR, PDR, FDR
12-10	Compressor Duty Cycle	CDR, PDR, FDR, and FAI
12-11	Compressor Lubricating Oil Details	CDR, PDR, FDR
12-12	Air Consumption and Reservoir Sizing	CDR, PDR, FDR, and FAI
12-13	Brake Indicator Design and Integration	CDR, PDR, FDR, and FAI
12-14	Test Fitting Types and Locations	PDR, FDR
12-15	WSP Operation Description	CDR, PDR, FDR
12-16	WSP Self-Test and Test-on-Demand Capability	CDR, PDR, FDR
12-17	WSP Brake Diagnostic System	CDR, PDR, FDR
12-18	Event Recorder Interface	CDR, PDR, FDR
SECTION 13 - COMMUNICATIONS		
13-01	Communication System Design and Integration Package	CDR, PDR, and FDR
13-02	Passenger Cellular Device Compatibility Plan	CDR, PDR

Table 25-2, Contract Deliverable Requirements List (CDRL)		
CDRL No.	**Title**	**Due Date**
13-03	Communication System Fault Tolerance Capabilities	CDR, PDR, and FDR
13-04	Communication System Self-Test Capabilities	CDR, PDR, and FDR
13-05	Automatic Passenger Counting System Design	CDR, PDR, and FDR
13-06	Video Surveillance System CHMM Test Procedure and Report	FDR, FAI
13-07	Video Surveillance System Design	CDR, PDR, and FDR
13-08	Onboard Dynamic Advertising System Design	CDR, PDR, and FDR
13-09	Communication System Content Lab Design	CDR, PDR, and FDR
SECTION 14 - INTERIOR AND EXTERIOR APPOINTMENTS		
14-01	Interior Arrangements	CDR, PDR
14-02	Industrial Design	CDR, PDR, FDR
14-03	Materials Samples and Finishes	PDR, FDR
14-04	Stanchion and Handrail Arrangement	CDR, PDR, FDR
14-05	Passenger Steps Samples	PDR, FDR
14-06	Floor Covering Arrangement, Installation and Repair	PDR, FDR
14-07	Emergency and Rescue Access Window Design and Arrangement	CDR, PDR, FDR
14-08	Seat Design and Installation	CDR, PDR, FDR
14-09	Equipment Locker and Access Panel Locations	CDR, PDR, FDR
14-10	Keys and Locks	PDR, FDR
14-11	Luggage Rack/Stack Design	CDR, PDR, FDR
14-12	Emergency Equipment Locker	CDR, PDR, FDR
14-13	Insulation Arrangement	CDR, PDR, FDR
14-14	Signage Design and Arrangement	PDR, FDR
14-15	Safety Appliance Arrangement	CDR, PDR, FDR
14-16	FRA Sample Car Inspection	FAI
14-17	Underframe Protective Device Arrangement	CDR, PDR, FDR
14-18	Underframe Equipment and Enclosure Arrangement	CDR, PDR, FDR
14-19	Inter-car Barrier Details	CDR, PDR, FDR
SECTION 15 - TEST PROGRAM		
15-01	Master Test Plan	180 days after NTP
15-02	Component Design Qualification Tests	FDR, FAI
15-03	Carbody Structure Design Qualification Tests	FDR, FAI
15-04	Carbody Structure Design Qualification Results	FDR, FAI
15-05	Appendix F Design Qualification Test	FDR, FAI
15-06	Appendix F Design Qualification Results	FDR, FAI
15-07	Subsystem Design Qualification Tests	FDR, FAI
15-08	Car and Married Pair Design Qualification Tests	FDR, FAI
15-09	On-Site Design Qualification Tests	FAI
15-10	Factory Routine Tests	FAI
15-11	Pre-Shipment Routine Tests	FAI
15-12	Routine Tests at SEPTA	FAI
SECTION 16 - MATERIALS AND WORKMANSHIP		
16-01	Recommended Cleaning Agents	Carbuilder to Propose
16-02	Certification of No Prohibited Materials	Carbuilder to Propose
16-03	Corrosion Control of Materials	Carbuilder to Propose

Table 25-2, Contract Deliverable Requirements List (CDRL)		
CDRL No.	**Title**	**Due Date**
16-04	Proposed Materials Not Covered by Specification or Standard	Carbuilder to Propose
16-05	Safety Data Sheets	Carbuilder to Propose
16-06	Fasteners Design Package	Carbuilder to Propose
16-07	Carshell Mill Certification Reports	Carbuilder to Propose
16-08	Stainless Steel Test and Inspection Plan	Carbuilder to Propose
16-09	HSLA Steel Test and Inspection Plan	Carbuilder to Propose
16-10	Steel Casting Qualification Test Report	Carbuilder to Propose
16-11	Steel Castings Radiographic Inspection Sampling Frequency	Carbuilder to Propose
16-12	Structural Forgings Design Qualification Test Report	Carbuilder to Propose
16-13	Aluminum Test and Inspection Plan	Carbuilder to Propose
16-14	Welding Procedure Qualification	Carbuilder to Propose
16-15	Production Weld Inspection Plan	Carbuilder to Propose
16-16	Production PJP and Fillet Weld Sampling Plan	Carbuilder to Propose
16-17	Ring Weld Sampling Plan	Carbuilder to Propose
16-18	Welding Machine Qualification Records and Welding Procedure Schedule Certifications	Carbuilder to Propose
16-19	Phenolic Composite Floor Panel Test Results	Carbuilder to Propose
16-20	FRP Repair Procedure	Carbuilder to Propose
16-21	FRP Performance Test Certificates	Carbuilder to Propose
16-22	Pneumatic System Design Analysis	Carbuilder to Propose
16-23	Air Brake Supplier's Written Approval	Carbuilder to Propose
16-24	Pressure Vessel Test Reports	Carbuilder to Propose
16-25	Paint Manufacturer's Data	Carbuilder to Propose
16-26	Paint Preparation and Application	Carbuilder to Propose
16-27	Paint Testing on First Car	Carbuilder to Propose
16-28	Floor Fire Test Report	Carbuilder to Propose
16-29	Floor Fire Test Drawings	Carbuilder to Propose
16-30	Electrical Fitting and Junction Box Product Line	Carbuilder to Propose
16-31	Documentation for Wire and Cable	Carbuilder to Propose
16-32	Electrical Insulation Test Reports	Carbuilder to Propose
16-33	Insulation Smoke Test Report	Carbuilder to Propose
16-34	Wiring Plan	Carbuilder to Propose
16-35	Wire and Cable Identification System	Carbuilder to Propose
16-36	Wire Termination Documentation	Carbuilder to Propose
16-37	Plastic Semiconductor Burn In Method	Carbuilder to Propose
16-38	PCB Extenders	Carbuilder to Propose
SECTION 17 - NETWORK AND TRAINLINE CONTROL		
17-01	Trainline and Network List	CDR, PDR, FDR
17-02	Network Interface Control Documents	PDR, FDR
17-03	Control Specification and Performance Analysis	CDR, PDR, FDR
17-04	Network Design Document	CDR, PDR, FDR
17-05	Signal Quality Plan	CDR, PDR, FDR
17-06	Discrete Propulsion and Braking Trainline Design	CDR, PDR, FDR
17-07	Network Self-Test Capability	CDR, PDR, FDR
17-08	Control-Level Specification	CDR, PDR, FDR
17-09	Network Interface Card (NIC) Specification	CDR, PDR, FDR

Table 25-2, Contract Deliverable Requirements List (CDRL)		
CDRL No.	**Title**	**Due Date**
SECTION 18 - MONITORING AND DIAGNOSTICS		
18-01	VMDS Design Document	CDR, PDR, FDR
18-02	VMDS Subsystem Interface Documents	CDR, PDR, FDR
18-03	VMDS Self-Test Capability	CDR, PDR, FDR
18-04	VMDS Fault Management Plan	PDR and FDR
18-05	Ride Quality Monitoring System Design Document	CDR, PDR, FDR
18-06	TWDT Design Package	CDR, PDR, FDR
18-07	TWDT Self-Test Capability	CDR, PDR, FDR
18-08	TWDT Diagnostic Subsystem	CDR, PDR, FDR
SECTION 19 - SOFTWARE ENGINEERING		
19-01	Benchmark Appraisal Disclosure Statement, Final Findings Presentation, and Performance Report	CDR and PDR
19-02	Organizational Unit Practice Characterizations and Final Findings Presentation	CDR and PDR
19-03	Project-Specific Remedial Action Plan	CDR, PDR, and Quarterly until End of Warranty
19-04	Software Not Compatible With 64-Bit Processors	PDR
19-05	Programmable Device Hardware	Carbuilder to Propose
19-06	Software Baselining	FDR
19-07	Software Parameters Utility	FDR
19-08	Software Parameter File	FDR
19-09	Software Package	Carbuilder to Propose
19-10	As-Built Software Documents	Carbuilder to Propose
19-11	Software Update Timing Analysis	PDR
19-12	Fleet-Wide Software Upgrade Campaigns Plan	FDR
19-13	Software Configuration Control Plan (SCCP)	FDR
19-14	Software Version Database	Prior to End of Warranty
19-15	Car Software Configuration Report	Conditional Acceptance
19-16	Non-Carborne Equipment Software Configuration Report	Conditional Acceptance
19-17	Software Verification Utility	FDR
19-18	Classification of Software	PDR
19-19	Software Documentation Methodology (SDM)	CDR
19-20	Software Project Management Plan (SPMP)	CDR and PDR
19-21	Software Quality Assurance Plan (SQAP)	CDR and PDR
19-22	Software Configuration Management Plan (SCMP)	PDR
19-23	Software Verification and Validation Plan (SVVP)	PDR
19-24	Software Verification and Validation Report (SVVR)	FAI
19-25	Software Test Plan (STP)	PDR
19-26	Software Requirements Traceability Matrix (SRTM)	PDR, FDR, and FAI
19-27	Software Requirements Specification (SRS)	PDR
19-28	Software Design Description (SDD)	PDR and FDR
19-29	Software Test Procedure (STPr)	FDR
19-30	Software Test Report (STR)	FAI
19-31	Software Version Description (SVD)	FAI
19-32	Software User Manual (SUM)	PDR and FDR
19-33	List of Any Commercially Available Software	PDR
19-34	Software Quality Metrics Report	FDR and Quarterly until End of Warranty

Table 25-2, Contract Deliverable Requirements List (CDRL)		
CDRL No.	**Title**	**Due Date**
SECTION 20 - AUTOMATIC TRAIN CONTROL – POSITIVE TRAIN CONTROL		
20-01	ATC/PTC General System Description	PDR, FDR, and FAI
20-02	ATC/PTC System Installation and Operation Details	PDR, FDR, and FAI
20-03	ATC/PTC Testing Details	PDR, FDR, and FAI
20-04	ATC/PTC Event Recorder Signals and Alerter Function	PDR, FDR, and FAI
SECTION 21 - RELIABILITY, AVAILABILITY, AND MAINTAINABILITY		
21-01	RAM Program Plan	CDR, PDR, and FDR
21-02	Reliability Prediction Report	PDR and FDR
21-03	Maintainability Analysis and Maintenance Allocation Chart	PDR and FDR
21-04	Reliability and Availability Demonstration Plan	PDR and FDR
21-05	Reliability and Availability Demonstration Progress Report	Monthly until End of Warranty
21-06	FRACAS Report	Monthly until End of Warranty
21-07	Maintainability Demonstration Plan	PDR and FDR
21-08	Maintainability Demonstration Progress Report	Monthly until End of Warranty
SECTION 22 - QUALITY ASSURANCE		
22-01	QA Program Plan	CDR
22-02	Inspection and Test Plan	CDR, PDR, FDR, FAI
22-03	Quality Assurance Manuals	CDR
22-04	Subcontractor/Supplier List	CDR
22-05	MRB Documentation	Manufacturing
22-06	Sampling Plan	PDR, Quarterly during Manufacturing
22-07	Statistical Quality Control Inspection List	Carbuilder to Propose
22-08	FAI Packages	FAI
22-09	Audit Checklists and Reports	Carbuilder to Propose
SECTION 23 - SYSTEM SAFETY AND SECURITY		
23-01	System Safety Program Plan (SSPP)	CDR, PDR, and FDR
23-02	Software Safety Program Plan (SWSPP)	CDR, PDR, and FDR
23-03	Sneak Circuit Analysis Report	PDR and FDR
23-04	Electromagnetic Field (EMF) Hazard Control Plan	CDR and PDR
23-05	Preliminary Hazard List (PHL)	PDR
23-06	Preliminary Hazard Analysis (PHA)	PDR
23-07	Hazard Tracking Log (HTL)	Monthly until End of Warranty
23-08	Failure Modes, Effects, and Criticality Analyses (FMECA)	PDR and FDR
23-09	Operating and Support Hazard Analysis (O&SHA)	PDR and FDR
23-10	Fault Tree Analyses (FTA)	PDR and FDR
23-11	Fire Hazard Analysis (FHA)	PDR and FDR
23-12	Flammability, Smoke Emission, and Toxicity Test Matrix	PDR and FDR
23-13	System Security Program Plan (SSePP)	CDR
23-14	Vehicle Threat and Vulnerability Assessment	PDR and FDR
23-15	Safety and Security Certification Report	FDR
23-16	Safety and Security Progress Reports	Quarterly until End of Warranty
SECTION 24 - CYBERSECURITY		

Table 25-2, Contract Deliverable Requirements List (CDRL)		
CDRL No.	**Title**	**Due Date**
24-01	List of Proposed Products and Countries	PDR and FDR
24-02	Software Bill of Materials and Hardware Bill of Materials	CDR, PDR, FDR, FAI, Annually until End of Warranty
24-03	List of External Information Systems	Pilot
24-04	Vehicle Communication and Control System Vulnerability Preliminary Assessment	PDR
24-05	Date/Time Dependent Function Confirmation	PDR and FDR
24-06	Independent Software and Firmware Security Assessment Plan	FDR
24-07	Independent Software and Firmware Security Assessment Findings Report	FAI
24-08	Independent Software and Firmware Security Assessment Findings Response and Corrective Action Plan	FAI
24-09	Independent Penetration Test Plan and Procedures	FDR
24-10	Independent Penetration Test Findings Report	FAI
24-11	Independent Penetration Test Findings Response and Corrective Action Plan	FAI
24-12	Identification of Subsystem, Associated Software, and Applicable NIST Checklist(s)	PDR and FDR
24-13	Completed NIST Checklist(s)	FDR
24-14	Vehicle Baseline Configuration	PDR, FDR, and Pilot
24-15	Product Logging Management Capabilities	PDR and FDR
24-16	Authentication and Password Management	CDR and PDR
24-17	Product Disabled Services	FDR
24-18	Product Security Features and Instructions	FDR
24-19	Product Development Bypass Disclosure and Removal	Pilot
24-20	Remote Access Entry Pathways	FDR
24-21	Access Control User and Roles Proposed Options	FDR
24-22	Recommended Methods Against Unauthorized Changes to BIOS and Firmware	FAI
24-23	Unauthorized Logging Device Removal Statement	Delivery
24-24	On-Board Intrusion Detection System Design	CDR, PDR, and FDR
SECTION 25 - PROGRAM MANAGEMENT AND COMMISSIONING		
25-01	Program Management Plan (PMP)	Every 3 Months until End of Warranty
25-02	Master Program Schedule	CDR, Monthly
25-03	Specification Compliance Matrix (SCM)	Monthly until End of Warranty
25-04	Monthly Progress Update Reports	Monthly until End of Warranty
25-05	Systems Engineering Plan	CDR
25-06	Systems Integration Testing Plan and Matrix (SITPM)	CDR, PDR, FDR, FAI
25-07	Interface Control Document	CDR, PDR, FDR
25-08	Network Interface Control Document	CDR, PDR, FDR
25-09	System Description	CDR, PDR, FDR
25-10	Subsystem Description	CDR, PDR, FDR
25-11	Configuration Management Plan	CDR
25-12	Warranty Plan	PDR
25-13	Spare Parts Provisioning Plan	FDR
25-14	Recommended Spare Parts List	FDR

Table 25-2, Contract Deliverable Requirements List (CDRL)		
CDRL No.	**Title**	**Due Date**
25-15	Spare Parts Control Numbering System	FDR
25-16	Drawing List	CDR, PDR, FDR
25-17	Arrangement Drawings	CDR, PDR, FDR
25-18	Dynamic Outline Drawing	CDR, PDR, FDR
25-19	As-Built Drawings	Prior to the acceptance of the last married pair
25-20	CDR Package(s)	CDR
25-21	PDR Package(s)	PDR
25-22	FDR Package(s)	FDR
25-23	Cab and Interior Soft Mock-ups	PDR, FDR
25-24	Virtual Reality Scenarios	CDR, PDR, FDR
25-25	Full Scale A-Car Design Mock-up	FDR
25-26	Seat Production Prototypes (by seat type)	FDR
25-27	Decorative Material Samples	FDR
25-28	Car History Books	FAI, manufacturing
SECTION 26 - MANUALS AND TRAINING		
26-01	Manuals Program Plan	Initial
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26-05	Conditionally Approved Manuals and Parts Catalogs	60 days before acceptance of pilot married pair
26-06	Final Published Manuals and Parts Catalogs	12 months after acceptance of pilot married pair
26-07	Updates to Manuals and Parts Catalogs	Every 6 Months until End of Warranty
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26-10	Training Lesson Plans	6 months before training
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28-03	Test and Inspection Vehicle Final Design Review	FDR
28-04	Test and Inspection Vehicle Testing	FAI
28-05	Test and Inspection Vehicle Pre-delivery Inspection	FAI
28-06	Test and Inspection Vehicle Required Documentation	CDR, PDR, FDR, FAI

SECTION 26
MANUALS AND TRAINING

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26.1 Manuals and Catalogs

26.1.1 General

A. Comply with the following:

1. Submit manuals and catalogs in accordance with the requirements of this Section and other sections of the Specifications.

2. Unless specifically stated otherwise, the use of the word "manual(s)" shall mean any and all manuals and catalogs specified anywhere in the Specifications.

3. Produce manuals specific to this Contract that accurately represent the completed as-built car, including but not limited to Contract-specific maintenance instructions, parts, wiring schematics, wiring diagrams, pneumatic schematics, piping diagrams, and component physical layouts.

4. Manuals shall be entirely in English and shall comply with the guidelines given in APTA PR-IM-RP-002-98.

5. Manuals shall comply with the style guide in Appendix VII. In case of a conflict between the style guide and the requirements in this Section, this Section shall prevail unless Approved otherwise by SEPTA.

   a. Manual format throughout the documents shall be consistent from subsystem to subsystem.

   b. All supplier material shall be reworked to conform to manual format unless otherwise Approved.

   c. Revisions to SEPTA's style guide may be proposed for Approval.

   d. Samples will be provided by SEPTA to demonstrate the required manual sizes.

6. The material in the manuals and parts catalog shall be similarly organized and sequenced with a standard numbering system.

26.1.1.1 Use of Subcontractor

A. Production of all manuals, catalogs, and other publications specified in this section shall be the responsibility of the Contractor. The Contractor may use a SEPTA Approved third-party subcontractor.

1. The Approved subcontractor shall have previous experience in the US preparing similar technical documentation for either an electric passenger heavy rail vehicle or a project of equal or greater magnitude and complexity, under contract to an industrial firm or government agency.

2. The Contractor shall place one qualified Approved individual in charge of all publications, who shall have full responsibility for fulfillment of this portion of the Contract.

3. The Contractor and any subcontractor shall participate in all meetings and in-process reviews related to manuals, catalogs, and other publications.

26.1.2 Functional Requirements

A. Treat the car as a whole and not as a grouping of disassociated parts. Organize the manuals logically with subsystems and elements considered in descending order of importance.

1. Index all material with an Approved standard numbering system in accordance with Approved outline.

2. The format of all data contained in each section of the maintenance and parts manual shall be consistent from section to section.

3. All statements shall be clear, positive, and accurate, with no possibility of incorrect implications or inferences. Use simple declarative statements to convey instructions.

4. Highlight safety precautions to be taken by operating and service personnel while operating cars and performing maintenance and servicing operations. Highlight other safety-related notes, cautions, warnings, etc. needed to maintain safe conditions and include in all manuals.

5. Include hypertext links within the text where possible, including the table of contents. Adequate cross-references shall be provided in each manual and catalog.

6. Use block diagrams to facilitate the description of assemblies and the relationship of components, assemblies, and subsystems such that significant card circuit functions can be discerned from the block diagrams.

7. The detailed contents of sealed assemblies need not be displayed, but explain the functions of such assemblies and note the appropriate values for each external test point. Include procedures appropriate to the replacement of sealed assemblies, including methods and tests.

8. Whenever a special tool is called for, include the tool's SEPTA part number.

9. Following the issue of each publication, submit revised pages covering changes, whether required by change of design or procedures or due to error. Keep these revisions current (revise every 6 months at a minimum) during the warranty period. Submit manual and catalog revisions before the arrival of the altered parts or components.

26.1.3 Manuals Program Plan

A. Submit a Manuals Program Plan (MPP). **(CDRL 26--01, Manuals Program Plan)**

1. The purpose of the MPP is to identify all the elements associated with the development of manuals for this Contract.

2. At a minimum, the MPP shall include the following:

a. A description of the process the manuals subcontractor intends to follow to develop the manuals, and the process the Contractor intends to follow to oversee this development.

b. The schedule for manuals development.

c. An organizational chart showing the person with primary responsibility for development, along with all persons, departments, or subcontractors who will be working on the manuals.

d. The methods to be used to ensure that the manuals reflect the reliability and maintainability analyses upon which they are based.

e. The revision tracking control methodology to be used for the manuals.

f. The subcontractor's approaches to using styles and developing the Style Guide, if distinct from the one presented as a template by SEPTA.

g. The quality program to be used to ensure the accuracy and completeness of the manuals.

h. The audit and sign-off sheets that shall be used during manuals development.

3. All Maintenance Manuals must be verified. **(CDRL 26-02 Maintenance Manual Verification)**

26.1.4 Outlines

A. Submit tables of contents and samples for each type of manual, and for the Illustrated Parts Catalogs in accordance with the formatting requirements specified below. **(CDRL 26--03, Manuals and Parts Catalogs Table of Contents and Samples)**

26.1.5 Design and Format

A. SEPTA has provided a Style Guide (see Appendix VII). All manuals and catalogs shall comply with the Style Guide. The Contractor or manuals subcontractor may propose modifications to the Style Guide for SEPTA Approval.

B. Comply with the following:

1. Design manuals for continuous, long-term service in a maintenance shop environment. The publications shall be complete and organized and shall contain no extraneous material.

2. Logically organize manuals, with subsystems and elements considered in descending order of importance.

    a. Section and paragraph numbering shall be provided to the sixth hierarchical level (e.g. Section 4.2.4.6.2.1).

    b. When the manual includes a procedure for an inspection or other task, this procedure shall be organized in a thought-out and ergonomic order to ensure that the recommended sequence is logical, intuitive, and efficient for the SEPTA employee to follow. The procedure shall clearly differentiate between the steps of the procedure and additional information provided for context and explanation.

3. Each manual shall contain the following general information:

    a. Title Page: This includes the Contract name and number, name of the Contractor, date, and revision of the submittal.

    b. Revision Tracking: This includes a listing and revision number of all pages, as well as a list of each revision, date of revision, and associated explanation of the revision.

    c. Table of Contents: This includes a list of all sections, a list of all figures, and a list of all tables. A Table of Contents shall be provided at the beginning of each manual.

    d. Index: This includes all relevant terms and page locations.

    e. Reproduction: This includes language that permits reproduction of the contents for training purposes.

4. Each manual section shall be subdivided, to the extent required by the subject matter, into the following topics:

    a. General description and operation of the subsystem

    b. Theory of Operation

    c. Block diagram

    d. Signal flow diagrams to the card circuit, pneumatic component, or software design level

    e. Functional schematics of subsystem equipment to the card level

f. Functional wiring and piping diagrams

g. Troubleshooting techniques

h. Software

i. Lubrication and cleaning including frequency, methods and trade identifications of recommended materials, component location, and description

j. Inspection and maintenance standards including wear limits, settings, and tolerances

k. Installation and removal

l. Test and evaluation procedures.

26.1.5.1 Paper and Binding

A. Comply with the following:

1. Each page of all final manuals, including drawings and figures, shall be printed on SEPTA-Approved high-grade paper with a reinforced binding edge and oversized punched holes for binding in a multi-ring, loose-leaf binder. The paper shall meet the following requirements:

   a. Tear-resistant

   b. Waterproof

   c. Grease, chemical, and stain resistant

   d. Polyester based synthetic, such as Revlar, by Relyco, or paper with similar qualities, as Approved

   e. Minimum 5 mil (0.13 mm) thickness

2. All pages, including diagrams and figures, shall be bound to the central binder and shall not be loose or in pockets.

3. All printed material shall be clearly understandable when reproduced in grayscale, as per the Style Guide.

4. Pages shall be printed on both sides. Sides of pages intentionally left blank shall be so noted.

5. Binders:

   a. Covers shall be approximately 0.0625-in (1.59 mm) thick and resistant to oil, moisture, and wear to a high degree, commensurate with their intended use.

b. Loose-leaf binder rings shall have locking triggers for opening and positive engagement closing.

c. Binders shall be Approved.

6. Manual sections shall be separated with heavy-duty, clearly labeled dividers with tabs to the extent required by the subject matter, as per the Style Guide.

26.1.5.2 Figures

A. Label figures, including diagrams, drawings, and illustrations, as figures. Folding pages will be permitted (as per the Style Guide) where the information to be conveyed cannot be presented clearly on single pages. When folded, pages shall not protrude from the other pages in the manual.

26.1.5.3 Electronic Format

A. Submit each specified manual electronically in both portable document format (PDF) and in a format that can be edited with the Microsoft Office software suite, such as .docx format. In addition, furnish copies of all drawings, diagrams, schematics, etc. in a format that can be edited with Autodesk AutoCAD software, newest version.

1. Comply with the following requirements when creating PDF version of each manual:

a. Create searchable, zoomable PDF directly from native format, not by scanning hard copy documents.

b. Create with sufficient resolution to allow zooming of graphics without loss of quality or resolution.

c. Size PDF the same as hard copy version to allow SEPTA to easily print new hard copy versions from electronic media without resizing PDFs.

d. Create a hierarchy of bookmarks, with each major section as a top-level bookmark, and subsections as bookmark subheadings. Bookmarks shall match the structure of the table of contents and include the headings and subheadings in the same hierarchical structure.

e. Create links via the table of contents and throughout the documents, where applicable, to necessary drawings and text for ease of navigation to corresponding information.

f. All URLs and other hyperlinks shall be fully functional, clickable links.

2. Revise electronic media versions in accordance with hard copy manual revisions.

26.1.6 Manual Descriptions

A. There shall be 14 manuals, as specified in the following 11 subsections.

26.1.6.1 Operator's Manual

A. The Operator's Manual shall contain all information needed for the optimum operation of the car.

1. It shall include the following:

a. General car familiarization material such as location, function, and operation of controls, gauges, indicators, cutouts, and switches.

b. Procedures for preparing the car for operation, securing the car from operation, and operation of the car itself in all modes, including cab signal and PTC modes.

c. A discussion of trucks, couplers, lights, environmental control, air springs, height control valves, automatic train control (cab signal and PTC), and other features of the car that the Operator may not be in a position to control or adjust but of which they should have some basic knowledge.

d. Operation and use of the Vehicle Monitoring Diagnostic Subsystem (VMDS), safe practices and procedures, emergency procedures, unusual or emergency modes of operation, trouble symptom and diagnosis methods, and Operator corrective action, if any. Arrange these procedures in a format to allow ease of use under emergency and time sensitive situations.

2. The manual shall be extensively indexed by operation and component identifying technical descriptions and associated corrective actions for each.

3. The manual shall be durable enough to be able to travel with each Operator in the course of their daily duties.

4. As specified in the Style Guide, unlike the other publications the Operator's Manual shall be "pocket sized. " It shall not be more than 1.25 inches thick.

26.1.6.2 Running Maintenance Manual

A. The Running Maintenance Manual shall be subdivided into four parts, as follows.

26.1.6.2.1 Part I: Scheduled Inspection and Maintenance Manual

A. The Scheduled Inspection and Maintenance (SIM) Manual shall be a detailed plan outlining all schedules and activities for car preventive maintenance. The frequency of inspections, and tasks required within each inspection, shall be as specified in Section 21, Reliability, Availability, and Maintainability.

1. Preventive maintenance shall comprise the tasks that are performed to defer or prevent an anticipated failure and worn condition.

2. The preventive maintenance schedule shall be time-, mileage-, and cycle-based, depending on what is appropriate for each subsystem, as determined by the Maintainability Analysis specified in Section 21, Reliability, Availability, and Maintainability.

3. The SIM Manual shall include an appropriate method for tracking and recording each type of maintenance interval, whether time-, mileage-, or cycle-based.

4. The SIM Manual shall be arranged and formatted similar to the existing SEPTA SIM Manual.

    a. The manual shall include a summary of inspection procedures for each time period, identifying items to be inspected as well as each task, allotted time, recommended tools, supplies, number of personnel, and skill levels required to accomplish the task.

    b. The manual shall contain all information needed to perform the periodic inspection and servicing requirement.

    c. Provide a complete list of the supplies necessary to perform the SIM, including cleaners, lubricants, and consumable parts, the required quantity of each, and the frequency and location of each required application. The supplies shall be identified by SEPTA's part number, as well as the manufacturer’s name and part number, and listed in the Illustrated Parts Catalog.

5. The manual shall contain the tasks and maintenance intervals identified by the Contractor as part of the Maintainability Analysis specified in Section 21, Reliability, Availability, and Maintainability. The maintenance intervals shall be developed so as not to impact the availability requirements specified in Section 21.

6. The manual shall include a checklist for each inspection procedure.

7. The manual shall contain a section summarizing the theory of operation of each subsystem or component being inspected.

8. To simplify future manual revisions over the lifetime of the car, the manual shall contain standalone sections for maintenance of each of the following subsystems:

    a. Carborne cab signal and PTC equipment

    b. Radio

    c. In-cab display screens

    d. Passenger-facing screens

26.1.6.2.2 Part II: Troubleshooting Manual

A. The Troubleshooting Manual shall contain an overview of car operation and a detailed description and analysis of the car, its subsystems, and the components of those subsystems. The manual shall contain all information required for on-car testing, and troubleshooting of equipment down to the lowest line replaceable unit (LLRU) level.

1. This manual shall contain the following:

a. A detailed description of all car subsystems and their components.

b. Procedures for post-inspection testing.

c. Detailed procedures for troubleshooting all subsystems and their major components. This shall include, as applicable, procedures both including and excluding PTU and BTE.

d. Procedures for removal and installation of subsystem components, down to the LLRU level.

e. Procedures for detailed inspection tasks that are more in-depth than those present in the SIM manual.

f. A detailed theory of operation of each subsystem, relating individual equipment subsystems one to another, and into the system overall.

g. Wear limits, settings, and tolerances.

h. Identification of each removable component and assembly that weighs more than 50 lb (23 kg), and its weight. Provide appropriate warnings if lifting these items is required.

i. Instructions for hoisting and jacking of the trucks and carbody.

j. A list of consumables, tools, and other supplies needed for each procedure.

2. To simplify future manual revisions over the lifetime of the car, the manual shall contain standalone sections for troubleshooting of each of the following subsystems:

a. Carborne cab signal and PTC equipment

b. Radio

c. In-cab display screens

d. Passenger-facing screens

3. The Data Network Troubleshooting Plan, as per Section 17, Network and Trainline Control.

26.1.6.2.3 Part III: Car Schematic Diagrams

A. The Schematic Diagrams shall contain all electrical schematics for the car and its subsystems down to the LLRU level, including for interfacing between car subsystems and for connections between cars and between married pairs.

1. Include electrical schematics included as part of the other manuals in the wiring diagrams portion of the manual so that a complete electrical schematic for both the A-car and the B-car are furnished.

2. Include legends and arrangement drawings to enable reading equipment enclosures, junction boxes, terminal boards and terminal points. The arrangement drawings shall include page and quadrant reference for terminals, pins, relay contacts, relay coils, and similar.

3. The Car Schematic Diagrams shall follow the wiring conventions specified for identification of wiring in Section 16, Materials and Workmanship.

4. Each Car Schematic Diagram shall include a description of the electrical schematic

5. Include a list of symbols used on the diagrams within, as well as a sample schematic diagram with key features of the diagram annotated.

6. Include relevant wiring documentation.

26.1.6.2.4 Part IV: Pin-to-Pin Manual

A. The pin-to-pin wire list portion of the manual shall identify every wire on both the A-car and B-car.

a. Include the wire size and type, wire termination points (to/from), and a quadrant reference to the wiring diagram(s) that contains the wire.

b. Identify multiconductor cables as such, and list color or other identification coding.

c. Include spare wires and identify and locate.

B. Include legends and arrangement drawings to enable reading equipment enclosures, junction boxes, terminal boards and terminal points. The arrangement drawings shall include page and quadrant reference for terminals, pins, relay contacts, relay coils, and similar.

C. The Pin-to-Pin Manual shall follow the wiring conventions specified for identification of wiring in Section 16, Materials and Workmanship.

D. Include relevant wiring documentation.

26.1.6.3 Heavy Repair Manual

A. This manual shall contain the maintenance procedures performed at the Heavy Repair level.

B. Heavy Repair is maintenance that requires holding a car out of service due to the longer time required to complete the work and includes maintenance tasks scheduled for three-year or greater intervals that are associated with car and equipment overhaul.

1. The opening section of the HRM shall be a table of Heavy Repair tasks, organized by interval, then by subsystem. The table shall refer to subsections of the HRM where procedures for each task may be found.

2. The manual shall be written from a car subsystem and component perspective.

3. Each subsystem section shall begin by illustrating the location of components within the subsystem.

4. Functional descriptions shall accompany the illustrations to facilitate servicing, repair, overhaul, adjustment, inspection, and test.

5. Detail the function of each significant component and circuit within each assembly, rather than furnishing descriptions of subsystem functions within the integrated car system.

6. Furnish maintenance procedures, including inspection, service, test, troubleshooting, adjustment, removal, repair, replacement, and overhaul, as applicable for this specific car or its subsystems, equipment, or parts. Include all test limits, settings, and tolerances. Include detailed step-by-step instructions, with a materials list. These instructions shall include and describe the use of BTE when necessary.

7. Assembly procedures shall each include pertinent assembly criteria, such as clearances, backlash dimensions, torque values, recommended tools, required supplies, necessary follow-on tasks (if applicable), and similar data.

8. Procedures shall include detailed instructions for troubleshooting all anticipated failure modes, including the use of necessary special tools, PTUs, and bench testers.

9. Furnish a listing of all tools required to perform maintenance on the cars and apparatus, including both special and commercially available tools. Each requirement, instruction, or procedure shall include a list of tools, shop equipment, and materials required to accomplish the task, including manufacturer’s name and product number, and SEPTA commodity number, as appropriate.

10. Include safe practices and procedures.

11. Identify each removable component and assembly that weighs more than 50 lb (23 kg) and specify its weight. Provide appropriate warnings if lifting these items is required.

12. Include the Paint Preparation and Application CDRL specified in Section 16, Materials and Workmanship.

13. The manuals shall include instructions for using portable testers, bench testers, or shop stands for adjustment, test, and troubleshooting functions to ensure the overhaul was correctly accomplished.

26.1.6.4 Component and PCB Repair Manual

A. This manual shall be a compilation of documents for the direct support of the back-shop component-level troubleshooting and repair using associated BTEs, PTUs, and special tools.

1. This manual shall include, at a minimum, the following:

a. Printed Circuit Board (PCB) Schematics

b. Instructions for use of BTEs and PTUs

c. BTE Test Routine Logic descriptions

d. BTE and special tools electrical and mechanical drawings

e. PCB Test Specifications

f. PCB Trace Layouts

g. PCB Component Layouts

h. Test Reports with Pass/Fail criteria

i. OEM Equipment Manuals

j. BTE PC Software Loading Manuals

k. PCB Schematic narratives

l. Software and firmware uploading procedures

m. Unit-under-test (UUT) reference tables

n. BTE Design Description manuals

o. PCB functional block diagrams

p. Unit, Module, and PCB disassembly and assembly procedures.

q. Detailed maintenance and bench test troubleshooting procedures for each board, including wave forms and voltages at critical locations of the circuitry.

26.1.6.5 Illustrated Parts Catalog

A. The Illustrated Parts Catalog shall enumerate and describe every component, down to the LLRU level, with its related parts including PCBs, including the supplier's number and commercial equivalents.

1. Include a separate column for insertion of SEPTA's stock numbers in future revisions.

2. Identify all parts using computer-prepared letter-quality text (indented format) with line artwork using cutaway and exploded drawings.

a. Each part shall include the Contractor's part number, and the supplier's part number if different.

b. Parts common to different components (for example, bolts and nuts) shall bear the same Contractor's number.

c. Include illustrations on a subcomponent level (vs. full component).

d. For bolts, nuts, and other similar hardware, furnish information relating to material, coating, all dimensions, and type. Identify each part or other component as being part of the next higher assembly.

3. Include cleaners and lubricants in the Illustrated Parts Catalog, as specified in TS 26.1.6.2.1.

4. Include an appendix that lists each supplier's contact information, including complete address, telephone number(s) for responsible office(s), and hyperlinked URL, and the manufacturer’s number for the components used, in order to expedite procurement.

5. If the same drawing is used in both the Illustrated Parts Catalog and another manual, the reference index in both manuals shall identify the same parts.

6. Furnish the illustrated parts manual text database and the Approved data management software for its use, licensed to SEPTA.

26.1.6.6 Maintenance Manual – Special Tools, Portable Test Equipment, and Bench Test Devices

A. Maintenance manuals for special tools and test devices shall include the requirements of Section 27, Special Tools and Test Equipment, and shall be presented in the format required by TS 26.1.5.

1. Include a section describing setup and testing procedures for each special tool and test device.

2. Include a section with all information needed for periodic inspection and servicing requirements of the equipment, including lubrication, inspection, calibration, and adjustment of all apparatus.

3. Include all drawings with dimensions, materials, and BOM of each special tool furnished to SEPTA.

26.1.6.7 Illustrated Parts Catalog – Special Tools, Portable Test Equipment, and Bench Test Devices

A. Parts Catalogs for special tools and test devices shall include the requirements of Section 27, Special Tools and Test Equipment, and shall be presented in the format required by TS 26.1.5.

26.1.6.8 Operation and Maintenance Manuals – Operator Training Simulator

A. Details are covered in TS 26.3.14.

26.1.6.9 Software Book

A. Provide software documentation conforming to the requirements of Section 19, Software Engineering, in separate binders. This documentation shall be subject to the same revision and formatting requirements imposed on manuals in this Section.

26.1.6.10 Engineering Data Book

A. The Engineering Data Book shall contain comprehensive information for repairing all components of the car, including the structure, in case of a derailment, collision, or major accident.

1. This shall include necessary carbody data, materials needed for wreck repair, shop practices, and detailed procedures, including for assembly joints, welding, and heat treating.

2. Include many illustrations for clarity at appropriate points throughout the text.

3. Include appropriate safety warnings and precautions at relevant points. SEPTA will provide a sample Engineering Data Book for reference.

4. The Engineering Data Book shall be subdivided into the following sections:

    a. Carbody Information

    b. Materials

    c. Damage Evaluation, Trim-Back, Part Salvage

    d. Wreck Repair

    e. Shop Practices

    f. Appendix: Specifications, Butt/Lap Weld Drawings, etc. This shall comprise data from the car's as-built drawings.

26.1.6.11 As-Built Technical Specifications

A. Provide copies of the specifications of all materials installed on the car, incorporating all revisions necessary to accurately reflect the as-built condition of the car. Continue to update this document, in accordance with Section 26.1.8, Revisions, throughout the warranty period.

26.1.7 Submission Schedule and Quantities

A. Draft manuals may be submitted to SEPTA for review on a chapter-by-chapter basis; however, each manual shall be submitted as a complete unit before receiving Approval. Submit in accordance with Table 26-1 as follows:

1. Draft manuals **(CDRL 26-04, Draft Manuals and Parts Catalogs**)

2. Conditionally Approved manuals, **(CDRL 26-05, Conditionally Approved Manuals and Parts Catalogs)**

3. Final published manuals **(CDRL 26-06, Final Published Manuals and Parts Catalogs)**

4. Comply with the following requirements for manual submittal schedules and quantities. Submit an electronic copy (via secure web download) of each draft, Conditionally Approved, and final manual in all required electronic formats. Also submit printed copies of each Conditionally Approved and final published manuals as required below:

Table 26-1, Submittal Schedule for Manuals						
	Draft Manuals		Conditionally Approved Manuals		Final Published Manuals	
	Quantity	Due Date[1]	Quantity	Due Date[1]	Quantity	Due Date
Operator's Manual	5	-330	20	+60	500	Note 2
Running Maintenance Manual Part I: Scheduled Inspection and Maintenance Manual	5	-330	5	+60	100	Note 2
Running Maintenance Manual Part II: Troubleshooting Manual	5	-330	5	+30	50	Note 2
Running Maintenance Manual Part III: Car Schematic Diagrams and Pin-to-Pin Manuals	5	-330	5	+60	50	Note 2
Heavy Repair Manual	5	-330	5	+150	20	Note 2
Component and PCB Repair Manual	5	-330	5	+60	20	Note 2
Illustrated Parts Catalog	1	-330	1	+90	20	Note 2
Maintenance Manual – Special Tools, Portable Test Equipment and Bench Test Devices	1	-330	1	+60	20	Note 2
Illustrated Parts Catalog – Special Tools, Portable Test Equipment and Bench Test Devices	1	-330	1	+90	20	Note 2
Operation and Maintenance Manuals – Operator Training Simulator	1	-90	1	+60	5	Note 2
Software Book	1	-90	1	+90	5	Note 2
Engineering Data Book	1	-60	1	+120	5	Note 2
As-Built Technical Specification	0	-330	1	+90	5	Note 2

Notes to Table:

1. Due dates shown in number of days (-) before or (+) after scheduled acceptance of the first married pair.
2. Submit final published manuals at the completion of the Contractor Reliability Monitoring Period specified in Section 21, Reliability, Availability, and Maintainability, or 12 months after acceptance of the first car, whichever occurs first.

26.1.7.1 Draft Manuals and Parts Catalogs

A. The intent of the Draft Manuals and Parts Catalogs is to allow SEPTA to review and provide feedback on the substance of the manuals with enough time for necessary modifications to be made to support SEPTA's Maintenance Training Program.

1. The Draft Manuals and Parts Catalogs shall be complete and thorough, and shall be prepared as if they were the final versions.

2. The Draft Manuals and Parts Catalogs shall reflect the current state of the cars at the time of publishing, and shall be a culmination of the discussions of the various manuals status meetings held with SEPTA.

26.1.7.2 Conditionally Approved Manuals and Parts Catalogs

A. The intent of the Conditionally Approved Manuals is to provide an interim comprehensive set of documentation that has incorporated the necessary SEPTA comments and that will support SEPTA's Training and Maintenance efforts until the Final Published Manuals and Parts Catalogs are available.

B. The Conditionally Approved Manuals and Parts Catalogs shall incorporate the necessary revisions as a result of SEPTA's review of the Draft Manuals and Parts Catalogs, and shall incorporate car modifications realized at the time of submittal.

26.1.7.3 Final Published Manuals and Parts Catalogs

A. Final Published Manuals and Parts Catalogs shall incorporate any and all revisions or modifications realized during the Warranty Period.

B. Submit, in both printed and electronic format, necessary revisions through the end of Warranty Period, as per Section 26.1.8, Revisions.

26.1.8 Revisions

A. Submit revisions every six months, or more often as required to reflect design changes in an accurate and timely manner.

1. First submit a plan outlining all changes to each manual for SEPTA review before submitting revised manuals. (At time of first manual revision provide all OEM manuals for information purposes. No revisions of the OEM manuals are required.)

2. A new revision sheet shall be provided for each manual showing the date of any changes made since the previous submittal and the pages that are affected.

3. Manual revisions shall be recorded on a control list in the front of each manual. The list shall be issued with each revision and shall show the date of each revision and the page reference.

4. "Track changes" shall be used within the document.

5. Revisions related to field alteration of subsystems or assemblies shall be issued with the associated service bulletin before the arrival of the components or retrofit packages.

6. Revisions of Draft and Conditionally Approved versions shall be alphabetically lettered, with the original denoted as 0 and the version type as a prefix, for example DR-0, DR-A, DR-B; CA-0, CA-A, CA-B. The Final manual shall have

revision letters in alphabetical order, with the original denoted as 0, without a prefix.

7. Submit revisions in the same media (electronic and/or printed) and in the same quantities as required in Table 26-1. **(CDRL 26-07, Updates to Manuals and Parts Catalogs)**

26.1.9 Manual Support System

A. Provide the capability of updating and modifying the delivered manuals and catalogs.

1. This shall include one set of the commercially available or custom-designed software used to create the deliverable manuals and catalogs with site license and original documentation, any special instructions needed to supplement that documentation and any special hardware which may be required to operate the software.

2. Submit authoring files in a Word or other Approved format.

26.1.10 In-Process Reviews

A. Conduct in-process reviews of the manuals and all aspects of the manual development process during this Contract.

1. Conduct the first review within 24 weeks after PDR. Coordinate subsequent review dates with SEPTA, but in no case shall they be held less than every 12 weeks.

2. Submit an agenda and materials to be presented during the review shall be submitted prior to the review date.

3. During these reviews:

a. Present the status of the manuals program versus the Contract document requirements, including action items status from previous reviews.

b. Present all completed manuals chapters or portions thereof for SEPTA review.

c. Present the results of any audits.

d. Present any issues related to the development of the manuals to be addressed by SEPTA.

e. At SEPTA's request, make available for interview those persons who are developing the manuals.

f. Record minutes to be published after the review, including any action items.

4. These reviews shall be conducted at a location to be selected by SEPTA.

26.1.11 Audits

A. Conduct periodic audits to ensure that the manuals accurately reflect equipment design, the reliability and maintainability analyses upon which they are based **(CDRL 21-02** and **CDRL 21-03)**, and the Specification requirements. The results of these audits shall be presented at the in-process review meetings.

26.1.12 Contractor Internal Review and Approval

A. Review all manuals for accuracy, consistency, and completeness. Review shall be performed by the appropriate Contractor engineering personnel, manuals department head, or the person responsible for manuals on this Contract, and program management personnel before submittal to SEPTA.

B. Each document submitted to SEPTA shall be accompanied by a sign-off sheet that includes the signatures (and date of signing) of all persons who conducted the review attesting to the accuracy and completeness of the submitted manuals.

26.2 Training

26.2.1 General

A. Furnish a training program for SEPTA's Training Instructors and supervisory staff of a quality and depth sufficient to permit satisfactory use, servicing, and maintenance of the equipment.

1. This program shall include classroom and hands-on instruction, mock-ups, models, manuals, diagrams, simulators, and parts catalogs. The program shall comply with the guidelines given in APTA-RT-RMT-RP-001-10.

2. The curriculum material shall be accurate, complete, and of professional quality.

3. Assume no knowledge of the features of the cars on the part of SEPTA's personnel and design the program to bring the level of knowledge to one fully adequate for the objective. Assume that SEPTA’s personnel have the basic skills pertinent to their crafts.

4. Prior to the initiation of classroom instruction, all Contractor's instructors shall attend a one-day orientation at SEPTA to become familiar with SEPTA safety regulations and facilities and the layout of the car, and to be advised of student qualifications and expectations.

5. All courses of instruction shall be presented in the English language.

6. All documents shall be created using Microsoft Office products, unless otherwise Approved.

7. Furnish a full-time on-site manager to coordinate the training program and ensure continuity of classes and proper distribution of training materials, and to interface with instructors.

8. The Contractor's instructor will be accompanied at all times by a qualified SEPTA instructor or supervisor to ensure that all SEPTA rules and procedures are followed.

9. All training materials, such as training aids and lesson plans, shall become the property of SEPTA at the completion of the training program. Maintain these materials in good condition for the duration of the training program, and replace all damaged materials, unless the damage is the result of neglect by SEPTA. SEPTA reserves the right to record training activities for use by SEPTA in later training programs.

26.2.2 Objectives

A. Maintenance Training Program: The primary objective shall be to train SEPTA's Instructors and Supervisors so that they are sufficiently proficient in the operation and maintenance of the car to provide effective instruction and training to SEPTA's maintenance personnel.

B. Operations Training Program: The primary objective shall be to provide Operators and Operations Supervisors with proficiency in the operation of the car.

26.2.3 Requirements for Scope of Training

A. The following listing gives the numbers of personnel to be instructed:

1. Operating personnel, including supervisors:

a. 5 within ten days of delivery of first married pair

b. 20 (including the original 5) within 90 days of delivery of first married pair

c. 100 additional within one year of delivery of first married pair

2. Maintenance personnel, including supervisors:

a. Furnish the following maintenance training for each of the subjects listed under Training Course Content below:

(1) Initial training: Upon delivery of the first vehicle, complete training for one group of up to 10 trainees.

(2) Additional training: After delivery of the first vehicle, train additional trainees as class size allows. Minimum of 30 additional trainees.

(3) Class size: Allow for hands-on training as needed.

b. Time period:

(1) Conduct the initial and additional training over a period of maximum 52 weeks.

c. Training hours:

(1) Initial and additional training: While the requirement is to provide instruction for the entirety of the agreed upon course materials, a minimum of 1600 instructor training hours are to be provided.

26.2.4 Training Course Format

A. The training program shall be conducted at SEPTA's facilities and shall include classroom and hands-on instruction for a selected group of Instructors, Supervisors, Mechanics/Technicians and Operators.

1. The program shall provide for a combination of classroom instruction and hands-on demonstrations in the shop and on the car of operations and maintenance functions. For most practical subjects, spend 50% of class time on hands-on activities. Integrate the classroom and hands-on portions so that the hands-on training reinforces the topics covered in the classroom. The total number of hours per course shall be as required to complete the agreed upon subjects.

2. Class size will generally be from 5 to 10 employees, depending on the nature of the course being taught.

3. Factory training may be a part of the training; however, the extent of instruction in the Contractor's and subcontractors' shops shall be at the discretion of SEPTA.

a. SEPTA may request access to these shops for a limited number of supervisory and technical personnel to familiarize them with assembly methods.

b. Make a reasonable effort to comply with such a request, but not to the detriment of production.

c. Similarly, grant SEPTA’s operating supervision access to all equipment for the purpose of familiarization.

4. Assign a qualified instructor to each group of students during training.

a. Instructors shall receive sufficient technical support to answer any questions that are not addressed during the training program.

5. The program shall include testing and evaluation to determine the proficiency of the students.

6. The training program schedule shall be synchronized with the delivery of manuals.

7. The training shall be task-oriented.

8. The first course session given of each type shall be a pilot course, used by SEPTA to evaluate the suitability of the course for its personnel. SEPTA intends for the students of the pilot course to be senior-level operators and maintainers, as well as instructors and supervisors, who will provide feedback on ways to improve the course. Following receipt of this feedback, the course shall be revised accordingly for the remaining sessions.

26.2.5 Training Course Content

26.2.5.1 Maintenance Training

A. The maintenance training program shall provide in-depth understanding of car assembly, subsystem installation function and operation, integration, and car verification testing.

1. Each training class shall begin with an overview of the class to be delivered. As part of this overview, introduce the class to the technical features of the Silverliner VI cars.

2. Students shall observe demonstrations of proper maintenance practices and shall be instructed in the requirements for and use of proper tools (e.g., special tools), the importance of proper torquing and sealing procedures, and the most efficient way to perform maintenance. The use of special tools, BTE, and PTU (as appropriate) shall be demonstrated, either on a training aid or on the vehicle, unless specified otherwise by SEPTA.

3. Classroom instruction for maintenance courses shall include the essentials of routine care including lubrication schedules, materials, Contractor's recommendations for test frequency, and tolerance limits and methods for testing, including instruments required, when applicable.

4. When methods of access, removal, dismantling, or application are not self-evident, the instruction shall cover these matters.

5. Students shall learn equipment theory of operation to the card circuit level, with troubleshooting, preventive (scheduled) maintenance, and corrective (unscheduled) maintenance operations.

6. Students shall have the opportunity to perform the more complex maintenance functions on the cars and in the shop, in addition to troubleshooting subsystems using the appropriate subsystem test devices.

7. The program shall include details of performing heavy maintenance repair and rebuilding of selected components. Examples include replacement of

compressor seals and traction motor bearings, axle and motor installation, and contactor rebuilds.

8. Present Equipment Overhaul procedures on a subset basis to SEPTA's shop personnel responsible for the respective subject area. Each subset shall include a detailed component description, complete disassembly, inspection, wear limit tests, and complete overhaul or remanufacturing instructions, including servicing, assembly, balancing, seasoning, lubrication, tests, and adjustments.

9. Divide courses into three classifications: electrical, mechanical, and HVAC. To enable student participation during demonstration and performance of maintenance functions, separate each course into these three classifications.

10. Maintenance courses shall be given in at least three separate sessions. The presentation of each topic shall include both a subsystem-wide review and in-depth discussion of the components of each subsystem (e.g. circuit breakers) as necessary. Topics to be covered in the Maintenance Training Program shall include, but not be limited to the following:

    a. Carbody

    b. Car logic control

    c. Propulsion

    d. Pantograph

    e. Friction brake

    f. Pneumatics

    g. Valve rebuilds

    h. Primary power

    i. Auxiliary power

    j. Trucks and suspension

    k. Coupler and draft gear

    l. Door control

    m. Heating, ventilation, and cooling

    n. Lighting

    o. Cab signal and PTC

    p. Communications and passenger signage

q. Monitoring and Diagnostics

r. Event Recorder

s. Network and Trainlines

t. Train-to-Wayside Data Transfer (TWDT)

u. Periodic Inspection

v. Removal, replacement, and adjustment of carbody materials and equipment, such as the following:

(1) Glazing

(2) Seats

(3) Doors

(4) Underfloor equipment

(5) Trucks

(6) Windshield wipers

w. Removal, replacement, and adjustment of rooftop equipment such as the following:

(1) HVAC Equipment

(2) Pantograph

(3) Antenna

(4) Equipment boxes

x. Removal, replacement, and adjustment, where applicable, of car electrical equipment, such as the following:

(1) Windshield wiper motor

(2) Heaters

(3) Circuit breakers

(4) Switches and indicators

(5) Light fixtures

y. Rerailing procedures

z. Emergency and rescue towing procedures

11. Qualified Maintenance Personnel Course

    a. A qualified maintenance personnel (QMP) qualification course shall be developed to establish training to certify and qualify maintenance personnel as required by 49 CFR 238.109 to actively perform inspection and testing to certify equipment for service per 49 CFR 238.301 through 49 CFR 238.319 of the Code of Federal Regulations.

    b. The following inspections and activities shall be developed by the Contractor and submitted to and Approved by SEPTA prior to the course being developed. Each inspection and/or test shall have two (2) separate parts consisting of a standalone procedure and a separate data sign off sheet. The courses shall consist of, at a minimum: Calendar day exterior mechanical inspection.

        (1) Calendar day interior mechanical inspection

        (2) 184-day inspection

        (3) 3-year air periodic brake equipment maintenance

        (4) Single car test

        (5) Class 1 brake test

        (6) Class 1a brake test

        (7) Class 2 brake test

26.2.5.2 Operations Training

A. Instruction in operations shall follow a logical progression involving the anatomy of the cars, differences between these cars and SEPTA's existing rolling stock and equipment, the manipulation of all controls, and actual operation of the cars.

    1. Operating instruction shall include trouble indications, their proper reporting, and corrective measures available to Operators.

    2. The Operator's Course shall be given in at least five separate sessions.

    3. Topics to be covered in the Operations Training Program shall include, but not be limited to, the following:

        a. Car specifications, controls, and indicators

        b. Car subsystems (e.g., propulsion, friction brake, electrical, truck and coupler assemblies, door control, HVAC, lighting, and communications)

        c. Car operations

        d. Troubleshooting procedures and recovery operations

e. Unusual and emergency modes of operation.

26.2.5.3 Familiarization Training

A. Instruction for other support personnel, such as transportation personnel or emergency responders, shall follow a logical progression involving the anatomy of the cars, differences between these cars and SEPTA's existing rolling stock and equipment. The familiarization training shall be video based and include, but not be limited to the following:

1. Basic car configuration
2. Door operation
3. Starting up process
4. Emergency features including exit windows and safety equipment
5. Lighting control
6. HVAC control
7. Announcement system.

26.2.6 Training Course CDRLs

A. The following CDRLs are required for training:

1. Submit a Training Plan and Summary Level Schedule: (**CDRL 26-08, Training Plan and Summary Level Schedule**)
2. Submit course outlines for each course at least nine months prior to the anticipated start date of each course. **(CDRL 26-09, Training Course Outlines)**
3. Submit lesson plans for each course **(CDRL 26-10, Training Lesson Plans)**
4. Submit detailed schedule data for the proposed courses (**CDRL 26-11, Training Detailed Schedule**).
5. Submit a detailed resume and statement of qualifications for each instructor. **(CDRL 26-12, Instructor Resume and Qualifications)**

26.2.7 Training Materials

A. Training materials used by the subcontractor shall be complete, accurate, and submitted to SEPTA for Approval three months prior to the beginning of training. SEPTA will give feedback on these materials within one month after receipt; Contractor shall provide responses to SEPTA's feedback within one month after receipt. Changes based on this feedback shall be implemented prior to the beginning of training.

B. Furnish an adequate supply of high-quality, professionally prepared paper copies of training materials, and such other training aids as may be necessary to impart the essential knowledge to the people involved and leave them with authoritative and up-to-date reference material.

26.2.7.1 Instructor and Student Guides

A. Submit Instructor and Student Guides for each course. **(CDRL 26-13, Instructor and Student Guides**)

26.2.7.2 Training Aids

A. Submit training aids for both the Operation and the Maintenance Training classes: **(CDRL 26-14, Training Aids)**

26.2.7.3 Training Material Updates

A. Make corrections and improvements to all training materials during the conduct of the course when examinations, tests, or instructor observations indicate that a majority of students fail to attain the learning objectives.

Update lesson plans as required during the course of instruction.

26.2.8 Instructor Qualifications

A. Hands-on instruction in both the maintenance and the operation of the cars shall be presented by instructors having thorough experience in maintenance services or operations, as the case may require.

1. All instructors furnished by the Contractor shall be fully capable of transmitting in-depth technical information that can be understood by participants. Instructors shall be fluent in English.

2. Instructors shall have their subject matter properly organized prior to commencement of the class.

3. SEPTA will recognize the instructor as qualified when they meet all the following criteria:

    a. Have been trained in adult teaching principles and methods and has had experience in conducting technical training courses.

    b. Have an in-depth knowledge of the subsystem under discussion, its interfaces with other subsystems, and the procedures for isolating faults and troubleshooting, and is able to communicate that information to students in an effective manner.

4. Instructor shall have the ability to elaborate sufficiently and shall not solely read information provided on PowerPoint Slides.

B. Following the conclusion of a training course session, students shall be allowed to provide evaluations of the instructors and the training material to SEPTA. SEPTA will review this feedback and advise the Contractor whether the instructors should adjust their teaching methods and course material.

26.2.9 Student Testing and Evaluation

A. Design written or practical tests and give at suitable points in each course to determine the extent to which students have learned and can apply the information.

1. Tests shall be conducted in an electronic format supplied by the Contractor. For problem solving questions, multiple choice format, with multiple possible answers may be used to test comprehensive understanding. Answer keys for multiple choice questions shall be provided. Grading criteria for problem solving questions shall also be provided.

2. Submit student test and evaluation results at the end of each training course. **(CDRL 26-15, Student Test and Evaluation Results)**

26.2.10 SEPTA-Provided Resources

A. SEPTA will assist the Contractor in preparing training materials as follows:

1. SEPTA will provide samples of current training materials, illustrating how it should be organized, and of how instructor guides, student guides, lesson plans and audiovisual aids shall be designed.

2. As training materials are being developed, work closely with SEPTA staff to ensure that SEPTA's standards are being met, with respect to the course organization, content, and overall quality of written documents.

B. SEPTA will assist the Contractor in conducting the classes as follows:

1. SEPTA will make available, upon proper notice and at no cost to the Contractor, shop or lead track space for cars used for instructional purposes, and will arrange for road operation as well as the furnishing of power, dispatching, and operational supervision as necessary.

2. Cars that have already been accepted by SEPTA will be made available for operational training purposes. All cars used for conducting maintenance training shall be furnished by the Contractor, and shall be made available at the most updated configuration.

3. SEPTA will provide a reasonable amount of classroom space and assistance in the movement of equipment within its own property, and will furnish suitable classroom furniture such as desks and chairs. However, the Contractor is

required to furnish all equipment required for conducting presentations – computers, projects, chalk, dry erase markers, etc. – unless specified otherwise by SEPTA.

4. SEPTA will also provide for the availability of trainees to accommodate training class schedules to the maximum extent possible within the constraints of individual work schedules and operational demands. Classroom schedules will be adjusted within reason to accommodate operational exigencies.

26.2.11 Training Bulletins

A. If warranty work done on cars necessitates a change in maintenance or operation that may require modifying manuals or course content, issue training bulletins to reflect the necessary changes. Training bulletin format shall be Approved by SEPTA.

26.3 Operator Training Simulator

26.3.1 General

A. Provide an Operator Training Simulator (OTS) as specified below. This procurement is for all labor, tooling, materials, parts, training, publications, support, warranty, spare parts and apparatus required for development and manufacturing of a Silverliner VI Cab Training Simulators. This procurement is also for all work needed to obtain fully tested and validated software installed on the Training Simulator and related computer systems, ready for operation when presented for final acceptance. Any items of material or equipment which are not fully described or are omitted in this Specification or the accepted Technical Proposal, but are necessary for the completion of the Training Simulator, shall be considered a part of the scope of supply.

1. Design the OTS to be compliant as a "Type II Simulator" as defined in 49 CFR 240.7, Definitions.

2. The OTS shall comprise of the following:

   a. An in-kind replacement of the existing Silverliner IV cab training simulators, (from CORYS) integrating fully with the existing Instructor Stations, Scenario Preparation/Data Administration Station, Remote Location Activity Station, Mobile Training Simulator Emulator Laptop, Instructor Remote Control Tablet, and all hardware and software interfaces with these. The supplier shall be CORYS, unless otherwise Approved.

   b. This shall include two (2) new Silverliner VI Student Cab Simulators, Spare Parts, Training, and Warranty Services.

3. Furnish for Approval a cybersecurity plan that outlines the proposed measures to ensure the cybersecurity of the OTS. The software for the OTS shall comply with the requirements for Category B software in Section 19, Software Engineering.

4. The Student Cabs shall be powered through either 120 Vac or through existing power infrastructure. The OTS shall be protected against power spikes and power losses.

5. As much as practical, OTS components in the Student Cab shall be identical to their equivalents on the car, to allow commonality of spare parts. The design of OTS components not present on the cars shall be robust, intended to serve in a simulator environment, and Approved.

6. The OTS shall be delivered, installed, and tested for acceptance by SEPTA no later than when the Conditionally Approved Operator's Manuals are submitted to SEPTA. The OTS shall be updated in accordance with TS 26.3.10, Updates.

7. The OTS shall accurately reflect SEPTA operating rules and procedures (i.e.: Cab Signals, PTC, Air Brake Systems, etc.), and student evaluation guidelines. Conduct meetings with relevant SEPTA departments, including Operations and Training, to ensure that the OTS accurately reflects SEPTA practices in these areas. These parameters shall be presented during OTS design review and FAI.

8. The Contractor is fully responsible for providing a complete, functional OTS that complies with government regulations and the provisions of the Specifications. This includes all required labor, equipment, materials, spare parts, training, warranty servicing, and documentation for the design, quality verification, installation, and setup of the simulator's hardware and software. If there is uncertainty or contradiction in the requirements, the Contractor shall promptly bring these to SEPTA’s attention for resolution.

9. Coordinate with SEPTA's IT department to facilitate remote access to the training simulators at SEPTA’s discretion. The OTS system shall not be designed to require this access for any functionality or warranty servicing.

10. The design life of the OTS shall be at least 15 years.

11. All information and intellectual property provided by SEPTA as part of the fulfillment of this section shall remain SEPTA’s property and shall not be copied, transmitted, displayed, performed, distributed (for compensation or otherwise), licensed, altered, framed, stored for subsequent use or otherwise used in whole or in part in any manner without SEPTA's prior written consent.

26.3.2 Student Cab

A. Comply with the following:

1. Each Student Cab shall accurately represent the Operator's area within the cab, forward of but not including the cab partition wall, including the following:

   a. The Approved Operator's seat

   b. HMI devices and interfaces

c. Screens to display the virtual environment, as seen by the Operator.

d. Microphone

e. Speakers

f. An Operator-facing camera

g. A tablet, at least 16 inches in size, that will represent controls mounted on the left side of the cab or on the rear wall of the cab.

(1) The tablet shall allow the Student to select the set of controls to be displayed, and to interact with those controls.

(2) When not in use the tablet shall be stowed in a pocket in an appropriate location in the Student Cab.

(3) The layout of the tablet's interface, and the location of the pocket, shall be submitted for Approval during OTS design review.

(4) The tablet shall be connected to the Student Cab via a non-proprietary wired connection.

2. The OTS controls, devices, and components shall replicate or simulate the correct status and response to all student actions, instructor actions, and car operation, including emergency situations and fault remediation.

3. All simulations within a given Student Cab (e.g. images, audio, simulated train behavior) shall be matched to one another and the operation of the controls. There shall be no undue lag or delay.

4. Provide both complete and accurate forward and side views.

5. All aspects of door operation shall be simulated, including visuals, sounds, and effects on passengers, but actual door leaves or other associated mechanical devices shall not be included.

6. The Student Cab shall interface with the Instructor Station, the Remote Location Activity Station and all voice communications.

7. The design of the Student Cab shall be presented during OTS design reviews and FAI.

26.3.3 Instructor Station

A. Ensure that the existing Instructor Station complies with these requirements, and enhance its functionality as necessary to ensure compliance.

1. The Instructor Station shall be a computerized workstation designed to support OTS operations, control the OTS, and initialize the OTS, equipped with the following:

a. A computer and multiple screens as necessary to support the specified functionality.

b. OTS computers, Approved no more than six months prior to delivery.

c. A mouse to dynamically control the inclusion and location of virtual elements.

d. Total of two tablets, including one spare.

e. A networked color printer.

2. The instructor shall be able to perform the following functions through the Instructor Station:

a. Select, start, end, pause, fast-forward, and replay training scenarios.

b. Start, pause, stop, archive, and refresh training sessions.

c. Move the student to a specific location on a line.

d. Trigger specific simulated events.

e. Insert dynamic objects (e.g., passengers, work crews, vehicles) into the training scenario.

f. Introduce situations within scenarios at will.

g. Select or modify the level of passenger loading.

h. Select subsystem failures (degraded operation), introduce faults, and introduce other service-related scenarios such as obstructions.

i. Modify the behavior of simulated wayside equipment including signaling equipment.

j. Monitor the student in real time, including but not limited to Operator's view, view of the Operator, speed, propulsion/braking, active faults, and door status.

k. Evaluate the student in real time, including inserting markers and comments at specific locations and times for later review.

l. Load scenarios from the Instructor Station or existing Remote Activity Stations.

m. Create after-action reports database including:

(1) The date, time, instructor, and student.

(2) The scenarios and situations encountered.

(3) Time synchronized snap shots of the student.

(4) A timestamped log of all student interactions with the controls.

n. Use after-action review tools to assist in reviewing student performance such as performance graphs over duration of the run, recorded video, and recorded sound.

3. The instructor shall be able to leave the Instructor Station and use the tablet to maintain the basic instructor functions specified above.

4. It shall be possible for the instructor to quickly modify existing training exercises and create new ones using templates, click-and-drag mouse controls, and simple keyboard commands.

5. Present the functionality and interface of the Instructor Station during OTS design reviews and FAI.

26.3.4 Scenario Preparation Station

A. Ensure that the existing Scenario Preparation Station and data administration system comply with these requirements, and enhance their functionality as necessary to ensure compliance.

1. The Scenario Preparation Station shall include:

a. One computer tower running the latest version of Microsoft Windows, or Approved equal

b. Four 24-inch LCD or LED monitors, with monitor stand(s) as needed

c. One desktop microphone

d. One set of desktop speakers

e. All appropriate software for the creation and validation of scenarios, training exercises, routes, and equipment, as well as any subcomponents of these. This shall include the ability to create, modify, or remove

wayside objects such as scenery. All products of this software shall be fully compatible with the OTS and with any future hardware/software updates.

f. The ability to operate through scenarios, which shall be identical in experience to the Student Cab except that the controls shall be displayed on the screen and interacted with using a mouse and keyboard.

2. The data administration system shall include:

a. All appropriate software for the exchange of scenarios and training exercises between the Scenario Preparation Station, Instructor Station, Student Cabs, as well as for data management and other administrative functions.

b. Storage, and backup, of trainee performance results.

c. A redundant design so that all stored data is maintained in its current status on a backup unit.

3. The Scenario Preparation Station and data administration system's functionality and interface shall be presented during OTS design reviews and FAI.

26.3.5 Graphics

A. Ensure that the existing Graphics comply with these requirements, and enhance their functionality as necessary to ensure compliance.

1. Provide high-resolution computer-generated images (CGI) to replicate SEPTA's entire operating environment for the existing Railroad division and including the Silverliner VI fleet including yards, and sidings. The existing simulator's imagery of SEPTA's operating environment may be used (and updated if necessary).

a. The OTS shall include updates to trackage, platforms, catenary, signaling (including cab signal and PTC), signage, yard changes and additions, and the right of way identified by SEPTA until before simulator FAI.

2. The OTS CGI shall be seamless and smooth panoramic wraparound without image splitting or flickering.

3. All presentations, regardless of number of video displays, shall correctly synchronize with all other presentations.

4. Imagery such as people and other on-track and off-track objects shall be realistic, including motion.

26.3.6 Audio System

A. Comply with the following:

1. The OTS shall exactly replicate all sounds of the cab and external environment as defined in the Specifications, including the following:

a. HVAC

b. Propulsion and braking, including emergency brake

c. Horn/bell

d. Opening and closing of doors

e. Announcements, warnings, and alerts from the cab console

f. Background radio chatter and other ambient noise representative of the operating environment

g. Interactions with passengers via the PEI

h. Crossing over bridges

i. Entry into tunnels and stations

j. Speed-dependent car sounds, including wheel-rail contact (including wheel defects such as flat spots), wind movement, and travel over joints and switches

k. Coupling sounds.

2. The sound shall be realistic and shall be at volumes consistent with the sound levels experienced in actual running on the route, and shall include the effects of acceleration and deceleration on these sounds.

3. The audio system shall use surround-sound technology.

4. All sounds shall be correlated to student action, car operation, environmental conditions, and images generated within the visual simulation.

5. Doppler effect shall be included as appropriate to indicate the presence of nearby vehicles, passing vehicles, or passing parked vehicles and structures.

26.3.7 Virtual Environment

26.3.7.1 General

A. Ensure that the existing Virtual Environment complies with these requirements, and enhance their functionality as necessary to ensure compliance.

1. Everything in the virtual environment shall be true to scale.

2. All objects shall be clear, visible, and their texture, shape, size, position, orientation, and movement shall be correct under all conditions.

3. People shall seamlessly transition between camera views as they move about all areas of the virtual environment.

4. All people including but not limited to passengers, employees, and contractors, modeled by the simulators shall include a diverse population representative of the multicultural background of SEPTA and its customers.

26.3.7.2 Virtual Train

A. The OTS shall accurately simulate the performance of the Silverliner VI cars:

1. Include degraded conditions with equipment faulty, cut out, isolated, or otherwise inoperable.

2. All information presented to the student shall match the information presented to the Operator on the actual train. This includes but is not limited to gauge reading, indicator status, TOD information, and behavior of the cab signal systems as would be appropriate the given environment.

3. The virtual train shall be able to move forward or reverse through the virtual exterior environment.

4. The movement of the virtual train through the virtual environment shall be physics-based, and shall accurately reflect the selected level of passenger loading.

5. Provide the functionality of coupling to other railcars and the uncoupling from other railcars.

26.3.7.3 Exterior Virtual Environment

26.3.7.3.1 General

A. Ensure that the existing Exterior Virtual Environment complies with these requirements, and enhance their functionality as necessary to ensure compliance.

B. The exterior virtual environment shall be based on the actual view from the Operator's position as outlined elsewhere in the Specifications.

C. All objects in the virtual environment shall have sufficient detail to enable determination of their relative position.

26.3.7.3.2 Chronological and Meteorological Conditions

A. The exterior virtual environment shall include the following conditions:

1. Time of day, including appropriate light conditions such as sunrise, sunset, twilight, and sun glare.

2. Weather conditions, including clear skies, rain, fog (with varying density), high winds, freezing rain, hail, snow, and blizzard conditions.

3. Track conditions and low wheel/rail adhesion coefficient, including dry, wet, icy, wet leaves, and snow covered, and various spill conditions (e.g., gravel, oil).

26.3.7.3.3 SEPTA System

A. The exterior virtual environment shall accurately simulate SEPTA's system, including:

1. All aspects of the entire alignment, including the right-of-way, tunnels, track switches (powered and hand operated), derails, grade crossings, crossovers, frogs, signals, signage including speed limit signs (permanent and temporary), station platforms, end terminals, yards, shops, bridges, tunnels, and supporting infrastructure.

2. Buildings, structures, and background images, including commercial, industrial, retail, and residential buildings; educational and recreational facilities; emergency and health services facilities; bridges, overpasses, parking lots, malls, and other typical buildings and structures found in an urban environment. This shall include accurate depictions of key landmarks as visible from the operating environment.

3. Trees, water surfaces, and distinct geological formations.

4. The system shall be updated to include any changes to the SEPTA system that occur before simulator FAI. SEPTA will provide details and drawings for any such changes to the Contractor.

26.3.7.3.4 Vehicles and People

A. The exterior virtual environment shall include the following:

1. A large number and variety of motor vehicles, including:

a. SEPTA-specific vehicles, including other SEPTA Railroad Division and Silverliner VI trains; existing and future Acela trains; SEPTA buses; and SEPTA supervisory, service, and recovery vehicles. Rail vehicles shall be modeled moving on or adjacent to the tracks within the Railroad operating environment, as appropriate. Their movement shall accurately represent permitted traffic directions.

b. Cars, vans, SUVs, light trucks, motorcycles, straight trucks, tractor trailers, and emergency vehicles (police, fire, and ambulance services).

2. A large number and variety of people, including:

a. Railroad Division passengers and customers.

b. Adults, seniors, children, and persons using mobility devices, reflecting the multicultural background of SEPTA customers.

c. Persons performing a variety of motions and actions such as entering, occupying, and exiting platforms, boarding and alighting trains, etc. At the instructor's discretion, persons shall trespass on the tracks or in other restricted areas, etc.

3. Work crews or other operational anomalies that may be present during or after service hours, including:

   a. Wayside workers, including SEPTA employees and contractors, wearing SEPTA-specific PPE.

      (1) Wayside personnel shall be capable of displaying a variety of hand signals as selected and controlled by the instructor.

   b. Work sites including cones, beacons, flashlights, flags, and signs, set up in accordance with SEPTA's Right-of-Way Rulebook.

   c. Wayside maintenance vehicles.

   d. Two unique rail maintenance vehicles, specific to SEPTA, shall be modeled and capable of instructor control as trains moving along the track network.

4. Up to ten additional instructor-controlled and globally placeable objects shall be modeled. These objects can include people, service animals, rail vehicles, and other vehicles. The specific list of additional movable objects shall be defined during design review.

5. Each scenario shall include a base number of vehicles and people autonomously reacting to and interacting with the virtual train and other vehicles, people, and objects within the virtual environment.

6. The instructor shall be able to dynamically create situations, as specified below, that include both compliance and non-compliance by people with laws and SEPTA Rule Books, as well as common passenger behavior during situations such as attempting to signal the Operator by waving arms.

26.3.8 Scenarios

A. Comply with the following:

1. The OTS shall be provided with 50 pre-programmed scenarios, as Approved. These shall include sufficient detail to instruct the Operator in the following:

   a. Train operations, including but not limited to the following:

      (1) Operating Operator's console including all controls.

(2) Understanding function of information and options displayed on the Train Operator's Display (TOD) and other console screens.

b. Yard procedures, including but not limited to the following:

(1) Coupling/uncoupling to/from another car, including visual verification of coupler alignment.

(2) Performing standing and running brake tests.

(3) Operator's reading of rail alignment, and proper handling of derails and misaligned switches.

(4) Checking for fouling equipment, including other cars, and responding accordingly.

(5) Entering/exiting a shop properly with the assistance of maintenance personnel.

(6) Entering/exiting a car wash properly.

(7) Entering a yard properly.

(8) Proper train handling.

(9) Rescuing a disabled train.

(10) Performing operations properly from a non-lead car.

c. Mainline procedures, including but not limited to the following:

(1) All appropriate procedures, and communication with appropriate personnel, before:

- Entering mainline
- Entering yard.

(2) Communication with the SEPTA Control Center.

(3) Interaction with trains ahead.

(4) Operator's reaction and communication with the SEPTA Control Center when facing a signal problem, including:

- A stop signal.
- A dark signal.
- Wayside/cab signal nonconformance.

- Route/aspect nonconformance.
- Cab signal and PTC failures.

(5) Crossover moves, including single track operations.

(6) Proper procedures when entering an active work zone, including communication with wayside personnel.

(7) PTSO operation.

(8) Dead tow condition.

(9) Proper procedures for train recovery of Silverliner VI with Silverliner VI, Silverliner V, Silverliner IV, ACS-64, and diesel locomotive that could presumably be used in a rescue scenario, and train self-recovery.

(10) Station overrun procedure.

(11) Reacting correctly to track obstacles, including flooding, snowdrifts, debris on the tracks, etc.

(12) Wayside Defect Detector Activation

(13) Speed Restrictions (FS-1)

(14) Operating under slippery rail conditions.

d. Troubleshooting procedures for situations including but not limited to the following:

(1) Brakes fail to apply.

(2) Brakes fail to release.

(3) Uncommanded Emergency Brake application.

(4) Doors Closed fails to illuminate.

(5) Horn failure.

(6) Passenger intercom fails to activate.

(7) Public address (PA) audio fails to activate.

(8) Cab radio transmit/receive errors.

(9) Failures of cab signal.

(10) Train will not take power.

(11) Loss of catenary power, including load shedding condition.

(12) Master Controller inoperable condition.

(13) Resetting low-voltage circuit breakers in accordance with the SEPTA Control Center's command.

(14) Unable to close doors.

(15) Unable to charge brake pipe.

(16) Loss of Main Reservoir air pressure.

(17) Penalty brake application without apparent cause.

(18) Activation of smoke detector.

(19) Other common or significant failure modes on the Silverliner VI fleet, as specified by the Contractor and SEPTA during design review or observed by SEPTA within 12 months after delivery of the pilot cars.

2. The OTS shall include the necessary software-authoring tools to allow SEPTA to modify and develop additional training exercises and scenarios.

3. Present the full list of scenarios and events during OTS design reviews and demonstrate during FAI.

4. FAI testing shall occur concurrently with Factory Acceptance testing.

26.3.9 Situations

A. The OTS shall allow for dynamic creation of situations by:

1. Selecting a base married pair or pedestrian within a scenario and controlling its behavior.

2. Introducing additional SEPTA or other trains (including Amtrak and freight trains), Silverliner VI trains, movable objects, or people into a scenario with either:

a. A predefined behavior

b. Instructor controlled behavior.

3. Controlling wayside and cab signals, including stop arms, both by setting the state of the signals/stop arms automatically and by manually changing them at any time (to simulate failures).

4. Controlling train switches.

5. Introducing car faults.

6. Introducing faults to wayside infrastructure, such as signals.

26.3.10 Delivery, Installation & Commissioning

A. The Contractor shall be completely responsible for correct installation, setup, commissioning, startup, and validation testing of the Training Simulator. The Contractor shall work with the appropriate SEPTA departments and shall supply all of the necessary instructions to ensure proper preparation for the installation of the Training Simulator.

B. All material and equipment to be delivered by the Contractor to SEPTA shall be shipped prepaid at the Contractor's expense using a common or contract carrier of the Contractor's choice. SEPTA shall not be liable for the payment of any shipping, transportation, delivery, customs or unloading costs under this Contract.

C. Training Simulator preparation and installation requirements shall include, as a minimum:

1. Technical drawings including the footprint of the Cab Training Simulator and the required facility dimensions.

2. Any specialized construction instructions.

3. Electrical requirements.

4. Temperature and humidity requirements.

26.3.11 Training

A. Provide an Approved Training Program. This program shall provide adequate coverage to ensure satisfactory operation, servicing, troubleshooting and maintenance of the Training Simulator and all other furnished equipment.

B. Assume that SEPTA's instructors and maintenance personnel have the basic skills pertinent to their crafts, and a high school education. When creating lesson plans and content, the Contractor shall also assume that such students will be new to the Training Simulator environment and its associated systems. Instructional content shall be sufficient to include the context of the subject matter along with theory of operation, troubleshooting, corrective actions for repairs and preventative maintenance instructions.

26.3.12 Spare Parts

A. Provide Spare Parts for all apparatus and components of the Cab Training Simulators. All assemblies shall be delivered as called for. All items shall be identical with corresponding items as supplied on the Cab Training Simulators, and any changes to parts made on the Cab Training Simulators before or during the warranty period shall

be made on applicable Spare Parts at no cost to SEPTA. Where appropriate, all parts shall be packaged for long-term and/or protected storage.

B. Provide an electronically controlled recording medium such as a database or spreadsheet where all parts and materials are listed by name, contractor part number, supplier part number, and quantities. A full record of deliveries and extractions from stock shall also be recorded within the medium as parts and materials are delivered or used.

26.3.13 Technical Support

A. Provide full technical support for the Training Simulators and all of its components, including Spare Parts and Peripherals for the duration of the Warranty.

26.3.14 Operation and Maintenance Manuals

A. The operation and maintenance manuals for the Operator Training Simulator (OTS) shall include all information needed for operation and maintenance of the OTS. This includes:

1. Complete documentation of the functions and capabilities of the simulator system for each type of user (student, instructor, maintenance technician, system administrator, and any others as appropriate).

2. Detailed instructions regarding the instructor's creation of custom scenarios, modification of existing scenarios, and assessment of student performance.

3. System documentation, including power requirements, electrical schematics, and a two-dimensional drawing of the layout, including dimensions.

4. Detailed procedures for troubleshooting and replacement of parts, down to the LLRU level.

26.3.15 Updates

A. Comply with the following:

1. Furnish and install updates, at least every six months throughout the warranty period of the fleet, to ensure that the OTS accurately reflects the Silverliner VI and all modifications implemented on the fleet. This shall include additional common or significant failure modes on the Silverliner VI fleet, as specified under TS 26.3.8.

2. SEPTA shall have the ability to implement minor modifications to the OTS, throughout the lifetime of the simulator, independently and at no cost. Minor modifications include the following at a minimum:

a. Changing the behavior of individual signals.

b. Adding, modifying, or removing wayside objects such as scenery.

c. Modifying the student scoring and assessment process to reflect additional or revised procedures or criteria.

26.3.16 Operator Training Simulator CDRLs

A. The following CDRLs are required for the OTS:

1. **(CDRL 26-16, Simulator Conceptual Design Review)**

2. **(CDRL 26-17, Simulator Final Design Review)**

3. **(CDRL 26-18, Simulator First Article Inspection)**

4. **(CDRL 26-19, CDRL 26-19, Simulator On-Site Acceptance Testing)**

26.4 Contract Deliverable Requirements List (CDRL)

The following contract deliverables have been identified in this section; however, the Contractor is responsible for providing and submitting anything necessary to fulfill the requirements of this contract, including those not identified by CDRL number.

CDRL 26-01, Manuals Program Plan 26-3
CDRL 26-02, Maintenance Manual Verification 26-3
CDRL 26-03, Manuals and Parts Catalogs Table of Contents and Samples 26-3
CDRL 26-04, Draft Manuals and Parts Catalogs 26-15
CDRL 26-05, Conditionally Approved Manuals and Parts Catalogs 26-15
CDRL 26-06, Final Published Manuals and Parts Catalogs 26-15
CDRL 26-07, Updates to Manuals and Parts Catalogs 26-18
CDRL 26-08, Training Plan and Summary Level Schedule 26-26
CDRL 26-09, Training Course Outlines 26-26
CDRL 26-10, Training Lesson Plans 26-26
CDRL 26-11 Training Detailed Schedule 26-26
CDRL 26-12, Instructor Resume and Qualifications 26-26
CDRL 26-13, Instructor and Student Guides 26-27
CDRL 26-14, Training Aids 26-27
CDRL 26-15, Student Test and Evaluation Results 26-28
CDRL 26-16, Simulator Conceptual Design Review 26-44
CDRL 26-17, Simulator Final Design Review 26-44
CDRL 26-18, Simulator First Article Inspection 26-44
CDRL 26-19, CDRL 26-19, Simulator On-Site Acceptance Testing 26-44

26.5 CDRL Details

This section lists the expected content for each CDRL required above. The lists provided for each CDRL are an outline only and should not be considered exhaustive, all CDRLs are subject to SEPTA review and Approval.

CDRL 26-01 Manuals Program Plan

1. The Manuals Program Plan must be included as part of the Bid Package.

CDRL 26-02 Maintenance Manual Verification:

1. All Maintenance Manuals must be verified by performing actual maintenance on actual vehicles, on SEPTA property with SEPTA personnel as part of the Approval process.

2. Verification will include that the manuals are correct and achievable. Sign off is required by both SEPTA and Contractor appropriate personnel.

3. This process may be staggered with Inspection, Running Repair and Heavy Maintenance phases.

4. This process may be performed in conjunction with Training.

5. Completion of the CDRL is a requirement for final Approval of the Manuals.

CDRL 26-03 Manuals and Parts Catalogs Table of Contents and Samples

1. The Manuals Parts Catalogs Table of Contents and Samples must be included as part of the Bid Package.

CDRL 26-04 Draft Manuals and Parts Catalogs

1. Draft Maintenance Manuals for the Running Maintenance Manual Part I: Scheduled Inspection and Maintenance Manual are to be available for the Maintainability Demonstration Test as per Section 21 Reliability Availability and Maintainability.

CDRL 26-05 Conditionally Approved Manuals and Parts Catalogs

1. Conditionally Approved Manuals must be delivered per Table 26-1, Submittal Schedule for Manuals.

CDRL 26-06 Final Published Manuals and Parts Catalogs

1. All Manuals must have successfully completed the Manual Verification outlined in **CDRL 26-02**.

2. Manuals must be completed as outlined in Table 26-1, Submittal Schedule for Manuals.

CDRL 26-07 Updates to Manuals and Parts Catalogs

1. Manuals are to be updated per TS 26.1.8.

2. Catalogs are to be updated per TS 26.1.2.

CDRL 26-08 Training Plan and Summary Level Schedule

1. It shall identify milestones for submitting the following:
    a. Course outlines, lesson plans, instructor/student guides, and training aids
    b. Providing mock-ups/simulators
    c. Conducting classes
    d. Administering written and practical tests
2. It shall identify each module of instruction and the general topics to be taught, and shall indicate the order in which modules will be conducted.
3. All training aids shall be identified and listed for each car subsystem.

CDRL 26-09 Training Course Outlines

1. Submit course outlines for each course at least nine months prior to the anticipated start date of each course.
2. Include Training Materials (i.e., Tests to be used for evaluation) to be provided for approval.
3. Course outlines must satisfy the requirements of TS 26.2.5.

CDRL 26-10 Training Lesson Plans:

1. Submit lesson plans for each course at least six months prior to the anticipated start date of each course.
2. Lesson plans shall include samples of tests specified in TS 26.2.10, for Approval.

CDRL 26-11 Training Detailed Schedule:

1. Group this information by type of course and indicate separately for each individual course proposed.
2. Start Maintenance Training courses within five days after delivery of the first married pair.
3. Start Operator Training courses within five days following delivery of the first married pair.
4. Schedule classes on the basis of a 40-hour work week, 8 hours per day, Monday-Friday.
5. No classes shall be scheduled on SEPTA's holidays.

6. Class instruction periods shall normally be 50 minutes in duration, with a 10-minute break between periods of instruction. The length of practical application periods is not fixed.

7. There shall be a three-month break following the first Maintenance Training Course and a 14-day break following the first Operator Training Class to permit SEPTA personnel to evaluate the quality of the instruction and to request changes to enhance the effectiveness of the training.

CDRL 26-12 Instructor Resume and Qualifications

1. The resume should include pertinent job qualifications.

2. Resume must demonstrate support for the qualifications listed in TS 26.2.8.

3. Instructors shall be required to supply PPE/Safety equipment.

CDRL 26-13 Instructor and Student Guides:

1. Instructor Guides: Shall provide a detailed outline for conducting the class, with specific references to training aids to be used. They shall be sufficient to guide SEPTA's instructors to conduct the same class at a later time.

2. Maintenance Manuals and Parts Catalogs shall be incorporated into the classroom discussion, but shall not serve as the Student Guides. Student Guides shall be distributed to all students in each class.

3. Student Guides:

    a. They shall highlight the classroom material to be covered, and emphasize important concepts or maintenance issues.

    b. They shall include step by step written and visual instructions for all hands-on training portions of the class.

    c. Notebook-size copies of all visual displays used by an instructor shall be included in the student handouts.

    d. Presentation slides shall be included in the Student Guides for subject matter that is not found in the Manuals (i.e., showing simplified schematics for purposes of emphasizing a concept). However, the Student Guides shall not be limited to only the PowerPoint slides.

    e. Whenever possible, actual Manuals sections should be referenced as having been used during the classroom discussion.

    f. The Student Guides shall have all pages numbered and such numbering shall be reflected on the corresponding Power Point presentation slides to aid with locating the subject material during classroom discussions.

g. The Student Guides shall include adequate space and extra pages for students to take notes.

CDRL 26-14 Training Aids

1. Training aids shall comply with the following general requirements:

   a. Training aids may include actual samples of manually operable devices or working samples of devices, the functions of which can be displayed without dismantling the device. The workings of other significant components shall be illustrated with diagrams or cut-away views, etc., displayed with sufficient scale and clarity to permit all participants to clearly see the material.

   b. Suitable protective covers shall be provided for the master reproducible of each audio-visual aid.

   c. Test points shall be included on any models or mock-ups, together with the hardware necessary for maintenance operations.

   d. Proper nomenclature for all components shall be applied, and shall be in accordance with the terminology used on schematics and wiring diagrams incorporated in operating and maintenance manuals.

   e. All training aids shall be developed with the target audience being the SEPTA personnel that perform the tasks in service.

2. Power Point Presentations:

   a. Shall be colorful, use photographs, video clips, and animated schematics, as much as is possible, and will be designed to grab the students' attention.

   b. Power Point presentations may be used to illustrate component locations, component cutaways, schematic signal information, schematic voltage information, arc logic, and wiring diagrams.

   c. Power Point presentation materials depicting pneumatic, and HVAC subsystems shall include direction of flow for the particular medium.

3. Computer based training (CBT) and Power Point Presentations for use during the propulsion, friction brake, APU, HVAC, Communications, side door operation and control, cab signal and PTC electrical maintenance course. Fulfilling the following requirements for either CBT or Power Point Presentations does not relieve fulfilling the requirements for the other:

   a. CBT shall include, but not be limited to, an animated schematic of the propulsion primary motor circuit, the friction brake pneumatic circuit, APU, HVAC, Communications, side door control signals, and signal paths as appropriate for the signaling system.

   b. The CBT and Power Point schematic animations shall:

i. Use the same page layout, graphic symbols, circuit notation, and terminology as the propulsion, friction brake, side door, and cab signal and PTC subsystem schematic diagrams found in the maintenance manuals.

ii. Accurately display subsystem configurations on screen, all motoring and electric braking configurations, and have the capability to change configurations without any noticeable delay for screen re-drawing or refreshing.

iii. Display animated schematics for each subsystem to present one subsystem at a time.

iv. Accurately display, on screen, current flow in all parts of the propulsion primary circuit for all modes and all configurations.

v. Accurately display, on screen, command and current in all parts of the door control circuit for all door operating mode and all configurations, including door subsystem operating parameter values such as door open/close time, obstruction detection, etc.

vi. Accurately display, on screen, propulsion subsystem operating parameter values for all propulsion, friction brake, cab signal and PTC modes and configurations.

c. The propulsion subsystem parameters displayed on screen shall include, but not be limited to the following:

i. Line currents

ii. Motor currents

iii. Motor voltages

iv. Tractive Effort

v. Brake cylinder pressures

vi. Train speed and acceleration

vii. Relay and contactor status

viii. Internal logic flags or variables that would ordinarily be monitored by maintenance personnel during maintenance or troubleshooting.

d. There shall be no noticeable delay in updating the parameters display. Any other parameters, which in the opinion of the Contractor or SEPTA would aid in a student's understanding of the operation of the propulsion, friction brake, APU, HVAC, Communications, side door, cab signal and PTC subsystems, shall be included in the display.

e. CBT shall allow the user to simulate changes to various propulsion, friction brake, APU, HVAC, Communications, side door, cab signal and PTC operating parameters including, but not limited to, trainline inputs, line voltage, car weight, and braking and tractive effort request, and door open/close/ reopen/selective door close for all door operating modes. The display shall then immediately show the effect of those changes on the propulsion, friction brake, APU, HVAC, Communications, side door, cab signal and PTC subsystems.

f. Make use of actual component photographs wherever applicable and useful.

g. The CBT shall allow the user to simulate common propulsion, friction brake, APU, HVAC, Communications, side door, cab signal and PTC subsystem faults and then immediately see the actual effect that those faults would have on the propulsion, friction brake, APU, HVAC, Communications, side door, cab signal and PTC subsystems. Faults shall include, but not be limited to the following:

   i. Low or high line voltage

   ii. High and low main reservoir and brake cylinder pressures

   iii. Propulsion faults

   iv. Friction brake faults

   v. Relay and contactor failures

   vi. Over-temperature conditions

   vii. Compressor failures

   viii. Loss of PTC

   ix. Possible door failure modes, e.g., no door open/close condition at all cars in the train or specific car(s) in the train.

   x. Door Obstruction and door cutout

   xi. Emergency door operation

h. Furnish all documentation, materials, and tools necessary to modify and recompile the software if any future changes to the propulsion, friction brake, side door, cab signal and PTC subsystems require that the display be updated.

4. Furnish a minimum of 10 interactive training videos covering all major subsystems plus subsystem interfaces in an Approved format:

   a. Each video shall be divided into segments that are 10 to 20 minutes in length.

   b. An interactive menu shall be included at the start that allows the user to select a specific segment to review.

c. Segments shall include, but not be limited to operation of the following:

i. Propulsion

ii. Friction brake

iii. Cab signal and PTC

iv. Doors

v. Communications equipment

vi. Portable test equipment and laptop-based troubleshooting equipment

vii. HVAC

viii. APU

ix. Communications

x. Cab activation

d. Each segment shall include at a minimum:

i. Introduction and theory of operation for subsystem being discussed.

ii. Identification of components as well as line replaceable units (LRUs) and LLRUs for subsystem being discussed.

iii. Portable test equipment and laptop-based troubleshooting equipment operation for subsystem being discussed.

5. Wiring diagrams, when used as training aids and reference material, shall be divided to facilitate comprehension.

a. There shall be single-line functional diagrams of subsystems.

b. Schematic diagrams shall include details of each component in the subsystems.

c. Where parts are identified by initials or reference numbers, a key shall be provided to permit precise identification.

6. Provide training aids consisting of actual car components, integrated to work as they do on the car, for the following equipment. Training aids shall remain with SEPTA after Contractor training has been completed:

a. Door subsystem (with simulated door leaves)

b. HVAC

c. Communications subsystem, including all components as specified in Section 13, Communications

d. Friction Brake subsystem (ECU and components)

e. APS/LVPS

f. TOD Simulator

g. Operator Cab

h. Trucks

7. Training aids shall also be provided for the following equipment and shall remain with SEPTA after Contractor training has been completed:

   a. VMDS

   b. Train Control Network

   c. TWDT

8. Special tools referenced by the training program shall be available during training.

9. Familiarization Training Videos

   a. Videos shall be 10-20 minutes in length.

   b. Shall be delivered prior to shipment of first production vehicle.

CDRL 26-15 Student Test and Evaluation Results:

1. Submit student test and evaluation results at the end of each training course.

2. Provide summary student test reports by student quarterly.

CDRL 26-16 Simulator Conceptual Design Review:

1. The Simulator CDR shall allow the Contractor, and all relevant subcontractors, to present the preliminary design approach of all hardware and software being developed and to seek SEPTA's early agreement on the approach to the design of the OTS. Discuss relevant SEPTA rules, regulations, and procedures that shall impact the scenarios and student evaluations.

2. In advance of the CDR, submit all required documentation to allow comprehensive discussion of the parameters in Item 1, including the following at a minimum:

   a. A narrative description of each major item of hardware and software, and the interfaces between these items.

   b. A list of SEPTA rules, regulations, and procedures that impact the scenarios and student evaluations, as understood by the Contractor.

   c. Engineering drawings including dimension and weight information for all components being provided or upgraded.

CDRL 26-17 Simulator Final Design Review (FDR):

1. The Simulator FDR shall allow the Contractor, and all relevant subcontractors, to present detailed designs of all hardware, software and scenarios being developed and detailed descriptions of the functional parameters of the simulator.

2. In advance of the DDR, submit all required documentation to allow comprehensive discussion of the parameters in Item 1, including the following at a minimum:

    a. Latest revisions of all documents submitted for the CDR.

    b. The following for all hardware and software items being provided or upgraded:

        i. Functional descriptions

        ii. Electrical schematic diagrams

        iii. Assembly drawings

        iv. Maintenance and repair procedures

CDRL 26-18 Simulator First Article Inspection:

1. The Simulator FAI shall allow SEPTA to examine all components of the OTS. The functionality of the OTS shall be demonstrated. The OTS Operations and Maintenance Manual shall be completed, to at least Conditionally Approved status, by this date.

2. Conduct the FAI using stand-in replacements for SEPTA's existing infrastructure with which the OTS will interface, in a manner Approved.

3. In advance of the FAI, submit all required documentation to allow adequate SEPTA preparation for the FAI, including the following at a minimum:

    a. Latest revisions of all documents submitted for the DDR.

    b. Proposed FAI procedure, including stand-in replacement procedure.

4. Submit for Approval:

    a. FAI report

    b. Factory Acceptance Test Reports.

CDRL 26-19 Simulator On-Site Acceptance Testing:

1. The Simulator On-Site Acceptance Testing shall demonstrate the complete integration and functionality of the OTS within the existing Training Simulator infrastructure.

2. The Approved OTS Operations and Maintenance Manual shall be validated during this test.

3. In advance of the On-Site Acceptance Testing, submit all required documentation and test procedures to allow adequate SEPTA preparation for the On-Site Acceptance Test. The Approved OTS Operations and Maintenance Manual shall be validated during this test.

4. Submit for Approval, the On-Site Acceptance Test Reports. Acceptance of the OTS requires:

    a. All On-Site Acceptance Testing to be successfully completed and any open items are addressed.

    b. All Spare Parts are delivered.

    c. All training materials, documentation and publications are delivered.

    d. All training activities have been completed.

26.6 Referenced Standards

The following standards are referenced in this Section:

APTA PR-IM-RP-002-98	Passenger Rail Equipment Technical Documentation
APTA-RT-RMT-RP-001-10	Rail Vehicle Maintenance Training Standards
49 CFR 238.109	Training, Qualification, and Designation Program
49 CFR 238.301 through 49 CFR 238.319	Code of Federal Regulations
49 CFR 240	Qualification and Certification of Locomotive Engineers

SECTION 27
SPECIAL TOOLS AND TEST EQUIPMENT

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27.1 General

A. Furnish Special Tools and Test Equipment (portable test units (PTU), bench test equipment (BTE), and other relevant test devices) as specified in this Section. Provide software meeting the requirements of Section 19, Software Engineering, when applicable.

1. In addition to the types of test equipment specified in this Section, furnish all test devices required for the test programs.

2. All special tools and test equipment shall be high quality and designed for industrial use and shall be subject to Approval by SEPTA. These tools and equipment shall be furnished with NIST traceable calibration certificates if they are calibratable devices.

3. Integrate all test software, configure all computer-based test equipment, and prior to on-site delivery, furnish all required licenses for test equipment software at no additional cost to SEPTA for the lifetime of the car.

    a. Furnish site licenses that allow SEPTA to use all items provided in accordance with this Section, without restriction.

    b. Furnish development licenses, allowing changes to parameters, for all items delivered as part of the test programs.

4. Use centralized diagnostic ports, as specified in Section 17, Network and Trainline Control, and all subsystem-mounted ports to connect a PTU to monitor car network traffic and to download diagnostics data.

5. Provide drawings, Bill of Materials (BOMs), schematic diagrams, Illustrated Parts Catalog (IPC), software documentation, and manuals, as specified in Section 26, Manuals and Training, and when applicable.

27.2 Warranty

A. Provide a minimum five-year warranty for all tools and test equipment specified in this Section.

27.3 Portable Test Units

27.3.1 General

To the extent possible, all tests and diagnoses required to maintain the car subsystems shall be accomplished using the Train Operator's Display (TOD) in maintenance mode. When this is not possible, such activities shall be accomplished through the use of PTUs.

27.3.2 PTU Description

A. The provided PTU laptops/notebooks shall be of modern, high-performance design that complies with the requirements below. Present PTU preliminary specifications to SEPTA at Conceptual Design Review (CDR) and submit a suitable commercially available product for Approval at Final Design Review (FDR).

B. At the kickoff meeting, present the overall approach to the PTU, addressing the requirements of this Section.

C. PTUs shall comply with the following requirements:

1. Provide PTUs with a ruggedized construction for use in harsh, industrial environments, that is resistant to shock, vibration, and EMI, and include the following:

a. Integrated pointing devices.

b. RJ45 network connector

c. Cellular and Wi-Fi hardware. Wi-Fi wireless networking capability shall be of the latest 802.11 standard available at NTP, with compatibility maintained for IEEE 802.11a/b/g/n/ac.

(1) LibreOffice installed and up to date

d. Latest version of the Windows operating system, as defined in the Operating Systems requirements in Section 19, Software Engineering.

e. Solid state drive, with a capacity of no less than 2 TB.

f. Secondary internal 2 TB backup solid state drive for RAID (Redundant Array of Inexpensive Disks) or equivalent to backup primary solid-state drive.

g. PC backup and restore software.

h. USB (3.0 or higher) ports. Compatibility shall be maintained with USB 2.0 devices.

i. A carrying case, with handle, that when closed protects the PTU from impact, dust, and water.

2. With every PTU include the following cables:

a. Cable types:

(1) Provide one 8P8C "RJ45" to 8CPC "RJ45" four-pair cable for connection between the PTU Ethernet port and the vehicle's service port.

(2) Provide one 8P8C "RJ45" to a four-pin (two-pair) D-coded M12 cable for connection between the PTU Ethernet port and 100Mbps subsystem and switch ports.

(3) Provide on 8P8C "RJ45" to an eight-pin (four-pair) X-coded M12 cable for connection between the PTU Ethernet port and 1000Mbps subsystem and switch ports.

b. Cable requirements:

(1) Category 6A, shielded S/FTP

(2) Conductors shall have diameter of 26AWG or larger

(3) Halogen free according to IEC 60754-1

(4) Flame resistance according to IEC 60332-1-2

(5) Oil resistant

(6) UV resistant

(7) Minimum of 10 feet or 3.0 meters

(8) Operating temperature from -40 °C to 80 °C.

c. Connector requirements:

(1) M12 connectors shall be plug type and meet IP67 (mated), with insertion/withdrawal cycles ≥ 100.

(2) 8P8C connectors shall be plug type and meet IP20, with insertion/withdrawal cycles ≥ 750.

(3) 30 um gold plated terminals.

3. Unless otherwise Approved, the weight for each PTU shall not exceed 10 lb (4.5 kg).

4. Power to operate the PTUs shall be from a power supply that plugs into a standard 120 Vac outlet and shall use a battery when outlet power is not available.

5. Unless otherwise Approved, PTUs shall not require the connection of external apparatus for their operation.

a. In cases where the use of external apparatus is Approved, provide terminals to allow connection of the external apparatus to the PTU.

b. Such external apparatus shall be considered part of the PTU.

6. Response indicators and input-signal generators shall be built into the PTUs as necessary and shall have accuracy commensurate with the alignment tolerances applicable to the system or subsystem under test.

7. SEPTA will consider non-computer-based PTUs proposed by the Contractor on a case-by-case basis. Present such proposals at the kickoff meeting.

27.3.3 PTU Software

A. Comply with the following:

1. Each subsystem shall use subsystem specific software compliant with Section 19, Software Engineering. The subsystem specific software shall operate under a common Windows operating system, as specified in TS 27.3.2.

2. Furnish all software modules, master copy, and licenses for each PTU program. Furnish a site license for all custom PTU software such that SEPTA can expand its number of PTUs by copying the software onto another computer, including SEPTA-managed computers, for use at SEPTA locations only.

3. Provide a master loading image to enable software revisions to be propagated across all PTUs. This shall be updated as required elsewhere in the Specifications.

4. Provide all revisions to software from delivery through the warranty period. Software revisions shall not require changing the PTU operating system.

5. All PTU software shall be web-browser based. The Contractor shall coordinate browser selection such that full compatibility testing is performed utilizing the latest version of the selected browser for all browser based PTU software.

6. The Contractor shall perform compatibility testing upon delivery of the pilot cars, and annually throughout the warranty period, utilizing the latest version of Microsoft Windows and latest available browser at the time of the test, for all PTU software delivered.

    a. The Contractor shall correct compatibility issues identified during the test and provide revised PTU software, required compatibility settings, or updated software for onboard subsystems compliant with the requirements of Section 19, Software Engineering.

27.3.4 PTU Function

A. PTUs shall be designed to produce all operating commands and other input signals necessary to perform functional testing of the particular subsystem under test, and to measure or indicate signals, responses, and outputs produced by the system.

1. The PTUs shall be capable of monitoring, testing, and verifying for every combination of input and output signals the system might encounter during actual train operation, while simultaneously monitoring subsystem responses

to determine whether the subsystem performs in accordance with the Specifications.

2. Control logic and signals from the subsystem shall be easily accessed using the PTU User Interface.

    a. Both analog and digital data and network data shall be readily accessible and shall have the ability to address logic signals significant to analysis and diagnosis, including signals to and from relays and contactors, internal/external inputs and outputs, and network data.

    b. The control logic shall have the capability of supplying a sufficient number of analog and digital signals for real-time recording of control signal data.

    c. The PTU shall have the ability to store, display, and print analog and digital data.

    d. Logic shall be arranged for the connection of a PTU to permit static testing, and running monitoring of the subsystem operation, accessing fault or other memory, and access to analog signals.

3. Requiring the test device technician to perform a visual check for subsystem response, such as closure of a contactor, will be acceptable, provided that the visual check does not:

    a. Necessitate the removal of the component to be checked, as well as other components or equipment.

    b. Require the test device technician to lose sight of the PTU screen while checking the component.

    c. Require contact with moving or electrical parts that may result in injury to maintainers during use.

4. The PTU shall be capable of identifying the line replaceable unit (LRU), and where feasible, the lowest line replaceable unit (LLRU), that must be replaced to restore the system to its design functionality.

5. All messages in the PTU shall be in clear English and shall not require the use of tables, look-up charts, or decoding of numerical sequences to identify the defective component that requires replacement.

6. Testing shall be automated to the maximum extent possible and shall require a minimum amount of physical interaction from the test device technician. An automatic test feature shall be provided, for use after activities such as component repair or overhaul, that exercises all functions of the subsystem to ensure that it is fit for return to service.

7. It shall be possible to repeat as many times as necessary an entire automated test or any portions of the test for the purpose of troubleshooting intermittent problems.

8. Each PTU shall be designed such that it cannot initiate car movement while connected to the car subsystems.

9. For each PTU application, submit a functional description as part of the applicable Subsystem Functional Description (SSFD), as specified in Section 25, Program Management and Commissioning.

27.3.5 PTU Quantity and Delivery

A. Provide 30 PTUs complete with all software installed. If the PTU - Protocol Analyzer, specified in TS 27.3.8, is Approved to be provided on separate hardware, provide 10 PTU - Protocol Analyzers. **(CDRL 27-01, Portable Test Units and Required Documentation)**

27.3.6 Subsystems Requiring PTU

A. Provide PTU for all subsystems specified below. If a referenced Specification section contains several subsystems, then the PTU shall provide the required functionalities (Section 27.3.4, PTU Function) for each subsystem specified in the referenced Specification section.

1. Side Passenger Doors: Section 6, Passenger Doors.

2. HVAC: Section 7, Heating, Ventilation, and Air Conditioning.

3. Auxiliary Power Supply System: Section 9, Auxiliary Power.

4. Propulsion Subsystem and Control: Section 10, Propulsion and High Voltage System.

5. Friction Brake Subsystem and Control: Section 12, Friction Brake.

6. Communications Subsystems: Section 13, Communications. Separate PTU applications may be provided for the subsystems defined in this section, as Approved.

7. Network and Trainline Control (including Protocol Analyzer): Section 17, Network and Trainline Control. Discrete trainlines may be handled by a special tool rather than the PTU, if proposed by the Contractor and Approved.

8. Monitoring and Diagnostic Subsystem: Section 18, Monitoring and Diagnostics.

9. Automatic Train Control: Section 20, Automatic Train Control – Positive Train Control.

10. Event Recorder: Section 20, Automatic Train Control – Positive Train Control.

27.3.7 PTU Access to Car

A. Use of PTUs shall not require the removal, dislodging, dismounting, or disconnecting of any carborne component, card, wire, chassis, terminal, or cable.

B. PTU ports on the car shall be 8P8C RJ45 Ethernet ports with permanently attached environmental sealing covers. Access to these ports shall be via the RJ45 cable that is furnished with each PTU and specified in TS 27.3.2.

27.3.7.1 Network PTU Universal Port

A. Provide an Ethernet USP in the car as specified in Section 17, Network and Trainline Control.

1. The USP shall provide remote access for the TCDN.

2. Remote PTU access shall support the same level of functionality, information search and status (e.g., via remote log in) as achieved via the subsystem PTU local service ports.

3. When used to perform uploads, the PTU shall interrogate the user as to whether the update must be executed locally, on specific cars, or across the train. The progress of the uploads (whether local or train-wide) shall then be visible from the PTU screen with graphical visualization of the subsystem's location in the train, and with a colored representation of the upload status.

27.3.8 Network PTU - Protocol Analyzer

A. Provide the following:

1. A PTU that is capable of performing detailed diagnostics and real-time monitoring of network activity for all of the networks provided under this Contract.

a. The diagnostic equipment shall translate all data, both in and out of the diagnostic units, into engineering units.

b. Any hexadecimal presentation of data shall be in addition to the engineering units.

c. Provide the protocol analyzer as an application on the same hardware as other PTU applications, unless otherwise Approved.

2. Protocol analyzers that are capable of testing at the subsystem, car, married pair, and train levels, as part of the PTU for all networks provided. The protocol analyzer shall:

a. Support the setting of capture filters that are typically used to narrow the recording of telegrams to only the ones needed/targeted.

b. Support the activation of display filters that allows the review of a limited/specific portion of a network log or to group the telegrams (at will) according to specific color schemes.

c. Provide trigger mechanisms that allow unattended start of the logs based on particular triggering events.

d. Analyze the protocol stack in a way where Preamble, Node/IP Addresses, Control Flags, Applications, and the CRC can be broken down and visualized into tiers of specific data packets (e.g., expanding/collapsing packet details).

e. Provide graphical bandwidth trends/IO Graphs and associated correlated error imaging that could be used to qualify design with intelligible benchmarks.

f. Support the saving of network logs into log files, or the retrieval and the rerunning of existing logs at a future time for the purpose of reviewing a log with different display filters or for reprinting statistical reports, bandwidth trends, etc.

g. Provide timestamps or a means to verify system response time (e.g., request/response, trigger/broadcast).

h. Support the generation of statistics into the form of reports, for example:

(1) Time Stamp of First and Last Packet (message)

(2) Elapse Time (Log Duration)

(3) Number of Recorded Packets

(4) Number of Lost Messages or Packets

(5) Log was paused (Yes/No), Capture Filter ON (Yes/No)

(6) Total Bad Packets Count

(7) Total Packets with CRC Errors

(8) Total Packets with Missed Preamble

(9) Total Corrupted Packets

(10) Total Discarded Packets (Circular bit error)

(11) Total amount and percentage of packets per service (protocol/message type), for example:

Packet Qty 431- 28% UDP-Single Cast

Packet Qty 25 - 1.6% UDP-Multi Cast

Packet Qty 112 - 7.3% TCP-FTP

3. Visualization software for all data networks to permit network signals to be viewed in a graphical format appropriate for the signal of interest.

    a. For example:

        (1) Boolean (on/off) signals might be represented as a lamp or LED.

        (2) Analog signals might be represented as a meter or waveform graph/strip chart.

    b. Present details of the visualization software at design review for SEPTA's Approval.

27.3.9 PTU Demonstration

A. PTUs shall be part of each subsystem's FAI:

1. Demonstrate the functionality and capability of the PTU for the subsystems specified in TS 27.3.6, at each subsystem FAI and at the first married pair FAI.

2. Conduct the demonstration on a fully operational married pair and show compliance with PTU functional description and other Contractual requirements. Include fault insertions and hardware-in-the-loop simulations as part of the FAI to demonstrate proper functionality of PTU.

27.4 Bench Test Equipment

27.4.1 General

A. Comply with the following:

1. Each BTE shall be a standalone device unless Approved otherwise.

    a. SEPTA will consider accepting integrated BTEs that can test multiple subsystems individually or concurrently, if integrated BTE ensures effective testing, troubleshooting, and calibration. If this option is selected, SEPTA reserves the right to increase the required number of sets of BTE.

    b. If an integrated approach is Approved, the Contractor shall provide one complete and fully operational set of LRUs and LLRUs which are intended to be supported by the proposed BTE to the BTE system integrator. The Contractor shall also supply all the detailed design information with test specifications for each level of LRU and LLRU to SEPTA and the selected test system integrator. The Contractor shall retain responsibility for system integration of an integrated BTE.

2. Each BTE shall include PCB extenders, when necessary, for effective troubleshooting.

3. Provide all related tools, fixtures, and equipment needed to enable the BTE to test all components of their respective subsystems.

4. Manual equipment may be provided in lieu of BTE for testing mechanical, non-electronic subsystems. This equipment shall be classified as a Special Tool and shall comply with the requirements of TS 27.6.

27.4.2 Subsystems Requiring BTE

A. Comply with the following:

1. Provide BTE for all subsystems specified below. If a referenced Specification section contains several subsystems, then the BTE shall provide the required functionalities (TS 27.4.4) for each subsystem and, depending on the subsystem structure, additional components such as power supplies, standalone relays, etc., specified in the referenced Specification section.

   a. Side Passenger Doors: Section 6, Passenger Doors.

   b. HVAC: Section 7, Heating, Ventilation, and Air Conditioning

   c. Auxiliary Power Supply Subsystem, including AC auxiliary motors: Section 9, Auxiliary Power.

   d. Propulsion Subsystem and Control, including traction motors: Section 10, Propulsion and High Voltage System.

   e. Friction Brake Subsystem and Control: Section 12, Friction Brake.

   f. Communications Subsystems: Section 13, Communications. Separate BTE applications may be provided for the subsystems defined in this section, as Approved.

   g. Specifically for PA and Passenger Information System equipment, the Communication Subsystems BTE shall have the ability to test a married pair's worth of equipment simultaneously and continuously.

      (1) In addition to allowing the testing of individual components, the communication subsystem BTE shall allow for swapping and troubleshooting interdependent components.

      (2) The BTE(s) shall have the ability to upload all relevant data (e.g., schedules, signage programs) to allow the components to function as they would on a train.

   h. Network and Trainline Control (Network Analyzer): Section 17, Network and Trainline Control.

i. Monitoring and Diagnostic System: Section 18, Monitoring and Diagnostics.

j. Event Recorder: Section 20, Automatic Train Control – Positive Train Control.

k. Automatic Train Control: Section 20, Automatic Train Control – Positive Train Control.

2. At the kickoff meeting, submit a list of BTEs to be provided under this Contract. **(CDRL 27-02, List of Bench Test Equipment)**

3. Deliver and commission two sets of bench test equipment per each required BTE as determined at the kickoff meeting. **(CDRL 27-03, Bench Test Equipment and Required Documentation)**

27.4.3 Bench Test Equipment Requirements

A. BTEs shall comply with the following requirements:

1. Each BTE shall be designed to prevent injury to test personnel. Provide safety devices, such as, but not limited to, red mushroom emergency stop buttons, slotted plexiglass shields for high-powered testing, etc.

2. BTE shall present all input signals that the item under test encounters when in actual operation and simulated loads for each output.

a. Each item under test shall be subjected to all combinations of input and output, including high and low operating voltages, and skewed, distorted, or off-frequency signals that could be encountered when in revenue service.

b. If such inputs and outputs are capacitive or inductive, the I/O shall reflect that.

c. If inputs and loads are variable on a train, a sampling of at least 10 levels across the full range of operation shall be presented to the item under test.

d. Each load shall simulate as closely as possible the actual loads normally encountered by the device under test.

3. The unit under test shall attach to or plug into the BTE with a minimum effort. Include component-specific connectors, such as connectors for testing circuit boards, with each BTE.

4. As part of the Operational Condition Assessment discussed in Section 15, Test Program, survey SEPTA's facilities (for space, power and air supplies, and cleanliness etc.), to ensure the compatibility of the BTE design with SEPTA's Shop facilities.

5. Unless otherwise specified or Approved, BTEs shall not require the connection of external apparatus for their operation.

    a. In cases where the use of external apparatus is specified or Approved, provide quick-disconnect connectors to allow connection of the external apparatus to the BTE. The use of terminals is allowed when Approved. Provide visual and tactile indication of connector locking.

    b. Such external apparatus shall be considered part of the BTE and shall be provided with it.

6. BTEs for electric and electronic controls shall be computerized devices. Each BTE shall include the following:

    a. A computer workstation including the following:

        (1) Modern, high-performance microprocessor

        (2) A 17-in (432-mm) monitor

        (3) LibreOffice installed and up to date

        (4) Latest version of the Windows operating system, as defined in the Operating Systems requirements in Section 19, Software Engineering

        (5) Integrated pointing devices

        (6) RJ45 network connector

        (7) Solid state drive, with a capacity of no less than 2 TB.

        (8) Secondary internal 2 TB backup solid state drive for RAID (Redundant Array of Independent Disks) or equivalent to back up primary solid state drive.

        (9) USB (3.0 or higher) ports. Compatibility shall be maintained with USB 2.0 devices.

        (10) Network connection devices for remote troubleshooting (for selected subsystems only as specified below)

        (11) Through the warranty period, the Contractor shall perform compatibility testing annually utilizing the latest version of Microsoft Windows, utilizing the latest available browser, for all BTEs delivered.

    b. All associated computer programs, data, test scripts, etc., delivered at the time the BTE is delivered.

(1) Update all such items in accordance with Section 19, Software Engineering.

(2) Provide a master loading image to enable software revisions to be propagated across all BTE. This shall be updated as required elsewhere in the Specifications.

c. Directions, scripts, schematics, drawings, parts lists, and required information provided electronically.

(1) Update these items to reflect changes to BTE design or functionality in accordance with the revision provisions of Section 26, Manuals and Training.

(2) Provide a method for SEPTA to revise these items after Contract close-out, independently and at no cost, in case the BTE needs to be modified over the lifetime of the Silverliner VI fleet.

d. Detailed functional description, including functional diagrams of all boards in the equipment.

(1) Submit each BTE functional description as part of the applicable Subsystem Functional Description (SSFD), as specified in Section 25, Program Management and Commissioning.

(2) The BTE SSFD shall include a test specification for each subsystem LRU and LLRU along with a test parameters matrix which includes a matrix of the signals needed to be applied to the unit under test to verify all inputs and outputs of that unit.

7. Computers used as part of BTEs shall be modern and of the highest performance level available in the commercial marketplace. They shall be suitably ruggedized for extended service in a harsh, industrial environment, and resistant to shock, vibration, and EMI.

8. BTE shall be portable, and shall include all required supporting benches, carts, heavy-duty locking casters, etc.

9. Each BTE shall include one set of all peripheral test equipment required to make the necessary tests and adjustments, such as frequency generators, digital voltmeters, oscilloscopes, etc.

a. They shall be rack mounted in racks provided by the Contractor, adjacent to and rear connected to the specialized equipment, such that the end result is neat and tidy.

b. These items shall be premium quality, heavy duty devices supplied by Keysight, Tektronix, Fluke, or other similar General Services Administration (GSA)-approved suppliers.

10. The BTE shall include all support devices required to enable testing of the LRUs and LLRUs without the need to remove additional equipment from the car to support the use of the BTE.

11. BTE shall be provided with removable covers to shield them from dust and other shop contaminants when the BTE are not being used.

27.4.4 Bench Test Equipment Function

A. Comply with the following:

1. BTEs shall supply the means for SEPTA's maintenance technicians to locate and replace failed parts within an LRU or LLRU, and to enable rapid repair of the equipment. BTEs shall not be designed as simple "go/no-go" test devices.

2. BTEs shall be able to load software onto units, for example to recover or initialize a component.

3. BTEs shall be capable of testing all modules of a subsystem as a whole, and of troubleshooting circuit boards, transducers, relays, and assemblies of the equipment either by insertion of such items directly into the BTE itself or into an adapter that connects to the BTE.

4. Each BTE shall provide, whenever possible, for unattended, multiple, repetitive testing of electronic systems so as to either verify proper operation or capture intermittent failures and identify the fault.

    a. It shall be possible to repeat an entire automated test or any portions of the test for the purpose of troubleshooting intermittent problems and logging failures.

    b. The BTE shall be capable of running in fully automatic mode, with no technician interaction, for a variable length of time that can be set by a technician, up to a maximum test cycle of at least 24 hours.

    c. The BTE shall allow the technician to manually step through tests as applicable, to allow step-by-step debugging and diagnostics.

5. Provision shall be made to enter the model, serial number, date, and any pertinent data for test record purposes.

6. Where applicable, such as in the case of a communications control panel, a test script may be provided to prompt the technician to operate switches, buttons, or potentiometers to ensure proper operation of the test device. Similarly, the script may prompt the technician to observe and report/record the status of any audible or visible indicators associated with the item under test.

7. BTEs shall be capable of troubleshooting the LLRU or LRU under test.

a. The BTE shall be capable of indicating, with operator assistance, which part(s) on the board are defective or out of tolerance.

b. A "guided probe" approach is an acceptable method for troubleshooting printed circuit boards.

c. The BTE shall feature functions to facilitate upload of fault and/or event logs from all intelligent subsystems for review, analysis, and troubleshooting.

8. In the troubleshooting of microprocessor-controlled devices, the following apply:

   a. Localized fault identification to a functionally related group of components, i.e., one active and multiple passive components, or identification of a signal name, i.e., address line #1, will be an acceptable approach.

   b. The BTEs shall be capable of distinguishing between properly operating and defective modules, and shall allow necessary adjustments to and proper calibration of items under test.

9. BTE shall use the inherent boundary-scan capability (as per IEEE Std 1149.1) of systems, circuit boards, and components to the maximum extent possible in order to attain high levels of testability. A boundary-scan controller shall be integrated into each BTE. Alternatively, one may be provided peripherally to each BTE upon Approval.

10. The BTE devices themselves shall be testable to verify proper functionality. This shall be accomplished by one or more of the following means, as Approved, to ensure that all functionality can be tested. Provide all equipment and components necessary for BTE testing, including "golden units," with each type of BTE unit.

    a. Testing using external test equipment such as calibrated voltage references, multimeters, network adapters, etc.

    b. Self-testing using golden units. This test is conducted by running the BTE on a known-working unit under test such that any failures can be traced to BTE faults.

    c. Built-in self-testing. All circuitry to test the BTE is either built into the BTE itself, or provided (e.g., wrap-around test harnesses).

11. Except for BTE for systems connected to the E-TCN, BTE shall be able to facilitate remote access by the supplier for troubleshooting. This access shall comply with the requirements of Section 19, Software Engineering, and Section 24, Cybersecurity, and shall be Approved.

27.4.5 Testability

A. All subsystem LRU and LLRUs shall be testable, irrespective of whether these components are vital or proprietary, except as Approved. SEPTA shall be able to use the BTEs to verify operational characteristics and obtain fault information in a timely and efficient manner, even for those components that are not repairable.

27.4.6 Repairability

27.4.6.1 Repairability of LLRUs

A. The lowest replaceable part of the unit or circuit board shall be established during design reviews of subsystems:

1. Create a list of LLRUs and LRUs for each part under test. Categorize the list into mechanical, electromechanical, electrical, electronic, pneumatic, refrigerant, and hydraulic devices.

2. Include a proposal for each LRU and LLRU regarding whether each item is considered to be repairable or not repairable by SEPTA. Make the repairability determination based on whether the part can be removed and repaired with the tools and methods available in a sophisticated shop environment. LRUs and LLRUs marked non-repairable shall be subject to SEPTA Approval.

3. Unless otherwise Approved, mechanical, electromechanical, electrical, electronic, pneumatic, refrigerant, and hydraulic devices shall be classified as repairable.

27.4.6.2 Repairability of Electronic Devices

A. Electronic devices shall be grouped into three subcategories as follows:

1. Subcategory 1: Single layer printed circuit boards with normal density of components, and for which component types and mounting allow manual probing of the board.

2. Subcategory 2: High density printed circuit boards that use multi-layer construction, surface mount components, large integrated circuits with close spacing of pins, or special integrated chips and other custom components.

3. Subcategory 3: Commercially available, off-the-shelf printed circuit boards purchased from industrial OEMs, where design information is not available from the OEM to support troubleshooting and repair.

B. Subcategories 1 and 2 shall be classified as repairable. Repairability of Subcategory 3 shall be determined at CDR. For items in Subcategory 3 that are Approved as not repairable, provide an Approved quantity of additional capital spares.

27.4.7 Bench Test Equipment Demonstration

A. BTE FAIs shall be held as separate activities from the associated subsystem FAI.

1. At each BTE FAI, demonstrate the functionality and capability of the BTE for the subsystems specified in TS 27.4.2. Comply with the FAI requirements in Section 22, Quality Assurance.

2. Conduct the demonstration on a fully operational unit and show compliance with BTE functional description and other Contractual requirements.

3. Verify the programming of programmable devices. Include fault insertions in the FAI procedure to demonstrate proper functionality of BTE.

27.4.8 Bench Test Equipment Installation and Commissioning

A. Install each BTE at a location designated by SEPTA.

1. Unless otherwise Approved, external power for BTEs shall be limited to 115 Vac, 60 Hz. The BTE shall produce other power outputs or air pressures necessary for its operation.

2. Submit a schedule for on-site demonstration for the BTE. **(CDRL 27-04, Bench Test Equipment Schedule for Installation and On-Site Demonstration)**

a. The installations shall be done in a manner that does not interrupt SEPTA's normal work activity at the installation site.

b. Prior to delivery and installation of the BTE at SEPTA, all related documentation (drawings, operating manuals, etc.) shall be Approved.

(1) The BTE FAI shall be completed and FAI report Approved.

(2) All open items previously identified during the BTE FAI shall be closed.

(3) The Acceptance Test Plan for commissioning of the BTE at SEPTA shall be Approved prior to submitting the request for shipment of the BTE to SEPTA.

3. Furnish training for SEPTA's Repair Technicians at the time of Commissioning, as specified in Section 26, Manuals and Training. Include the training schedule with the installation schedule. If commissioning issues arise, delay BTE training until the issues are resolved.

4. Calibrate BTE before delivery such that at least nine months of calibration remains upon completion of Commissioning/Training at the SEPTA facility.

5. BTE shall be supplied with all properly configured LRUs and LRRUs in order to conduct BTE commissioning and training.

27.5 Required Documentation

A. Comply with the following:

1. PTU and each BTE shall be accompanied by the following:

    a. Complete drawings, diagrams, schematics, parts listings, functional description incorporated into each applicable SSFD, assembly and construction drawings, and maintenance and calibration instructions for the device itself.

    b. Complete maintenance, calibration, and troubleshooting procedures for printed circuit boards for the associated carborne system, to the board level for PTUs, and to the LRU and LLRU level for BTEs.

2. Submit and furnish the above documentation on the BTE in addition to and in accordance with the maintenance manuals required by Section 26, Manuals and Training.

3. All PTU and BTE applications shall include built-in electronic documentation with details on functionality and testing procedures. This documentation shall include an indexed and searchable table of contents. This documentation may consist of relevant excerpts from the manuals prepared in accordance with Section 26, Manuals and Training.

4. Include documentation and drawings related to PTUs for each subsystem in the subsystem CDR (draft) and in the FDR (final).

5. Include documentation and drawings related to BTE for each subsystem in the subsystem CDR (draft) and in the FDR (final).

27.6 Special Tools

27.6.1 General

A. Special tools include but are not limited to jigs, fixtures, equipment, hand tools, power tools, and other tools and equipment necessary to inspect, calibrate, adjust, maintain, repair, assemble, and disassemble the car or subsystems. Tools commonly available in a shop environment (e.g., screwdrivers) are not considered special tools. PC board extenders are considered special tools.

1. Minimize the use of special tools without complicating the car design. Special tools, where required, shall be subject to Approval. At the kickoff meeting, present the systems where special tools are proposed to be used.

2. Special tools shall be kitted in cases by subsystem and location (bench or shop).

3. Provide the following special tools at a minimum, unless the car design does not require their use:

    a. Tools to activate tamper-proof fasteners and access panels.

b. Four sets of special tools, fixtures, plates, and adapters (as applicable) to be used in combination with jacking pads for lifting and re-railing operation.

c. Three full sets of equipment that will allow SEPTA to perform routine dynamic testing on the cars, including equipment to perform data acquisition during dynamic testing.

d. Door Subsystem:

(1) Gauges and jigs required for door installation and adjustments

(2) Obstruction detection tools, including force gauge.

e. HVAC Subsystem:

(1) Vacuum pump

(2) Refrigeration recovery and charging test manifold.

(3) Holding fixture

(4) Leak tester, electronic

(5) HVAC unit lifting fixture:

- Furnish minimum six.
- Lifting straps
- See Section 7, Heating, Ventilation, and Air Conditioning for requirements.

(6) HVAC unit storage frames:

- Furnish minimum quantity necessary to store quantity of spare -units plus two.
- Storage Frames to allow for effective and reliable storage of the HVAC subsystems.

f. Propulsion Subsystem:

(1) Tools for traction motor disassembly and re-assembly

(2) Non-standard wrenches and gauges

g. Truck Assembly:

(1) Tools for gearbox and coupling disassembly, gear unit overhaul, and reassembly.

(2) Journal-bearing puller

(3) Truck assembly stand

(4) Truck alignment jigs

(5) Wheel back-to-back gauge

(6) Wheel press and wheel set assembly (not including the wheel press)

h. Friction Brake Subsystem:

(1) Caliper assembly tools

(2) Actuator assembly tools

(3) Accumulator servicing gauge and fittings

(4) Vericom V-SENSE DAQ or Approved equal

(5) Single-car air test equipment

i. Communication Subsystems:

(1) Furnish minimum ten sets of diagnostic test equipment necessary to test and maintain the assistive listening subsystem.

j. Pantographs

(1) The Contractor shall supply four complete sets of all specialized tooling, jigs, fixtures. measurement devices and so forth which are necessary for the inspection, testing maintenance, removal, replacement, repair, disassembly, assembly, lubrication or overhaul.

(2) Storage frames to allow stacking four high.

k. Other equipment:

(1) Tools for all speed sensors

(2) PC board extenders, as appropriate

27.6.2 Special Tools Documentation

A. Furnish documentation as follows:

1. Include information on how to use the special tools in the appropriate maintenance manual, as specified in Section 26, Manuals and Training.

2. Include documentation and drawings related to special tools for each subsystem in the subsystem CDR (draft) and in the FDR (final). Special tools shall be part of each subsystem's FAI.

3. Documentation and drawings related to gauges shall include the condemning limits.

4. Furnish complete as-built drawings of the special tools (weight, detailed dimensions, material type, Bill of Materials, etc.) to enable SEPTA to have additional special tools manufactured.

    a. All related special tools documentation (drawings, manuals, etc.) shall be Approved prior to shipment of special tools to SEPTA.

    b. Furnish complete pre-shipment inspection reports with each shipment of special tools.

    c. Clearly identify each special tool furnished by drawing or part number.

27.6.3 Special Tools CDRLs

A. Comply with the following:

1. Submit a list of all special tools to be delivered at each subsystem CDR. **(CDRL 27-05, List of Special Tools)**

2. Deliver and commission Special Tools per each item in the list specified in CDRL 27-06. Except where quantities are specified above, provide a minimum of four sets of special tools to be used during running maintenance (required by procedures in the Running Maintenance Manual, as per Section 26, Manuals and Training), and a minimum of two sets of other special tools. **(CDRL 27-06, Special Tools and Required Documentation)**

27.6.4 Specific Equipment's Special Tools

27.6.4.1 General

A. Minimize the use of Special Tools. However, SEPTA will require the special tools specified below.

27.6.4.2 PCB Extenders

Provide PCB extenders for each subsystem where the extenders can facilitate the subsystem’s testing on the car. The amount of PCB extenders to be provided per board type shall be as specified in Section 16, Materials and Workmanship.

A. These are in addition to the PCB extenders that may be necessary for testing with BTE.

27.6.4.3 Coupler Checking Gauges

A. Furnish Go/No-Go gauge to inspect coupler assemblies for proper dimension and suitability for service. This shall include alignment gauges for electrical head contact pins. Go/No-Go gauge shall be accompanied by a master gauge, so marked and placed into storage at SEPTA so that measurement accuracy can be verified.

27.6.4.4 Cab Signal and PTC Special Tools

A. Provide the following Cab Signal and PTC special tools:

1. Rigs necessary to maintain Cab Signal and PTC equipment installation tolerances.

2. Cab Signal and PTC Test Unit that allows SEPTA personnel to perform maintenance functions and to generally exercise the subsystem in a shop environment.

   a. The Cab Signal and PTC Test Unit shall consist of a code box and loop. The code box shall have the capability to generate all wayside speed commands as well as simulate the car's speed signal.

   b. The Cab Signal and PTC subsystem shall contain test points to allow interface of the Cab Signal and PTC Test Unit’s speed simulation circuitry for injection of the simulated signal into the cab signal subsystem.

   c. The cab signal current level shall be adjustable over the full operating range of SEPTA's Railroad Division.

B. The simulated speed signal shall be adjustable to generate speed between 0 mph and 100 mph, to allow for simulation of an overspeed above the maximum line speed as specified in Section 2, Design and Performance Criteria.

27.6.4.5 Railroad Industry Standard AB Type Test Rack

1. Pneumatic components shall be capable of being tested on a railroad industry standard AB type test rack. The Contractor shall provide test equipment to perform this function. The design and operation of such test equipment shall be suitable for SEPTA use. Test procedures shall be provided by the Contractor to SEPTA for testing and maintaining the friction brake equipment of the locomotive.

2. The Contractor shall provide test schedules and three sets of any cables, hoses, adapters and fittings necessary to perform testing on a standard test rack.

3. The electro pneumatic and digital logic driven components shall also be capable of being tested in conjunction with pneumatic components of the friction brake equipment of the locomotive.

27.7 Calibration

A. Calibrate all special tools and test equipment as needed throughout the required warranty period for these items. The last calibration shall be conducted no more than 30 days prior to the end of the warranty period.

B. Thirty days before the end of the warranty period, submit a price quote (valid for at least 60 days) to continue calibration beyond the warranty period.

27.8 Contract Deliverable Requirements List (CDRL)

The following contract deliverables have been identified in this section; however, the Contractor is responsible for providing and submitting anything necessary to fulfill the requirements of this contract, including those not identified by CDRL number.

CDRL 27-01, Portable Test Units and Required Documentation.....27-6
CDRL 27-02, List of Bench Test Equipment.....27-11
CDRL 27-03, Bench Test Equipment and Required Documentation.....27-11
CDRL 27-04, Bench Test Equipment Installation Schedule and On-Site Demonstration ...27-17
CDRL 27-05, List of Special Tools.....27-21
CDRL 27-06, Special Tools and Required Documentation.....27-21

27.9 CDRL Details

This section lists the expected content for each CDRL required above. The lists provided for each CDRL are an outline only and should not be considered exhaustive, all CDRLs are subject to SEPTA review and approval.

CDRL 27-01 Portable Test Units and Required Documentation:

1. Provide at least two of each type of PTU, with all required finalized software and documentation, before the beginning of any training that will use that PTU, or before conditional acceptance of the first pilot married pair, whichever comes first. If the PTU - Protocol Analyzer, specified in TS 27.3.8, is Approved to be provided on separate hardware, provide 3 PTU – Protocol Analyzers and associated documentation one month prior to conditional acceptance of the first married pair.

2. Deliver the remaining units prior to acceptance of the 10th married pair.

3. If non-standard hardware or cables are needed for software transfer, as specified in the Transfer of Software to Replacement Devices requirements of Section 19, Software Engineering, then provide two sets of hardware and cables with each PTU unless otherwise Approved.

CDRL 27-02 List of Bench Test Equipment:

1. Include a basic physical description of each BTE.

2. Update the list at intervals no longer than 90 days as the development of the BTE progresses.

CDRL 27-03 Bench Test Equipment and Required Documentation:

1. Deliver all BTE and a copy of the finalized required documentation six months prior to the end of the Warranty Period for the first married pair.

CDRL 27-04 Bench Test Equipment Schedule for Installation and On-Site Demonstration:

1. Submit a Master Installation Schedule that includes the installation and on-site demonstration for the BTE.

2. Submit at least 120 days in advance of the first planned BTE installation date.

CDRL 27-05 List of Special Tools:

1. Arrange by car subsystem and include a description of each item, nomenclature, and manufacturer's part number. The list shall also delineate whether the tool is to be used for periodic inspection and associated maintenance, or for heavy repair.

2. Update the list of special tools and verify as accurate at each design review.

3. Include a list of tools needed to maintain each subsystem but not being furnished by the Contractor (COTS tools).

CDRL 27-06 Special Tools and Required Documentation:

1. Submit a copy of finalized required documentation with the delivery of the first set of Special Tools.

2. For Special Tools that are required for training, deliver one set of applicable Special Tools prior to associated training, along with a finalized copy of all documentation, including documentation required by Section 26, Manuals and Training.

3. Deliver the remaining sets of Special Tools no later than Conditional Acceptance of the Pilot Cars.

27.10 Referenced Standards

The following standards are referenced in this Section:

IEEE Std 1149.1	IEEE Standard for Test Access Port and Boundary-Scan Architecture
IEEE 802.11a/b/g/n/ac	Wireless Local Area Network
IEC 60754-1	Test on gases evolved during combustion of materials from cables - Part 1: Determination of the halogen acid gas content

IEC 60332-1-2	Tests on electric and optical fiber cables under fire conditions - Part 1-2: Test for vertical flame propagation for a single insulated wire or cable

SECTION 28
TEST AND INSPECTION VEHICLE

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28.1 General Topics and Scope

28.1.1 General Requirements

A. This section defines the requirements for the supply of a Test and Inspection Vehicle, to be developed in coordination with SEPTA. The requirements in this section only apply if the Option for the Test and Inspection Married Pair is executed. The requirements in this section augment or supersede requirements found in Sections 1 through 27 of the Silverliner VI technical specification for the Test and Inspection Vehicle.

B. All requirements of the Silverliner VI Technical Specification Sections 1 through 27 shall apply to the Test and Inspection Vehicle, except as specifically noted in this Section as changed or as new requirements.

C. Requirements for the Test and Inspection Vehicle shall include, but are not limited to, those related to performance, function, design, maintainability, and validation of the vehicle.

D. This Section is written to include a subsection which matches each main section of the Silverliner VI Technical Specification. Each subsection identifies changes to be made to the Silverliner VI Technical Specification for the Test and Inspection Vehicle, additional requirements for the Test and Inspection Vehicle, or notes that the Silverliner VI Specification remains unchanged for the Test and Inspection Vehicle.

E. The Test and Inspection Vehicle shall be equipped with all test and inspection equipment as provided in Section 28.18. The test and inspection equipment and all associated vehicle modifications shall be treated as a single subsystem for the purpose of design review submittals.

F. The Test and Inspection Vehicle shall be equipped with all multimedia equipment as provided in Section 28.13. The multimedia system and all associated vehicle modifications shall be treated as a single subsystem for the purpose of design review submittals.

G. The carbuilder, in collaboration with the test and inspection equipment supplier(s), shall be responsible for the integration of these systems within the vehicle.

H. The integration of the test and inspection equipment and the multimedia system shall impose a minimal number of deviations from the design of the Silverliner VI.

I. The installation of all test equipment, measurement equipment, multimedia system equipment, seating, workstations, as well as all modifications required to integrate these systems into the design of the Silverliner VI shall not impede, interfere, obstruct, or prevent car inspection, periodic maintenance activities nor adversely affect the operation and performance of the vehicle under all operating conditions as defined in Section 2, Design and Performance Criteria.

J. All test and inspection equipment shall function and perform as intended by the supplier under all operating conditions as defined in Section 2, Design and Performance Criteria.

K. All externally mounted test and inspection equipment shall be sufficiently protected from damage from impact by wayside debris.

L. All equipment installed on the Test and Inspection Vehicle are subject to all Technical Specification requirements. Conformance to the provisions contained in Sections 2 Design and Performance Criteria and Section 15, Test Program, must be demonstrated.

M. Interior layout arrangements shall be proposed and agreed upon during Conceptual Design review. (**CDRL 28-01 Test and Inspection Vehicle Conceptual Design Review)**

28.1.2 Changes to the Silverliner VI Section 1 Requirements

A. No change from the Silverliner VI Technical Specification.

28.2 Silverliner VI TS Section 2: Design and Performance Criteria

A. The Contactor shall demonstrate compliance of the Test and Inspection Vehicle with the requirements of:

1. Weight Balance Criteria

2. Weight Reporting

3. All test and inspection equipment and associated mounting provisions comply with vibration requirements

4. All test, inspection, and Multimedia System components comply with Electromagnetic Interference and Compatibility requirements

(CDRL 28-04 Test and Inspection Vehicle Testing)

28.3 Silverliner VI TS Section 3: Carbody

28.3.1 Changes to Silverliner VI Section 3 Requirements

A. Add new item 3.2.4.1.E: “The Test and Inspection Vehicle shall have a distinguishable exterior appearance unique from the Silverliner VI. The contractor shall submit at least two proposals with accurately colored 3D renderings for Approval.”

(CDRL 28 – 01 Test and Inspection Vehicle Conceptual Design Review)

28.4 Silverliner VI TS Section 4: Coupler and Draft Gear

A. No Change from the Silverliner VI Technical Specification.

28.5 Silverliner VI TS Section 5: Operator's Cab

28.5.1 Changes to Silverliner VI Section 5 Requirements

A. In Section 5.1.10 Miscellaneous Cab Items, add new item C.: "A through-the-floor access port shall be provided within each cab. The access port shall consist of two, one-inch diameter conduits located in the cab wall or cab partition to be used by SEPTA for running of instrumentation wiring. The conduits shall have removable caps on both ends. The through-floor access ports, and all material used in the through-floor access ports, shall meet the flammability and smoke emission requirements of Section 16 Materials and Workmanship."

28.6 Silverliner VI TS Section 6: Passenger Doors

A. No Change from the Silverliner VI Technical Specification.

28.7 Silverliner VI TS Section 7: Heating, Ventilation and Air Conditioning (HVAC)

A. No Change from the Silverliner VI Technical Specification.

28.8 Silverliner VI TS Section 8: Lighting

A. No Change from the Silverliner VI Technical Specification.

28.9 Silverliner VI TS Section 9: Auxiliary Power

28.9.1 Changes to Silverliner VI Section 9 Requirements

A. In Section 9, add new item 9.5.4.C: "All circuit breakers for the test, inspection, and Multimedia System equipment shall be located within the car interior and be installed in a separate enclosure subject to Approval."

B. In Section 9, add new item 9.5.4.D: "An uninterrupted power supply shall be provided to facilitate data retention in the event of power loss. The UPS shall possess the capacity to perform this function for a period of no less than 30 minutes."

28.10 Silverliner VI TS Section 10: Propulsion and High Voltage System

A. No Change from the Silverliner VI Technical Specification.

28.11 Silverliner VI TS Section 11: Trucks

A. No Change from the Silverliner VI Technical Specification.

28.12 Silverliner VI TS Section 12: Friction Brakes

A. No Change from the Silverliner VI Technical Specification.

28.13 Silverliner VI TS Section 13: Communications

28.13.1 Changes to Silverliner VI Section 13 Requirements

A. In Section 13.2.A, add new item 13: “Independent Multimedia audio and visual display system (A-car only)

1. The following requirements apply to the Independent Multimedia audio and visual display system:

a. The system shall be independent of all other existing vehicle networks unless otherwise Approved.

b. Each seated passenger must be able to view at least one display.

c. Audio shall be distributed using the existing Public Address system or other Approved method in the A-car only.

d. The system shall have an Approved method for SEPTA to play audio and visual content from laptops and other electronic devices.

e. The contractor shall submit a multimedia system arrangement of the vehicle for Approval. This shall include a detailed drawing which shows the multimedia system display positions.”

(CDRL 28-02 Test and Inspection Vehicle Preliminary Design Review)

28.14 Silverliner VI TS Section 14: Interior and Exterior Appointments

28.14.1 Changes to Silverliner VI Section 14 Requirements

A. In Section 14.1.11, add new item B: “One duplex GFCI protected outlet shall be provided in each storage locker compartment. Each outlet shall be rated for 20 amps. The location of the outlets shall be Approved.”

B. Add new Section 14.4.2.K: “The seating configuration of the Test and Inspection Vehicle shall be modified to include the following features:

1. Fixed Workstation Tables.

a. All fixed workstation tables shall comply with APTA PR-CS-S-018-13 Fixed Workstation Tables in Passenger Railcars.

b. The top surface of all fixed workstation tables shall be slip-free material as Approved.

2. The A-Car shall be fitted with ten fixed table workstations positioned at the following locations:

a. At the F-End of the car, immediately behind the Operator's Cab, two positions, one on each side of the car, equipped with 2+2 fixed forward facing seating.

b. Adjacent to the accessibility/mobility aid parking positions, one on each side of the car. These fixed workstation tables shall not be equipped with fixed seating.

c. Between the high-level boarding doors, six fixed workstation table workstations, three per side, equipped with forward and rearward facing 2+2 seating.

3. The B-Car shall be fitted with nine fixed table workstations positioned at the following locations:

a. At the F-End of the car, immediately behind the Operator's Cab, two positions, one on each side of the car, equipped with forward and rearward facing 2+2 fixed seating.

b. Forward of and adjacent to the F-end doors on the right side of the car with a pathway compliant with ADA regulations. This fixed workstation table shall not be equipped with fixed seating.

c. Between the high level boarding door positions, four fixed workstation table workstations, two per side, equipped with forward and rearward facing 2+2 fixed seating.

d. The remaining two fixed workstation tables shall be positioned on each side of the car at the A-End adjacent to and rearward of the A-End doors, one per side, equipped with forward and rearward facing 2+2 fixed seating.

4. Two storage lockers shall be provided and located at each side of the A-end of the car. Each locker shall be equipped with provisions to install a removeable rod designed to hang outerwear clothing and/or shelving.

5. On the B Car, two storage enclosures of sufficient size and suitable for the storage of equipment and PPE shall be positioned on the right side of the car between the high-level door boarding locations. The enclosure shall be equipped with doors and internal shelving. The storage enclosures shall not obstruct side windows. The top surface covering shall be slip-free material as Approved.

6. On the B Car, a storage locker equipped with drawers and doors shall be installed at the A-End left side. The storage enclosure shall not obstruct side windows. The top surface covering shall be slip-free material as Approved.

7. Trash receptacles shall be provided on both sides and both ends of the car. The receptacle capacity shall be maximized consistent with the space available. The trash container shall be stainless steel and shall be sized to hold a thirteen

gallon trash bag liner. The top of the trash bag shall be capable of being secured over the top edge of the stainless steel container. Means shall be provided to prevent overfilling or trash from dropping down the outside of the trash container.

8. All enclosures and workstations shall be designed to aesthetically blend with the interior of the car."

(CDRL 28-02 Test and Inspection Vehicle Preliminary Design Review)

28.15 Silverliner VI TS Section 15: Test Program

28.15.1 Changes to Silverliner VI Section 15 Requirements

A. Comply with the following:

1. Prior to shipment of the Test and Inspection Vehicle, the test and inspection equipment shall be subjected to comprehensive functional, performance and validation testing to demonstrate compliance with the specifications of the supplier and the Technical Specification. A qualified supplier representative shall witness all testing activities and attest the test procedure and test report. **(CDRL 28-05 Test and Inspection Vehicle Pre-delivery Inspection)**

2. Prior to shipment of the Test and Inspection Vehicle, the Multimedia System shall be subjected to comprehensive functional and validation testing to demonstrate compliance with the specifications of the supplier and the Technical Specification.

3. Upon delivery, and prior to on-site qualification testing of the Test and Inspection Vehicle, the test and inspection equipment shall be subjected to comprehensive functional, performance and validation testing to demonstrate compliance with the specifications of the supplier and the Technical Specification. A qualified supplier representative shall witness all testing activities and attest the test procedure and test report.

4. Upon delivery, and prior to on-site qualification testing of the Test and Inspection Vehicle, the Multimedia System shall be subjected to comprehensive functional and validation testing to demonstrate compliance with the specifications of the supplier and the Technical Specification.

5. Perform on-site qualification testing of the Test and Inspection Vehicle to demonstrate and verify compliance with the specified function and performance requirements of the test and inspection equipment supplier when subjected to all operating conditions.

6. Perform on-site qualification testing of the Test and Inspection Vehicle to demonstrate and verify compliance with the specified function and performance requirements of the Multimedia System equipment supplier when subjected to all operating conditions. **(CDRL 28-04 Test and Inspection Vehicle Testing)**

28.16 Silverliner VI TS Section 16: Materials and Workmanship

A. No Change from the Silverliner VI Technical Specification.

28.17 Silverliner VI TS Section 17: Network and Trainline Control

A. No Change from the Silverliner VI Technical Specification.

28.18 Silverliner VI TS Section 18: Monitoring and Diagnostics

28.18.1 Changes to Silverliner VI Section 18 Requirements

A. In Section 18.2 Vehicle Monitoring and Diagnostic Subsystem, add new item 18.2.10: "Comply with the following:

Install the following test equipment as supplied by ENSCO or approved equal:

1. Zero Speed Track Geometry Measuring System
2. Rail Profile Measurement System
3. Autonomous Vehicle/Track Interaction Monitor
4. Ride Quality Measurement System
5. Ultrasonic Rail Flaw System
6. Rail Corrugation Measurement System
7. Joint Bar Imaging System
8. Point Asset Inspection System
9. Tunnel Wall Imaging System
10. Thermal Imaging System
11. Clearance Measuring System
12. Overhead Wire Measuring System
13. Driver View Imaging System – Installation required on both F-End cabs.
14. Overhead wire Imaging System
15. Track view Imaging System
16. Rail Surface Imaging System
17. Rail Component Imaging System
18. Track Component Imaging System

19. Signal and Communication Inspection System

20. Global Positioning system

B. The following requirements apply to the test equipment:

1. All user interfaces shall be web-browser based, and compatible with common Internet web browsers, including Google Chrome, Microsoft Edge, Safari, and Mozilla Firefox.

2. All data acquired and/or generated by the test and inspection equipment shall be processed and stored via a cloud-based host server with a web-based user interface.

   a. Data shall be transferred using the existing TWDT system in an Approved manner.

3. Means to locally download all data acquired and/or generated by the test and inspection equipment shall be provided via an Approved method."

(CDRL 28-03 Test and Inspection Vehicle Final Design Review)

28.19 Silverliner VI TS Section 19: Software Engineering

A. All required licenses required to permit SEPTA to operate and maintain the Test and Inspection Vehicle systems shall be included at no additional cost to SEPTA.

28.20 Silverliner VI TS Section 20: ATC-PTC

A. No Change from the Silverliner VI Technical Specification.

28.21 Silverliner VI TS Section 21: Reliability, Availability and Maintainability

A. No Change from the Silverliner VI Technical Specification.

28.22 Silverliner VI TS Section 22: Quality Assurance

28.22.1 Changes to Silverliner VI Section 22 Requirements

A. The Test and Inspection Vehicle pre-delivery inspection will be performed jointly by SEPTA, the contractor and ENSCO, or Approved equal supplier. All parties shall sign the pre-delivery inspection results. **(CDRL 28-05 Test and Inspection Vehicle Pre-Delivery inspection)**

28.23 Silverliner VI TS Section 23: System Safety and Security

A. No Change from the Silverliner VI Technical Specification.

28.24 Silverliner VI TS Section 24: Cybersecurity

A. No Change from the Silverliner VI Technical Specification.

28.25 Silverliner VI TS Section 25: Program Management and Commissioning

A. No Change from the Silverliner VI Technical Specification.

28.26 Silverliner VI TS Section 26: Manuals and Training

28.26.1 Changes to Silverliner VI Section 26 Requirements

A. Add new Section 26.1.13: "Test and Inspection Vehicle Documentation and Training"

B. Add new Section 26.1.13.1: "Comply with the following requirements for manual submittal schedules and quantities. Submit an electronic copy (via secure web download) of each draft, Conditionally Approved, and final manual in all required electronic formats. Also submit printed copies of each Conditionally Approved and final published manuals as required below:

Table 26-2, Submittal Schedule for Manuals

	Draft Manuals		Conditionally Approved Manuals		Final Published Manuals	
	Quantity	Due Date[1]	Quantity	Due Date[1]	Quantity	Due Date
Test and Inspection Vehicle Operating, Inspection and Maintenance Manual	5	-90	5	+60	5	Note 2
Test and Inspection Vehicle Schematic Diagrams	5	-180	5	+60	5	Note 2
Test and Inspection Vehicle Illustrated Parts Catalog	2	-180	2	+90	5	Note 2

Notes to Table:

1. Due dates shown in number of days (-) before or (+) after scheduled acceptance of the Test and Inspection Vehicle.
2. Submit final published manuals with 120 days after acceptance of the Test and Inspection Vehicle.

(CDRL 28-06 Test and Inspection Vehicle Required Documentation)

C. The provisions of Section 26.2.3 Requirements for Scope of Training apply to the Test and Inspection Vehicle limited to the equipment listed in Section 28.13.1.A and Section 28.14.1.B.

D. The provisions of Section 26.2.3 shall be complied with and modification as follows:

1. The following listing gives the numbers of personnel to be instructed:

a. Test and Inspection Equipment operating personnel:

(1) 10 within ten days of delivery of the Test and Inspection Vehicle.

b. Multimedia System operating personnel:

(1) 10 within ten days of delivery of the Test and Inspection Vehicle.

2. Maintenance personnel:

a. Furnish the following maintenance training for each of the subjects listed under Training Course Content below:

(1) Initial training: Upon delivery of the Test and Inspection Vehicle, complete training for one group of up to 10 trainees.

(2) Refresher training: Conduct one year after delivery of the last vehicle.

(3) Class size: Allow for hands-on training as needed.

b. Training hours:

(1) Initial and additional training: The requirement is to provide instruction for the entirety of the agreed upon course materials. Classroom and hands-on hours are to be provided for the attendees to attain and demonstrate proficiency.

(2) Refresher training: The requirement is to provide instruction for the entirety of the agreed upon course materials. Classroom and hands-on hours are to be provided for the attendees to attain and demonstrate proficiency.

28.27 Silverliner VI TS Section 27: Special Tools and Test Equipment

A. Special tools and equipment shall be provided in accordance with recommended practices of the supplier of the test and inspection equipment supplier and the multimedia system supplier.

28.28 Contract Deliverable Requirements List (CDRL)

A. The following contract deliverables have been identified in this section; however, the Contractor is responsible for providing and submitting anything necessary to fulfill the requirements of this contract, including those not identified by CDRL number.

CDRL 28-01 Test and Inspection Vehicle Conceptual Design Review

CDRL 28-02 Test and Inspection Vehicle Preliminary Design Review

CDRL 28-03 Test and Inspection Vehicle Final Design Review

CDRL 28-04 Test and Inspection Vehicle Testing

CDRL 28-05 Test and Inspection Vehicle Pre-delivery Inspection

CDRL 28-06 Test and Inspection Vehicle Required Documentation

28.29 CDRL Details

A. CDRL 28-01 Test and Inspection Vehicle Conceptual Design Review

1. Submit equipment data sheets for all test, inspection, and multimedia system equipment.

2. Submit engineering drawings including dimension and weights for all test and inspection equipment.

3. Submit 3D renderings of interior appointments including seating, storage, outlet locations, switches, circuit breakers, Information screens and equipment racks and underfloor layout, workstation relocation methods.

4. Submit 3D renderings of the exterior appointments including equipment placement and exterior design.

5. Submit vehicle weight distribution analysis including the weight of each test and inspection equipment and the vehicle.

6. Submit interior and exterior arrangement drawings.

B. CDRL 28-02 Test and Inspection Vehicle Preliminary Design Review

1. Submit the latest revisions of all documents submitted for the CDR.

2. Submit a functional description for test and inspection instrumentation and the multimedia system, including a system arrangement drawing.

3. Submit detailed analyses and validation of methods used to size the UPS to support the storing of data and the proper shot-down of the equipment in case of a power failure. The submittal shall contain all descriptions, analyses, reports, and other features necessary for SEPTA to understand how the UPS meets this specification's requirements.

C. CDRL 28-03 Test and Inspection Vehicle Final Design Review

1. The Final Design Review (FDR) shall be conducted after the virtual mockup has been performed.

2. Submit the latest revisions of all documents submitted for the PDR.

3. The FDR shall confirm that the installation of each test equipment's and its subsystem under review satisfies the Contract requirements.

4. Demonstrate that all design-related safety hazards have been mitigated.

5. Submit a master test plan.

D. CDRL 28-04 Test and Inspection Vehicle Testing

1. Submit test procedures and test reports as prescribed in Sections 28.2 and 28.15.

E. CRDL 28-05 Test and Inspection Vehicle Pre-Delivery Inspection

1. The Inspection and Test Vehicle pre-delivery inspection shall allow SEPTA to examine all components of the vehicle.

2. In advance, submit all required documentation to allow adequate SEPTA preparation for the pre-delivery inspection, including the following at a minimum:

    a. Latest revisions of all documents submitted to FDR.
    b. Proposed pre-delivery inspection procedure.

3. Submit for Approval:

    a. Pre-delivery inspection reports.
    b. Factory acceptance test reports.

F. CDRL 28-06 Test and Inspection Vehicle Required Documentation

1. Submit additions and updates to maintenance manuals and parts catalog. The Test and Inspection Vehicle chapter shall follow the same design and format specified in Section 26, Manuals and Training.
2. Submit all Electrical schematic drawings, down to the individual signal or wire level, for each electrical circuit and wire runs to the test equipment's.
3. Provide all required finalized software and documentation, before the beginning of any training that will use that requires software, or before conditional acceptance of the testing and Inspection vehicle whichever comes first. Software documentation shall be provided by the OEM.

28.30 Referenced Standards

A. The following standards are referenced in this Section:

APTA PR-CS-S-018-13	Fixed Workstation Tables in Passenger Railcars

SEPTA SILVERLINER-VI RAILCAR

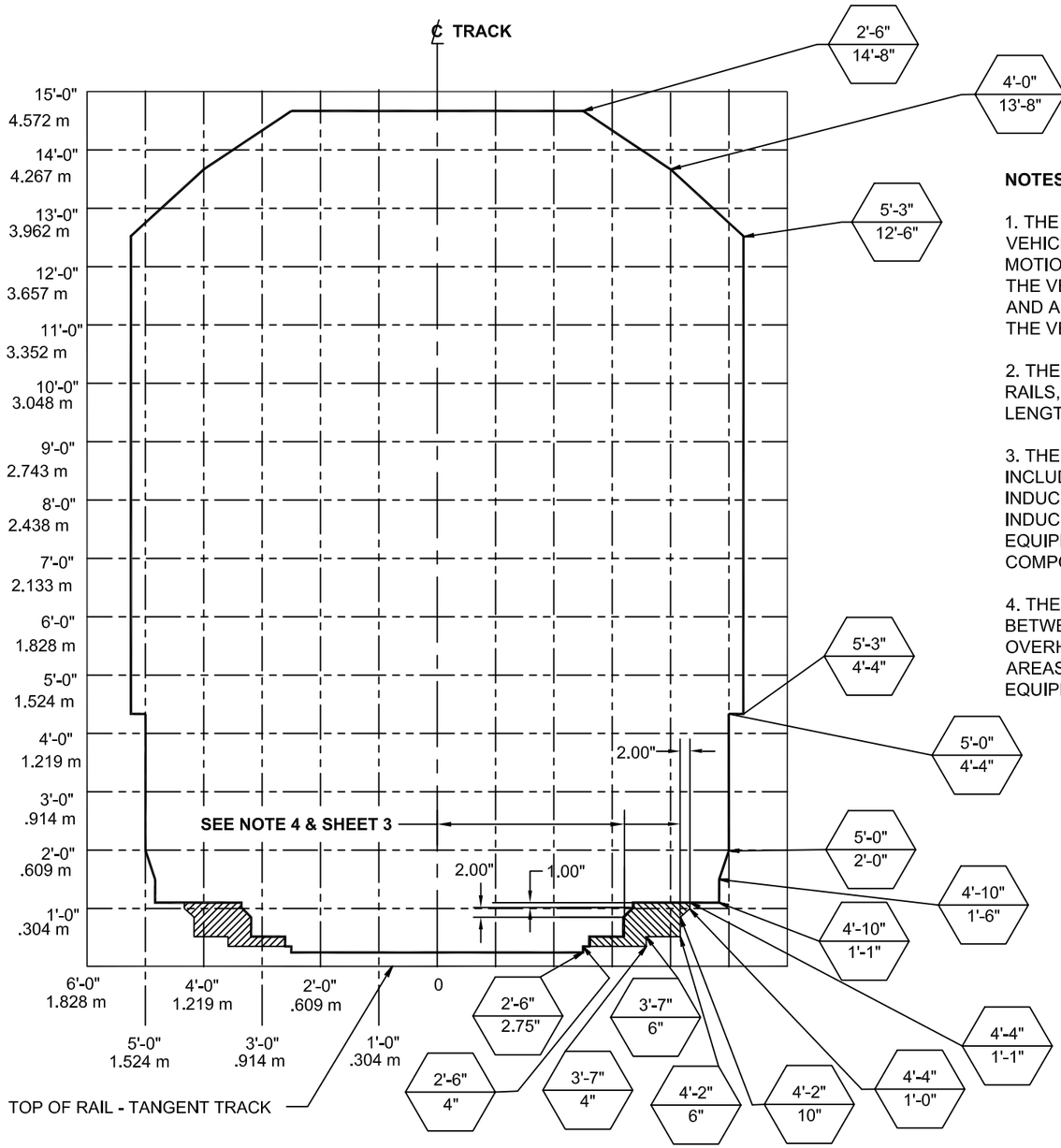
TECHNICAL SPECIFICATIONS

Appendix I

Amtrak Clearance Diagram

DRAWING NUMBER	REV.
D 05-1355	E

REVISIONS				
LTR	ZONE	DESCRIPTION	DATE	APPR'D
D	-	REVISED & REDRAWN	01/29/05	MLB
E		CHANGED LATERIAL & VERTICAL DIMENSIONS ON SHEETS 2 & 3	03/15/06	MLB



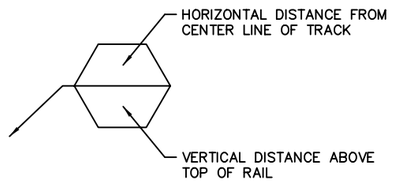
NOTES:

1. THE STATIC OUTLINE (SHEET 1) REPRESENTS THE MAXIMUM STATIC DIMENSIONS OF THE VEHICLE. THE DYNAMIC OUTLINE (SHEET 2) REPRESENTS THE MAXIMUM DYNAMIC RANGE OF MOTION OF THE VEHICLE, AND IS NOT TO BE USED AS THE STATIC CONSTRUCTION OUTLINE OF THE VEHICLE. PROVIDED THE VEHICLE MEETS THE REQUIREMENTS OF THE DYNAMIC OUTLINE AND ALL NOTES, THE STATIC OUTLINE MAY BE USED AS THE STATIC CONSTRUCTION OUTLINE OF THE VEHICLE.

2. THE STATIC OUTLINE AND DYNAMIC OUTLINE IS REFERENCED TO THE PLANE OF THE TOP OF RAILS, FOR TRACK WITH AND WITHOUT SUPERELEVATION, FOR A VEHICLE HAVING A MAXIMUM LENGTH OF 85'-0", AND A TRUCK CENTER DISTANCE OF 59'-6".

3. THE VEHICLE MUST REMAIN WITHIN THE DYNAMIC OUTLINE UNDER ALL CONDITIONS, INCLUDING LATERAL AND VERTICAL MOVEMENT OF THE VEHICLE ON ITS SUSPENSION, ROLL INDUCED BY UP TO 6" SUPERELEVATION (WITH THE VEHICLE STOPPED OR IN MOTION), ROLL INDUCED BY THE DESIGN CANT DEFICIENCY, RANGE OF MOTION OF THE TILT SYSTEM (IF SO EQUIPPED), NORMAL WEAR, VARIATIONS OF LOAD, FAILURE OF ANY SINGLE SUSPENSION COMPONENT, AND ANY COMBINATION OF THESE CONDITIONS.

4. THE HORIZONAL DISTANCE FROM CENTER LINE OF TRACK, FOR VERTICAL DISTANCES BETWEEN 2.75" AND 1'-1" ABOVE TOP OF RAIL, MUST ALLOW FOR THE INSIDE AND OUTSIDE OVERHANG OF THE VEHICLE ON A 12°-30' CURVE, AS SHOWN ON SHEET 3 AND THE SHADED AREAS OF THE STATIC OUTLINE AND THE DYNAMIC OUTLINE. ALL VEHICLE STRUCTURE, EQUIPMENT, AND APPLIANCES, MUST REMAIN WITHIN THIS OUTLINE UNDER ALL CONDITIONS.



STATIC OUTLINE

CONFIDENTIALITY - CONTRACTORS SHALL KEEP CONFIDENTIAL ALL INFORMATION, DRAWINGS, SPECIFICATIONS, OR OTHER DATA FURNISHED BY AMTRAK, OR PREPARED BY THE CONTRACTOR, OR SUB-CONTRACTOR, THEY SHALL NOT DIVULGE OR USE SUCH INFORMATION, DRAWINGS, SPECIFICATIONS OR DATA FOR THE BENEFIT OF ANY OTHER PARTY. CONTRACTORS SHALL NOT IN ANY MANNER ADVERTISE OR PUBLISH THE FACT THAT THEY HAVE FURNISHED, OR CONTRACTED TO FURNISH, TO AMTRAK THE GOODS OR SERVICES HEREIN MENTIONED WITHOUT PRIOR WRITTEN CONSENT OF AMTRAK.

THE AMTRAK DRAWING IS THE GOVERNING DOCUMENT, AND SUPERSEDES ANY LIKE INFORMATION ON REFERENCE DRAWINGS, PART NUMBERS, SPECIFICATIONS, ETC.

QTY	PART NUMBER	DESCRIPTION	MATERIAL	MFG/SPEC	AMM'S NUMBER	ITEM
						1

LIST OF MATERIAL

REFERENCE DRAWINGS: AM70070A

AMTRAK
Mechanical Department
Bureau of Rolling Stock Engineering
National Railroad Passenger Corporation
4001 Vandever Ave. Wilmington DE 19802

TITLE: CLEARANCE DIAGRAM

Drawn	Date	Approved	Approved
L.A. CAMPBELL	01/29/05	M. L. BURSHTIN	M. TROSINO
Checked B. F. HOFFMAN	Date 01/31/05	Approved	For Issue

STANDARD TRACK PLAN | PROGRAM | NEXT ASS'Y | USED ON

REPORT ALL CHANGES TO ENGINEERING DEPARTMENT

DO NOT SCALE DRAWING

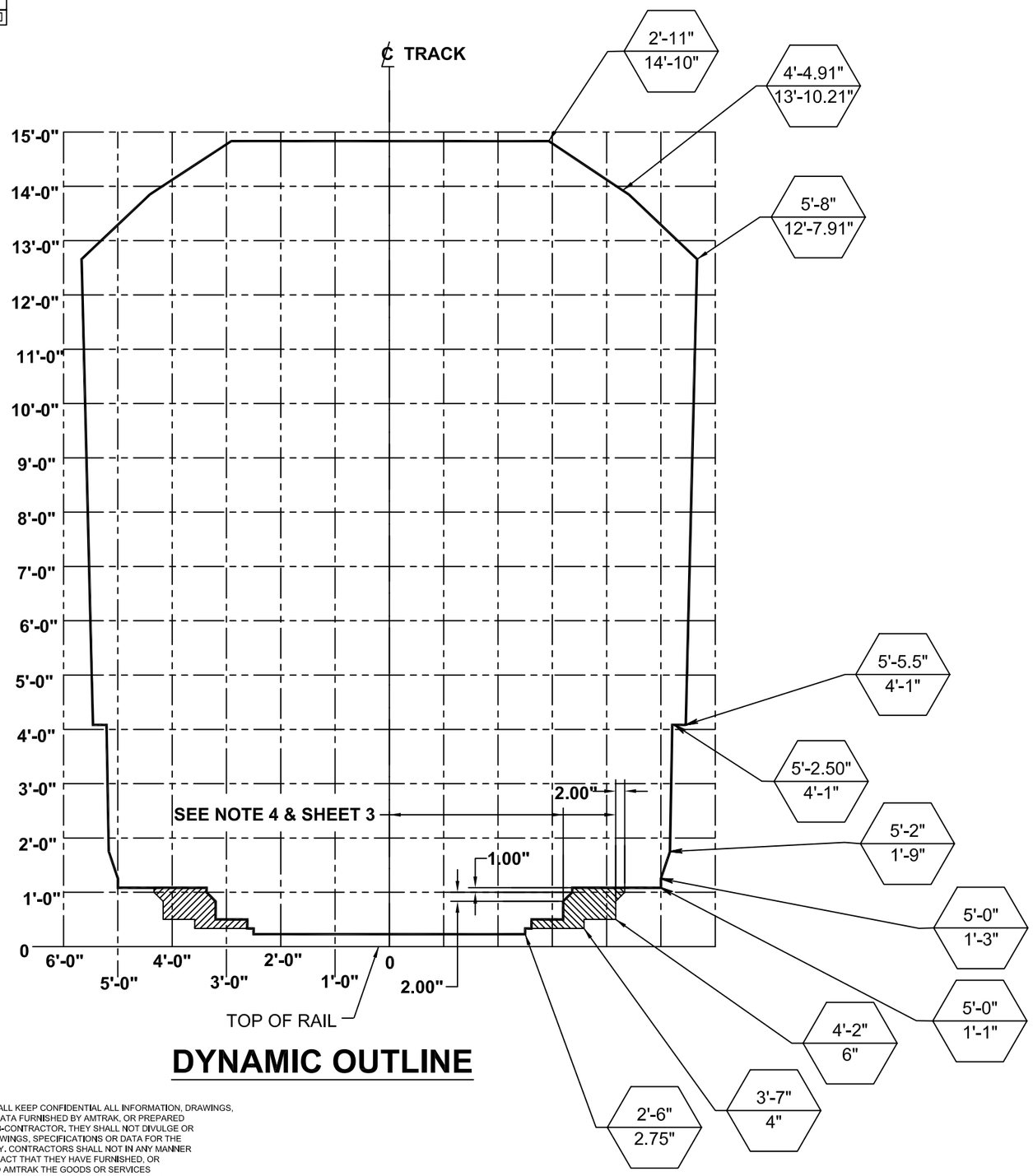
TOLERANCES: Dimensions are in inches unless otherwise specified. Decimals xx ± .03, xxx ± .010. Angles ±½°. Remove all burrs & break sharp edges.

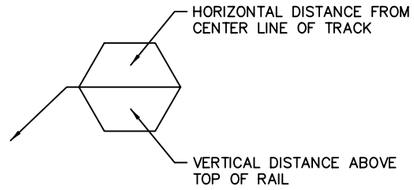
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1 FILED AS 05-1355_rE_s1-3

DRAWING NUMBER	REV.
D 05-1355	E

REVISIONS				
LTR	ZONE	DESCRIPTION	DATE	APPR'D
E	-	SEE SHEET 1	01/29/05	M.L.B.





DYNAMIC OUTLINE

CONFIDENTIALITY - CONTRACTORS SHALL KEEP CONFIDENTIAL ALL INFORMATION, DRAWINGS, SPECIFICATIONS, OR OTHER DATA FURNISHED BY AMTRAK, OR PREPARED BY THE CONTRACTOR, OR SUB-CONTRACTOR. THEY SHALL NOT DIVULGE OR USE SUCH INFORMATION, DRAWINGS, SPECIFICATIONS OR DATA FOR THE BENEFIT OF ANY OTHER PARTY. CONTRACTORS SHALL NOT IN ANY MANNER ADVERTISE OR PUBLISH THE FACT THAT THEY HAVE FURNISHED, OR CONTRACTED TO FURNISH, TO AMTRAK THE GOODS OR SERVICES HEREIN MENTIONED WITHOUT PRIOR WRITTEN CONSENT OF AMTRAK.

THE AMTRAK DRAWING IS THE GOVERNING DOCUMENT, AND SUPERSEDES ANY LIKE INFORMATION ON REFERENCE DRAWINGS, PART NUMBERS, SPECIFICATIONS, ETC.

QTY	PART NUMBER	DESCRIPTION	MATERIAL	MFG/SPEC	AMM'S NUMBER	ITEM
						1

LIST OF MATERIAL

REFERENCE DRAWINGS
AM70070A

AMTRAK
Mechanical Department
Bureau of Rolling Stock Engineering
National Railroad Passenger Corporation
4001 Vandever Ave. Wilmington DE 19802

TITLE CLEARANCE DIAGRAM

Drawn	Date	Approved	Approved
J. A. CAMPBELL	01/29/05	M. L. BURSHTIN	M. TROSINO
Checked	Date	Approved	For Issue
B F HOFFMAN	01/31/05		

STANDARD TRACK PLAN

PROGRAM | NEXT ASS'Y | USED ON

REPORT ALL CHANGES TO ENGINEERING DEPARTMENT

DO NOT SCALE DRAWING

Dimensions are in inches unless otherwise specified. TOLERANCES: Decimals xx ± .03, xxx ± .010; Angles ± 5°

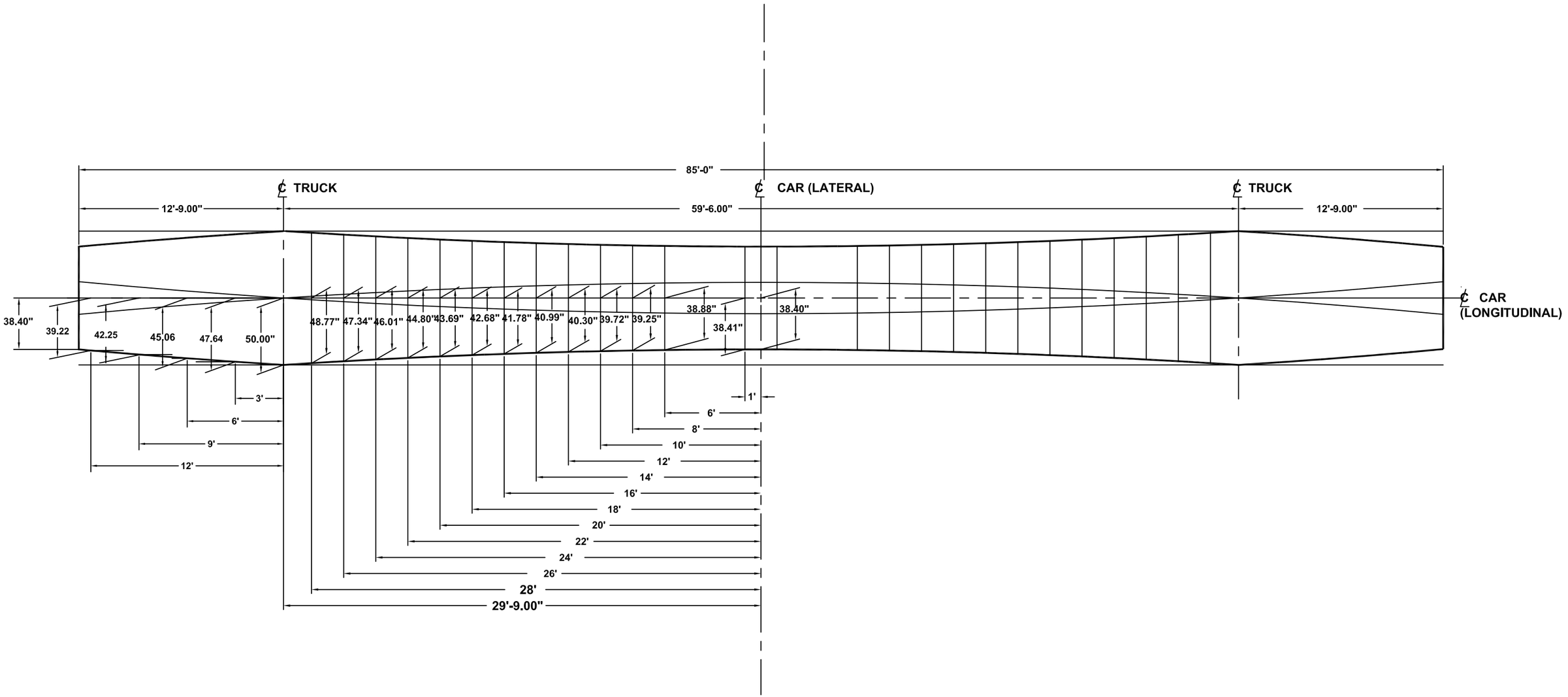
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Scale SCALE | SHT. 2 OF 3 | DRAWING NUMBER D 05-1355 | REV. E

1 FILED AS 05-1355_rE_s1-3

REV.	DRAWING NUMBER
E	D 05-1355

REVISIONS				
LTR	ZONE	DESCRIPTION	DATE	APPR'D
E	-	SEE SHEET 1	01/29/05	M.L.B.



TANGENT OFFSETS
FOR 85'-0" CAR WITH 59'-6" TRUCK CENTERS

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QTY	PART NUMBER	DESCRIPTION	MATERIAL	MFG/SPEC	AMM'S NUMBER	ITEM
						1

LIST OF MATERIAL

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TITLE: CLEARANCE DIAGRAM

Drawn J. CAMPBELL	Date 01/29/05	Approved M. L. BURSHTIN	Approved M. TROSINO		
Checked B F HOFFMAN	Date 01/31/05	Approved	For Issue		
Scale SCALE	DRAWING NUMBER D 05-1355			REV. E	
SHT. 3 OF 3					

TOLERANCES
Dimensions are in inches unless otherwise specified.
Decimals xx ± .01, xxx ± .010
Angles ±4'
Remove all burrs & break sharp edges.

STANDARD TRACK PLAN			REPORT ALL CHANGES TO ENGINEERING DEPARTMENT
PROGRAM	NEXT ASS'Y	USED ON	DO NOT SCALE DRAWING

FILED AS 05-1355_rE_s1-3

SEPTA SILVERLINER-VI RAILCAR

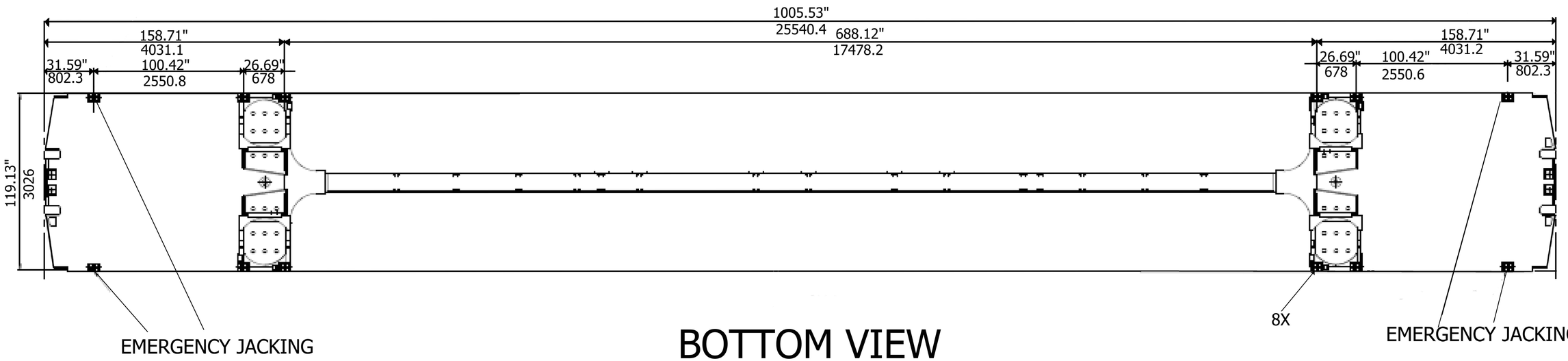
TECHNICAL SPECIFICATIONS

Appendix II

Jacking Pad Locations

A-END

B-END



BOTTOM VIEW

NOTE 1: DRAWING IS NOT TO SCALE.
NOTE 2: END-TO-END DIMENSION DOES NOT INCLUDE BUFFERS OR COUPLERS/DRAWBARS.

SEPTA

SILVERLINER VI

APPENDIX II: JACKING PAD LOCATIONS
FOR INFORMATION ONLY
SEPTEMBER 1, 2025

SEPTA SILVERLINER-VI RAILCAR

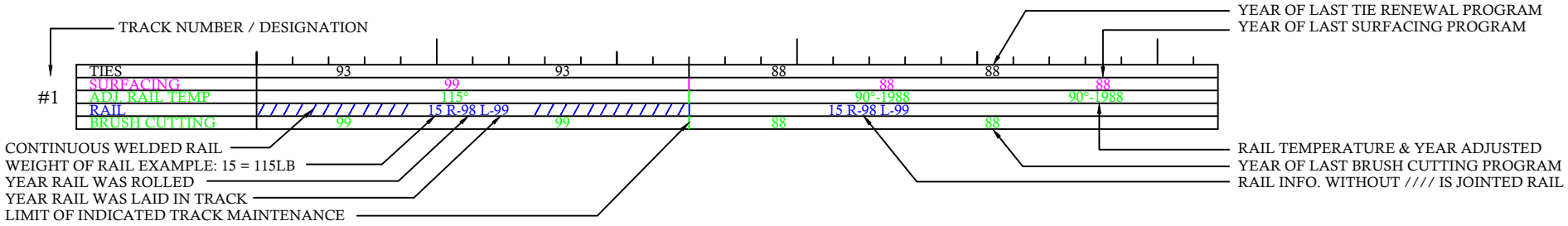
TECHNICAL SPECIFICATIONS

Appendix III

Track Charts

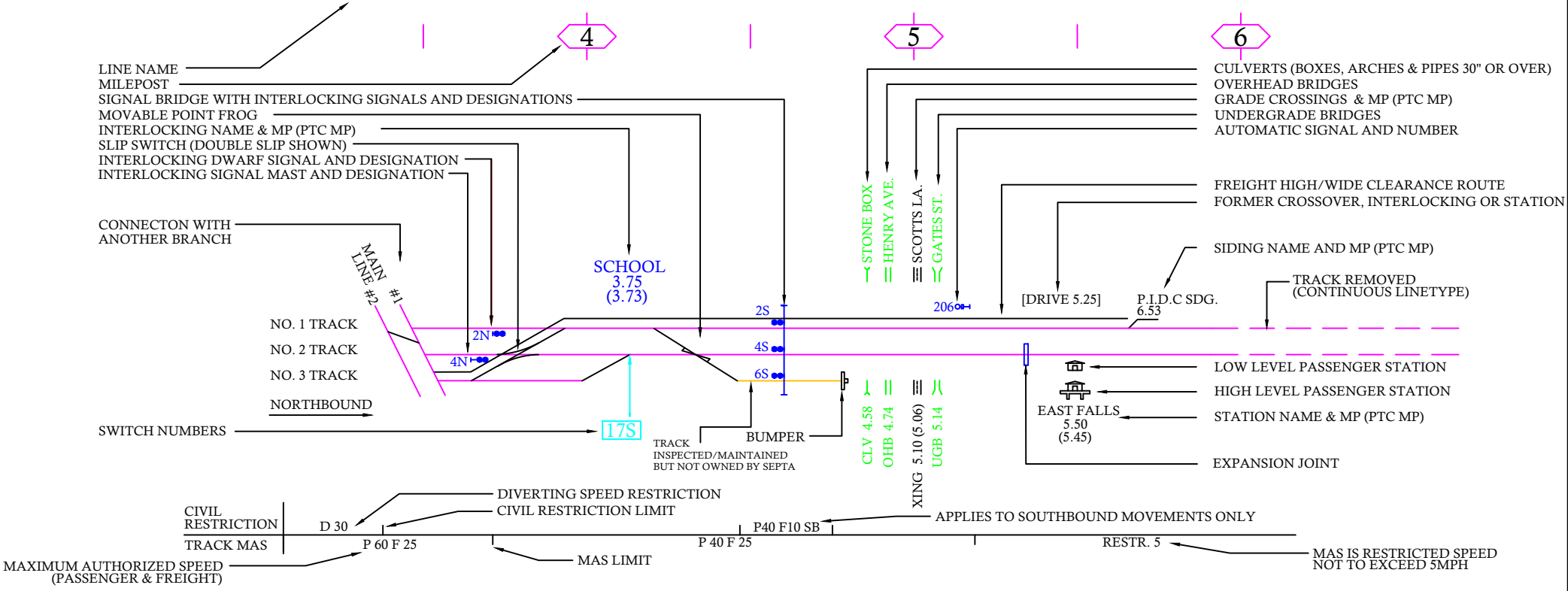

SEPTA
SOUTHEASTERN PENNSYLVANIA TRANSPORTATION AUTHORITY
TRACK CHARTS
0:00 R1 AIRPORT
0:00 R2 NEWARK
0:00 R3 ELWYN
0:00 R5 THORNDALE
0:00 R6 CYNWYD
0:00 R7 CHESTNUT HILL EAST
0:00 R8 CHESTNUT HILL WEST
0:00 R1 GLENSIDE
0:00 R2 WARMINSTER
0:00 R3 WEST TRENTON
0:00 R5 DOYLESTOWN
0:00 R6 NORRISTOWN
0:00 R7 TRENTON
0:00 R8 FOX CHASE
COVER BY

TRACK CHART LEGEND



NORRISTOWN LINE

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 6/2022 BY L. McGRATH



CONTENTS

RAIL LINE	BETWEEN	MP to MP
Airport Line	Phila. to E-F Terminals	3.60 - 9.50
Bethlehem Branch	Dale to EOT	24.20 – 25.00
Chestnut Hill East Line	Wayne to Chestnut Hill East	5.10 - 10.80
Chestnut Hill West Line	N. Phila to Chestnut Hill West	0.00 - 6.60
Doylestown Line	Dale to Doylestown	0.00 - 10.00
Fox Chase Line	CP - Newtown Jct. to N. Fox Chase	6.20 - 11.30
Harrisburg Line	Styles to Overbrook	3.60 - 5.10
Ivy Ridge Line	Valley to Cynwyd	4.00 - 6.10
Main Line	Zoo to Dale	2.68 - 24.20
Neshaminy Line	Jenkin to Trent	10.80 - 32.60
Norristown Line	16th St. Junction to Elm Street	3.50 - 18.10
Warminster Line	Carmel to Warminster	0.00 - 8.30
West Chester Line	Schuylkill to Wawa	0.80 - 18.46

AMTRAK MAINTAINED LINES – UNCONTROLLED REFERENCE

Amtrak Northeast Corridor (Amtrak Maintained) SEPTA Service to Newark Station, Newark, DE	38.90 - 0.00
Amtrak Harrisburg (Amtrak Maintained) SEPTA Service to Thorndale Station, Thorndale. PA	35.30 - 2.00
Amtrak Northeast Corridor (Amtrak Maintained) SEPTA Service to Trenton Station, Trenton, NJ	88.00 - 56.70

#4		2019
	TIES	2019
	SURFACING	2019
	ADJ. RAIL TEMP	
	RAIL	
	BRUSH CUTTING	

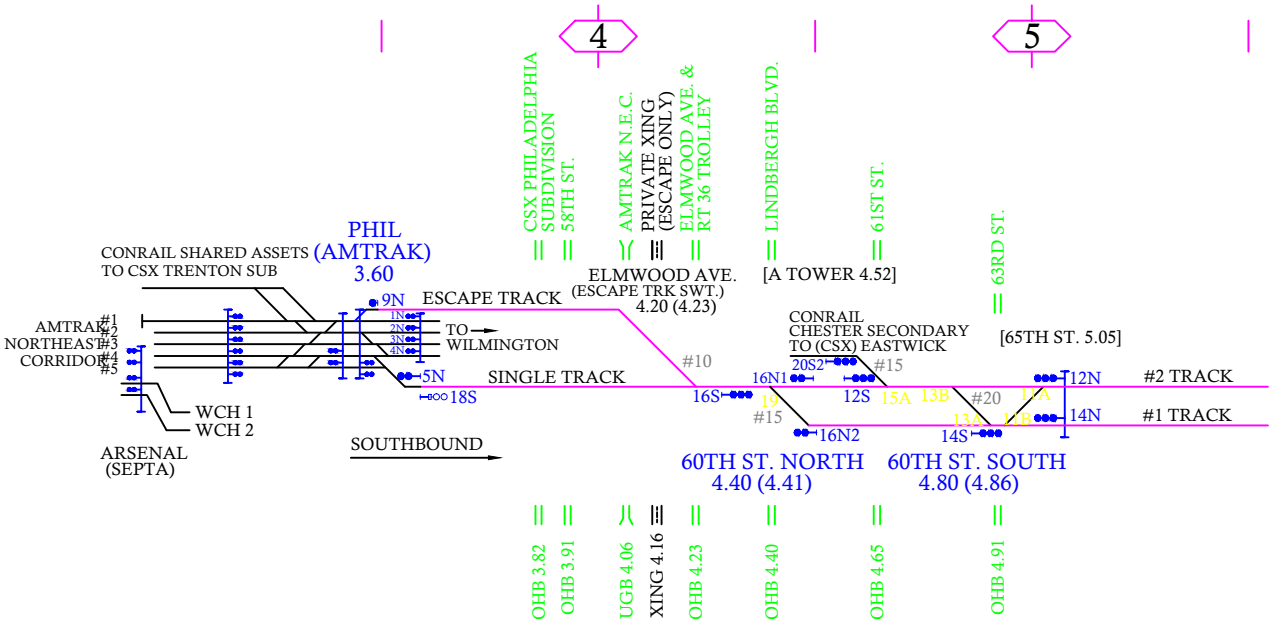
ESCAPE			#2 TRACK
		2019	2019
		2019	2019
		85°-81	JOINTED 110°-00
31 R46 L46		19 R-80 L-81	32 R-02 L-02 32 R-80 L-80
		00	00

#5		2019
	TIES	2019
	SURFACING	2019
	ADJ. RAIL TEMP	
	RAIL	
	BRUSH CUTTING	

SINGLE			#1 TRACK
		2019	2019
		2019	2019
		JOINTED	110°-00
		32 R-19 L-19 H.R ONLY- 32 R-23 L-23	32 R-80 L-80
		00	00

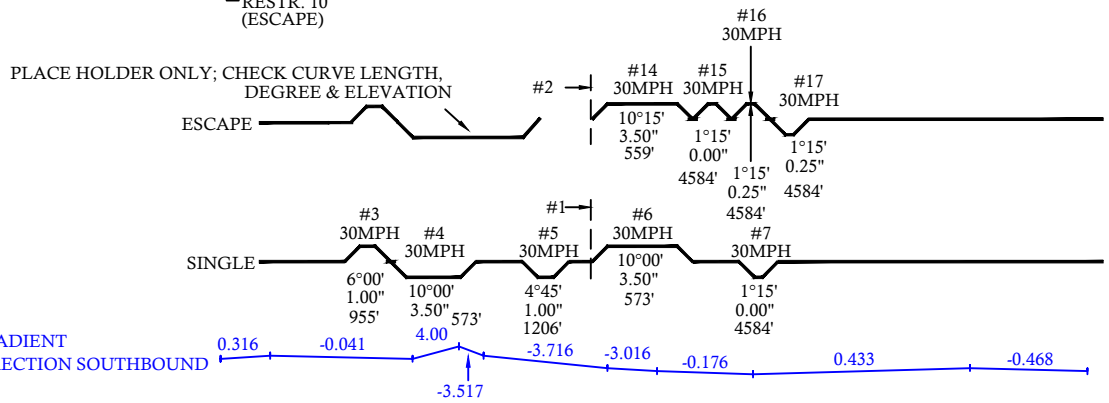
AIRPORT LINE

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV -01/2024 BY A. BELABBAS



CIVIL RESTRICTION				
TRACK MAS	P 30 F 10 (SINGLE); RESTR. 10 (ESCAPE)	P30 F 10	P30 F 25 (#1); P30 F 25 (#2)	P 79 F 40

RESTR. 10 (ESCAPE)

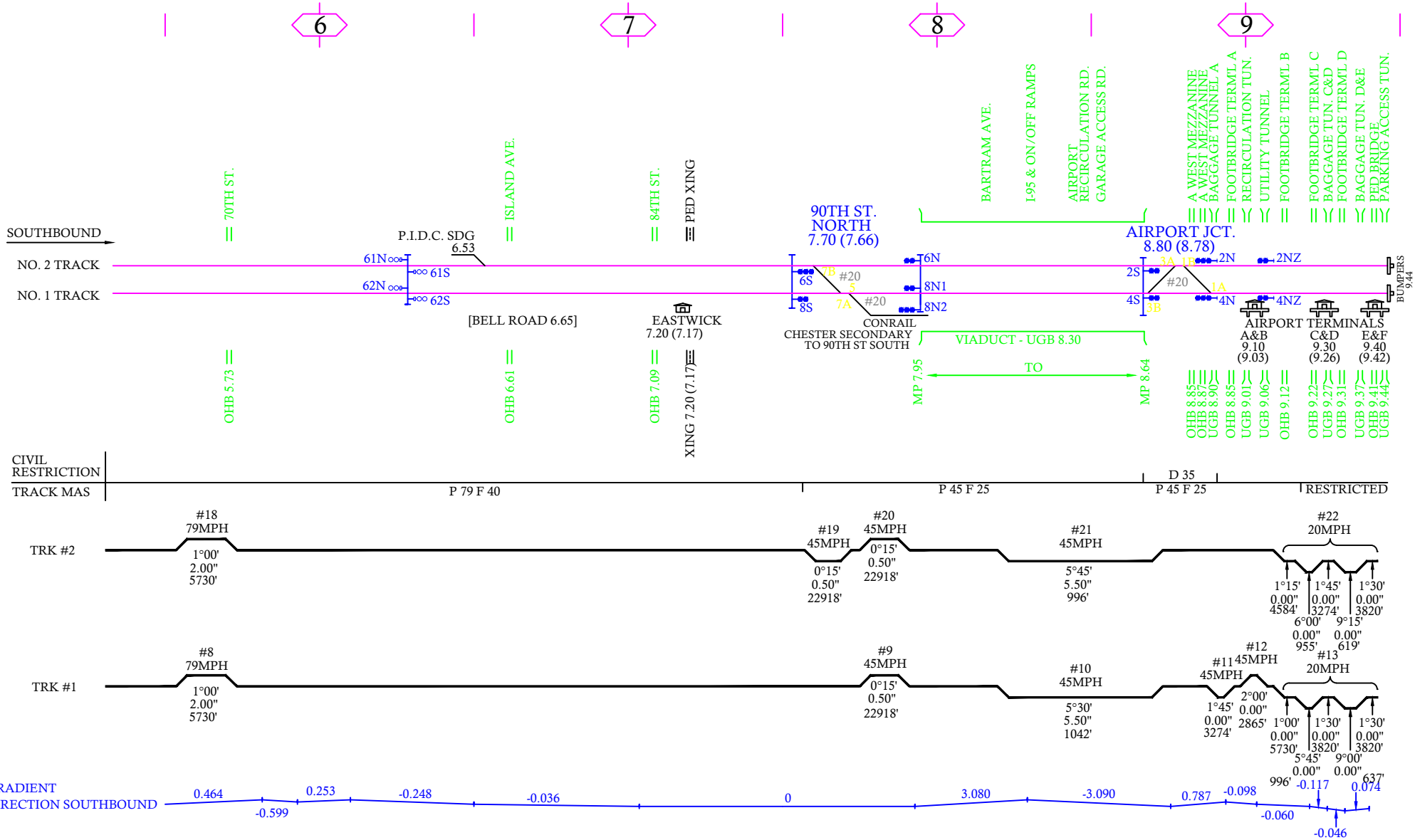


#2					
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SURFACING	2019	2019	2019	2019	
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RAIL	32 R-80 L-80	32 R-80 L-80	32 R-80 L-80	32 R-18 L-19	32 R-80 L-80
BRUSH CUTTING	00	00	00	00	

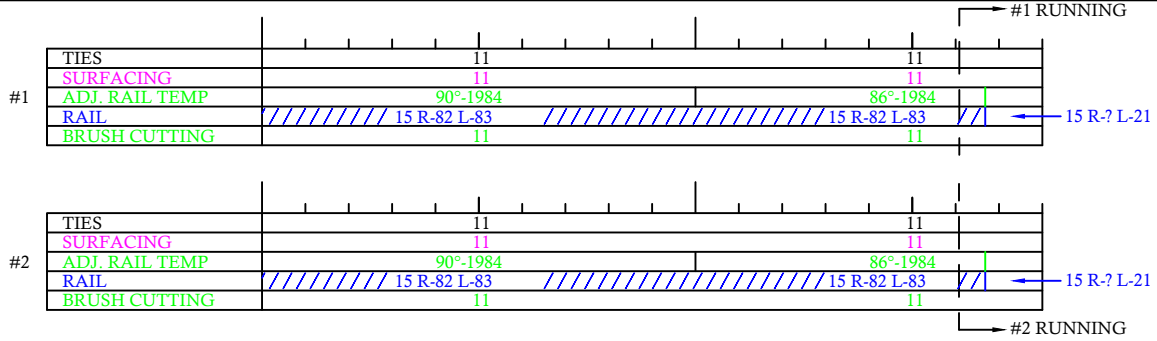
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SURFACING	2019	2019	2019	2019	
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RAIL	32 R-80 L-80	32 R-80 L-80	32 R-80 L-80	32 R-18 L-19	32 R-80 L-80
BRUSH CUTTING	00	00	00	00	

AIRPORT LINE

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 4/2022 BY T. MCCABE



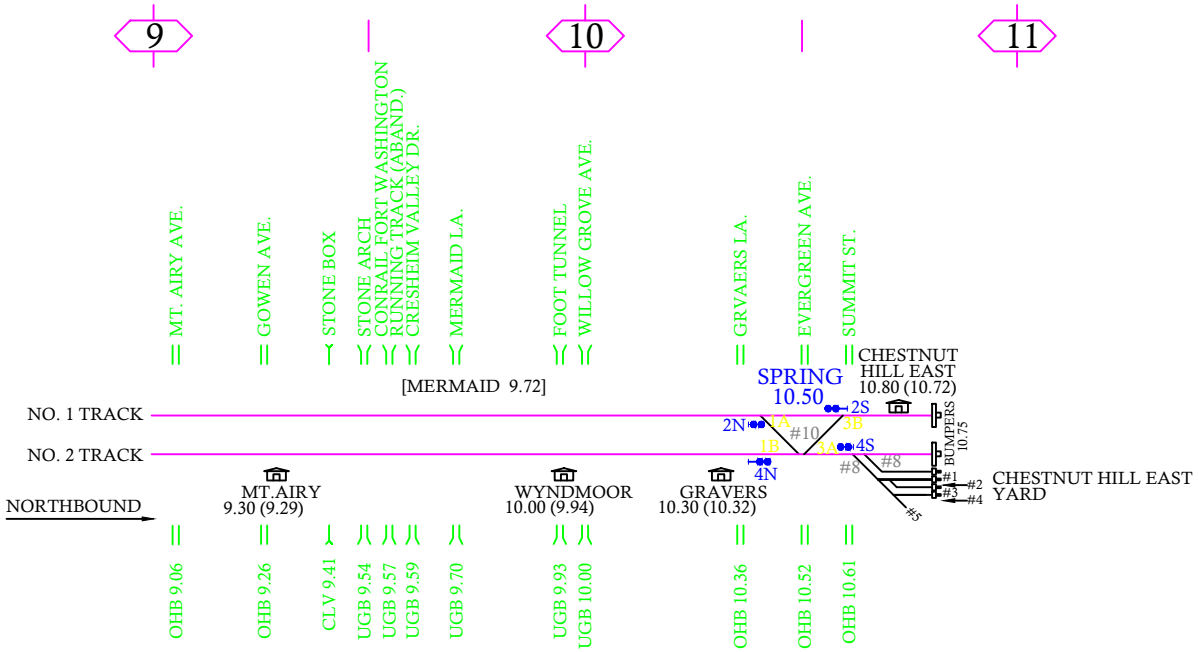
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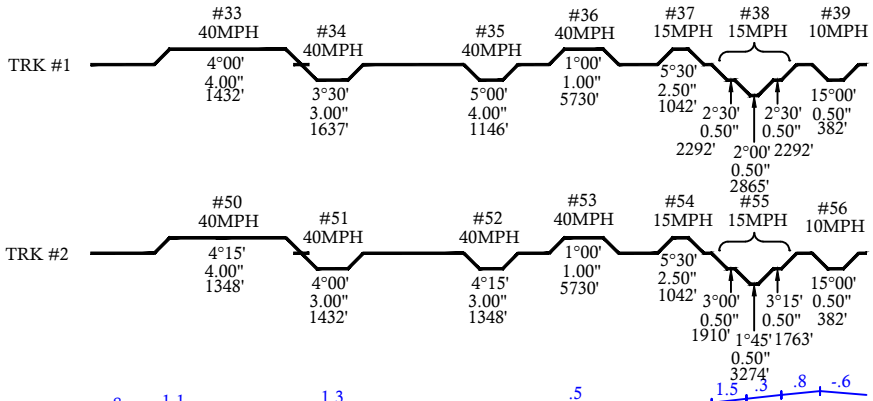
CHE YARD	
TIES	11
SURFACING	11
ADJ. RAIL TEMP	
RAIL	15-11
BRUSH CUTTING	

CHESTNUT HILL EAST LINE

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 1/2024 BY B.BRINSON

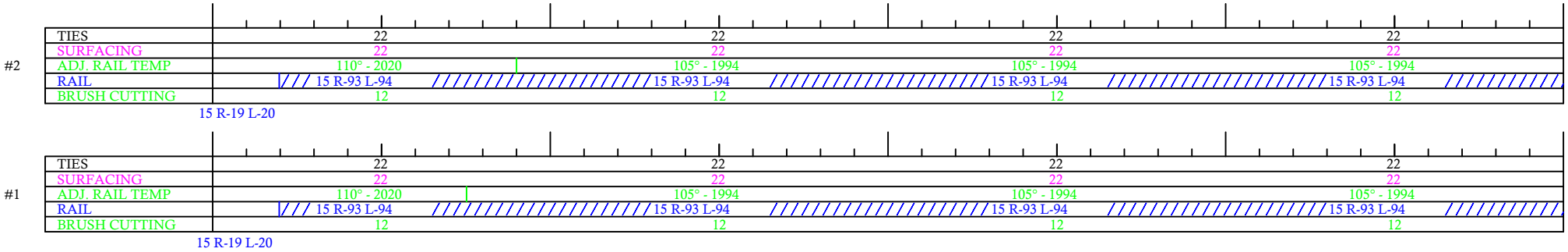


CIVIL RESTRICTION
TRACK MAS — P 40 F 30 — P 15 F 10 — RESTR. 10 (#1 & #2); RESTR. 5 (YARD)



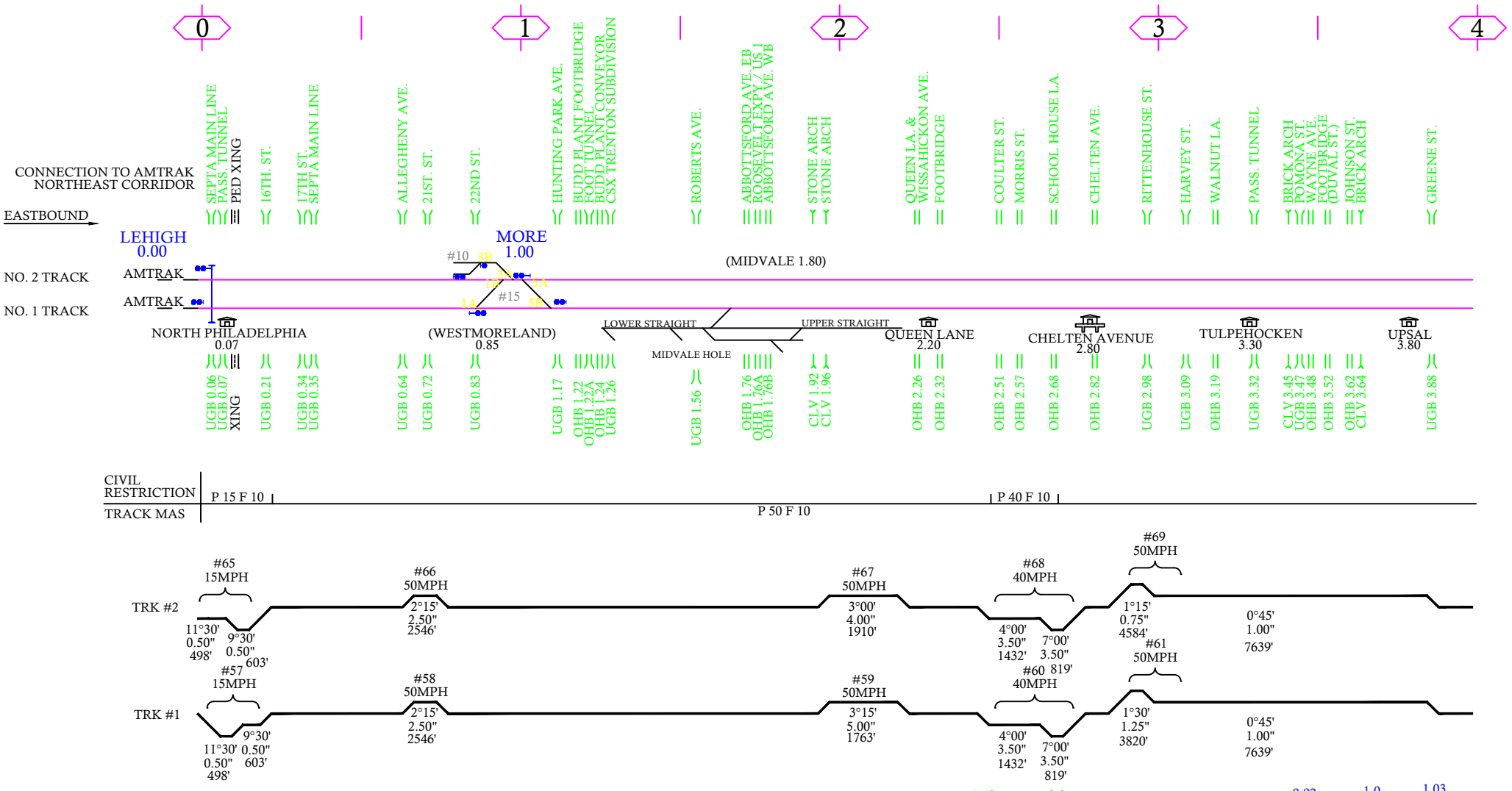


GRADIENT
DIRECTION NORTHBOUND



CHESTNUT HILL WEST LINE

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 10/2023 BY B. BRINSON

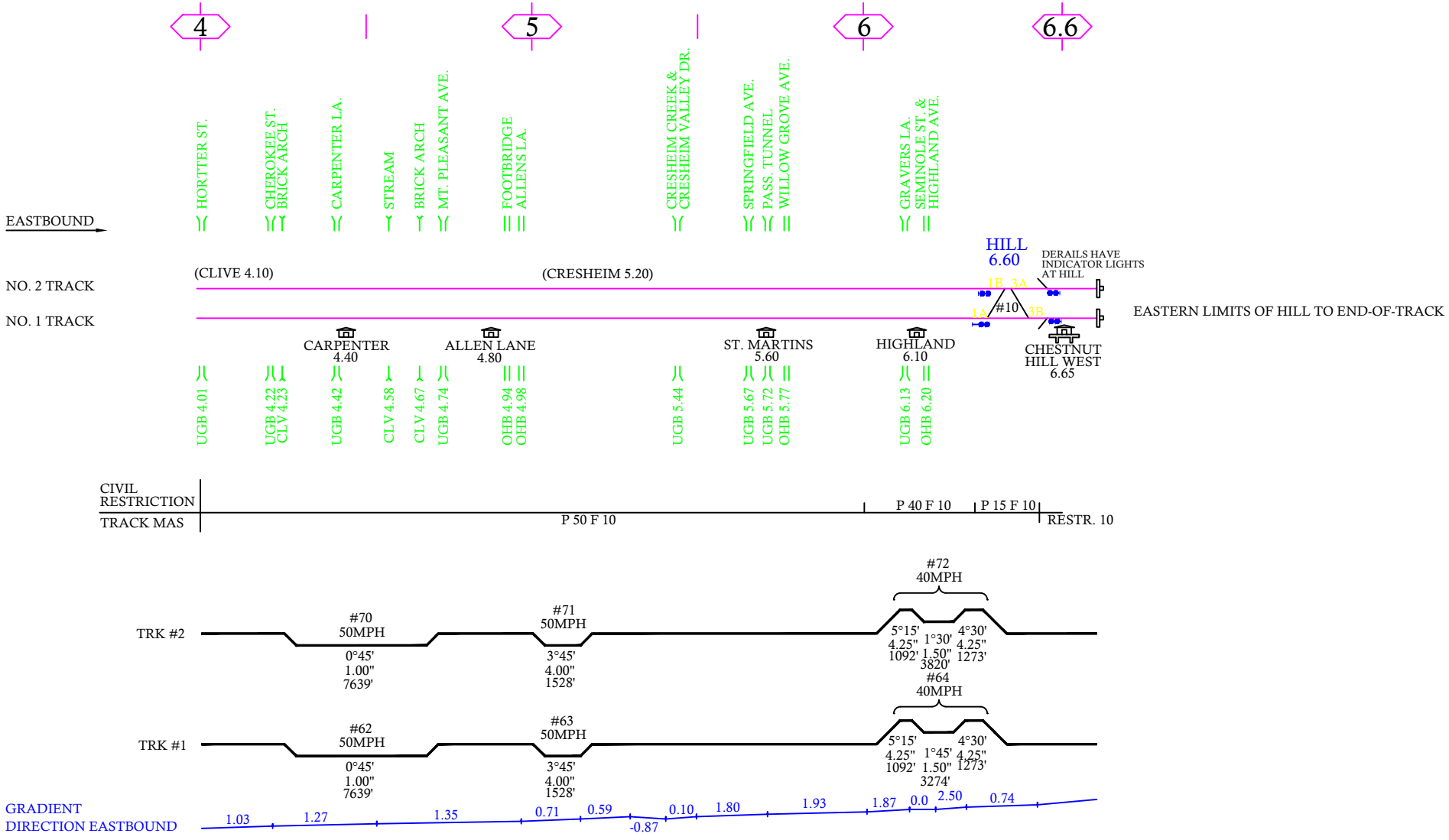


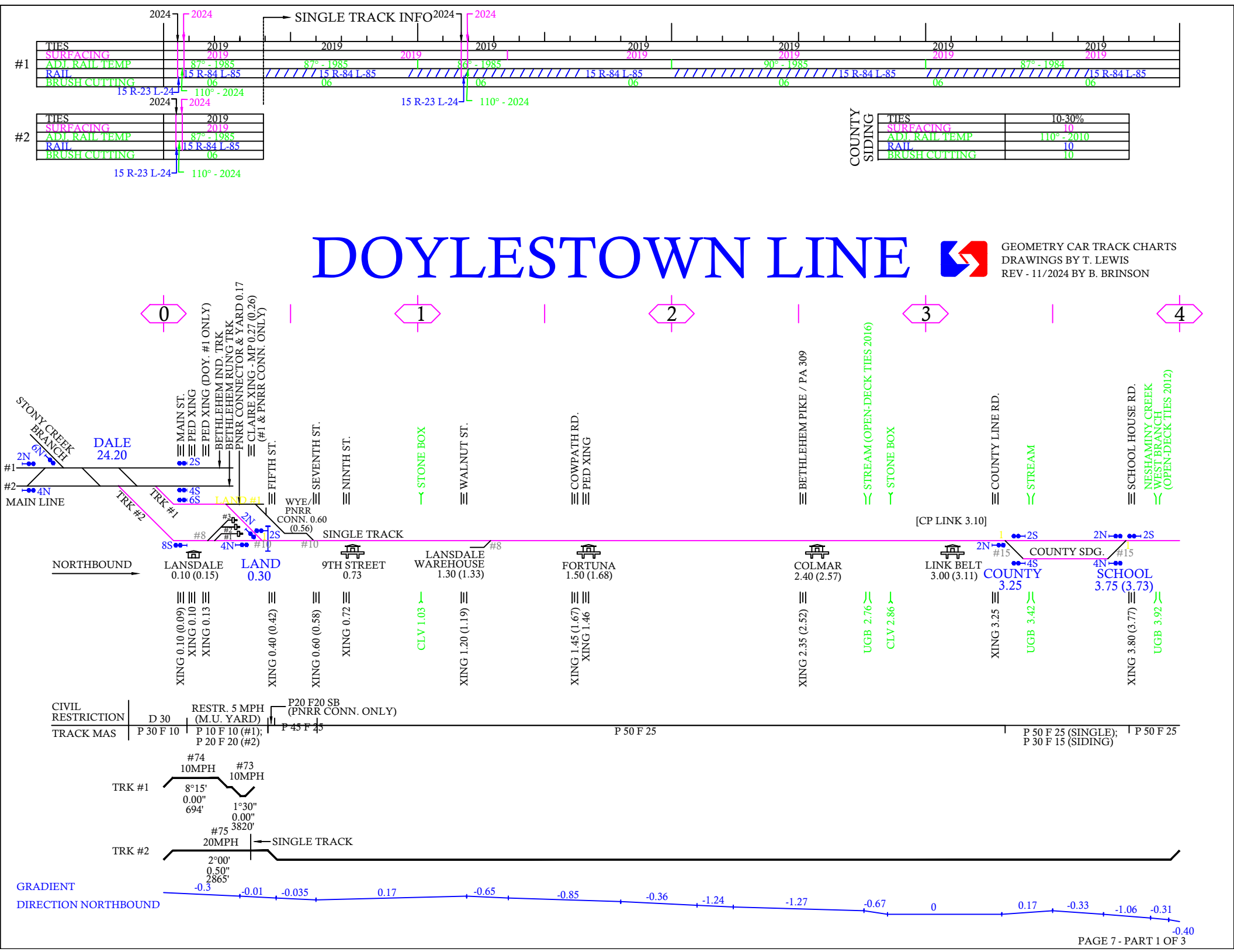
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	SURFACING	12	12
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	RAIL	15 R-? L-20	15 R-? L-20
	BRUSH CUTTING	12	12

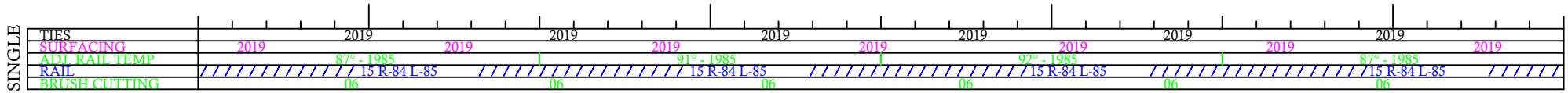
#1	TIES	12	12
	SURFACING	12	12
	ADJ. RAIL TEMP	105° - 1994	105° - 1994
	RAIL	15 R-? L-20	15 R-? L-20
	BRUSH CUTTING	12	12

CHESTNUT HILL WEST LINE

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 10/2023 BY B. BRINSON

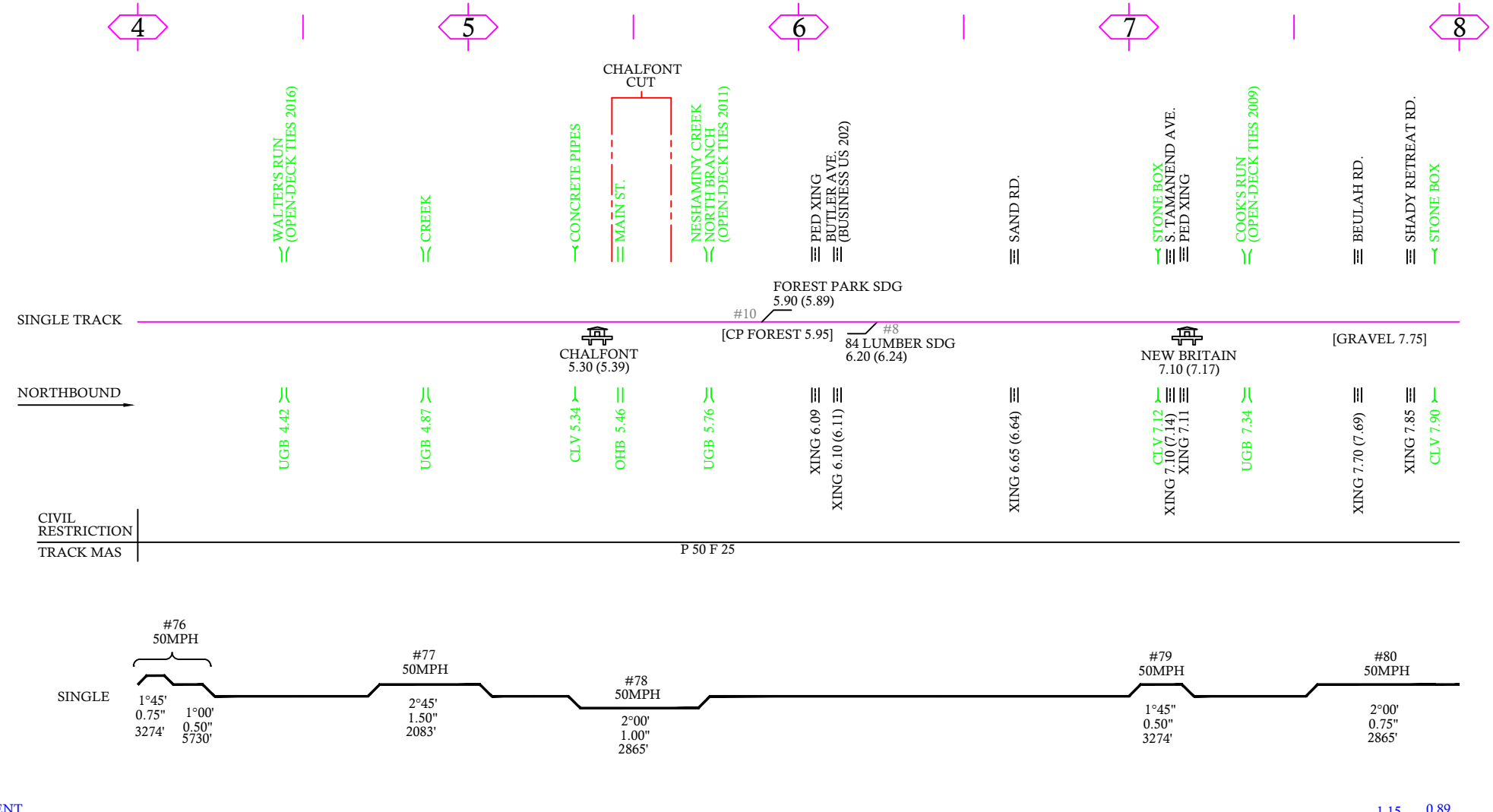



SINGLE TRACK INFO
#1
TIES 2019
SURFACING 2019
ADJ. RAIL TEMP 87° - 1985 | 87° - 1985 | 87° - 1985 | 90° - 1985 | 87° - 1984
RAIL 15 R-84 L-85
BRUSH CUTTING 06
2024
15 R-23 L-24
110° - 2024
#2
TIES 2019
SURFACING 2019
ADJ. RAIL TEMP 87° - 1985
RAIL 15 R-84 L-85
BRUSH CUTTING 06
COUNTY SIDING
TIES 10-30%
SURFACING 10
ADJ. RAIL TEMP 110° - 2010
RAIL 10
BRUSH CUTTING 10
DOYLESTOWN LINE
GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 11/2024 BY B. BRINSON
0
1
2
3
4
STONY CREEK BRANCH
DALE 24.20
MAIN ST.
PED XING
PED XING (DOY. #1 ONLY)
BETHLEHEM IND. TRK
BETHLEHEM RUN'G TRK
PNRR CONNECTOR & YARD 0.17
CLAIRE XING - MP 0.27 (0.26)
(#1 & PNRR CONN. ONLY)
FIFTH ST.
SEVENTH ST.
NINTH ST.
STONE BOX
WALNUT ST.
COWPATH RD.
PED XING
BETHLEHEM PIKE / PA 309
STREAM (OPEN-DECK TIES 2016)
STONE BOX
COUNTY LINE RD.
STREAM
SCHOOL HOUSE RD.
NESHAMINY CREEK
WEST BRANCH
(OPEN-DECK TIES 2012)
MAIN LINE
TRK #1
TRK #2
LAND #1
WYE/ PNRR CONN. 0.60 (0.56)
SINGLE TRACK
[CP LINK 3.10]
NORTHBOUND
LANSDALE 0.10 (0.15)
LAND 0.30
9TH STREET 0.73
LANSDALE WAREHOUSE 1.30 (1.33)
FORTUNA 1.50 (1.68)
COLMAR 2.40 (2.57)
LINK BELT 3.00 (3.11)
COUNTY 3.25
COUNTY SDG.
SCHOOL 3.75 (3.73)
XING 0.10 (0.09)
XING 0.10
XING 0.13
XING 0.40 (0.42)
XING 0.60 (0.58)
XING 0.72
CLV 1.03
XING 1.20 (1.19)
XING 1.45 (1.67)
XING 1.46
XING 2.35 (2.52)
UGB 2.76
CLV 2.86
XING 3.25
UGB 3.42
XING 3.80 (3.77)
UGB 3.92
CIVIL RESTRICTION
TRACK MAS
D 30
P 30 F 10
RESTR. 5 MPH (M.U. YARD)
P 10 F 10 (#1); P 20 F 20 (#2)
P20 F20 SB (PNRR CONN. ONLY)
P 45 F 45
P 50 F 25
P 50 F 25 (SINGLE); P 30 F 15 (SIDING)
P 50 F 25
TRK #1
#74 10MPH
#73 10MPH
8°15' 0.00" 694'
1°30" 0.00" 3820'
TRK #2
#75 20MPH
SINGLE TRACK
2°00' 0.50" 2865'
GRADIENT
DIRECTION NORTHBOUND
-0.3
-0.01
-0.035
0.17
-0.65
-0.85
-0.36
-1.24
-1.27
-0.67
0
0.17
-0.33
-1.06
-0.31
-0.40



DOYLESTOWN LINE

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 10/2023 BY B.BRINSON



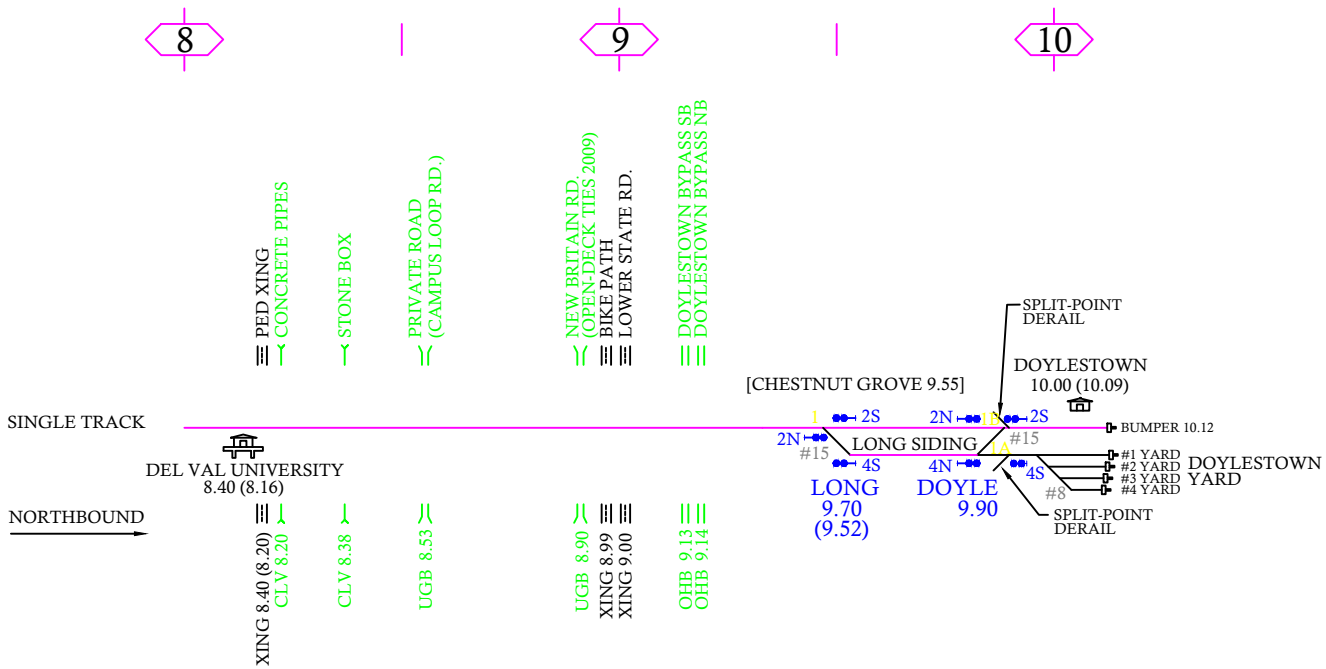
SINGLE				
TIES	2019	2019	2019	
SURFACING	2019	2019		
ADJ. RAIL TEMP	86° - 1985		87° - 1985	
RAIL	15 R-84 L-85		15 R-84 L-85	
BRUSH CUTTING	06	06	06	

LONG SIDING	
TIES	2010
SURFACING	2010
ADJ. RAIL TEMP	
RAIL	15-2010
BRUSH CUTTING	2006

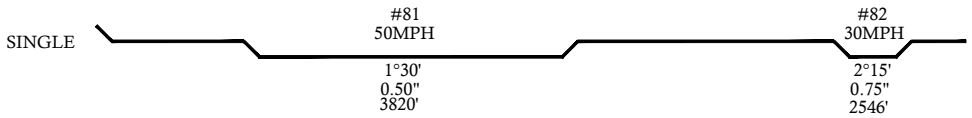
YARD	
TIES	2010
SURFACING	2010
ADJ. RAIL TEMP	
RAIL	15 R-?, L-10
BRUSH CUTTING	2010

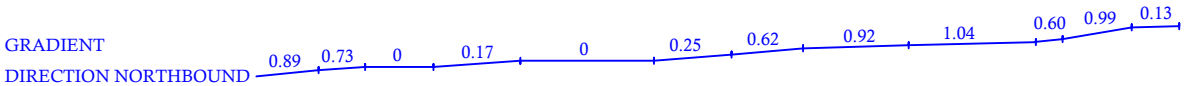
DOYLESTOWN LINE

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 10/2023 BY B. BRINSON



CIVIL RESTRICTION			
TRACK MAS	P 50 F 25	P 30 F 15	RESTR. 5





SINGLE

TIES	22	22	22	22	22	22	22
SURFACING	22	22	22	22	22	22	22
ADJ. RAIL TEMP		95° - 1986	95° - 1986	95° - 1986	95° - 1986	95° - 1986	110° - 02
RAIL	32 R-92 L-92	33 R-49 L-60	33 R-49 L-60	33 R-49 L-60	33 R-49 L-60	33 R-49 L-60	15 R-02 L-02
BRUSH CUTTING	11	11	11	11	11	11	11

15 R-91 L-92 CWR

SIDING

TIES		
SURFACING		
ADJ. RAIL TEMP		
RAIL		
BRUSH CUTTING	11	

FOX CHASE LINE

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 8/2023 BY B. WASZENA

6 | 7 | 8 | 9 | 10

10TH ST. | CONRAIL BERKS ST. INDUSTRIAL TRACK (ABANDONED) (OPEN-DECK TIES 2016) | 5TH ST. | 3RD ST. | TABOR RD. & MASCHER ST. | OLNEY AVE. | TACONY CREEK | ADAMS AVE. | NEWTOWN AVE. | PED XING | LEVICK ST. | STREAM | MARTINS MILL RD.

CSX OWNED; SEPTA LEASED & MAINTAINED — SEPTA OWNED

9.60

NEWTOWN JCT 6.20

OLNEY 7.30 (7.38)

[ADAMS RUN 8.08]

[CRESCENTVILLE 8.31]

LAWNDALE 9.00 (8.99)

LAWN 9.05

CHELT 9.39

CHELTENHAM 9.70 (9.72)

SINGLE TRACK

NORTHBOUND

SEPTA MAIN LINE

8S

[CP CRESCENT 8.10]

2S 2N #15 4S 4N — LAWNDALE SDG

2N 2S #15 4N

[CHELTENHAM JCT.] 9.60

CSX TRENTON SUBDIVISION

CSX TO CP NICE

UGB 6.44 | UGB 6.68 | UGB 6.87 | UGB 7.03 | UGB 7.25 | OHB 7.53 | UGB 7.95 | UGB 8.15 | UGB 8.22 | XING 9.00 | OHB 9.15 | UGB 9.25 | OHB 9.66

CSX TO CP BERRY

CSX OWNED; SEPTA LEASED & MAINTAINED

CIVIL RESTRICTION: P 40 | P 40 | P 30 F 25 (SIDING)

TRACK MAS: P40 F25 | P 60 F 40 | P 50 F 40 | P30 F25 | P 50 F 25

SINGLE

#85 40MPH: 1528' 3°45 3.00" | 1348' 4°15' 4.00" | 4584' 1°15' 2.25"

#86 40MPH: 1348' 4°15' 4.00" | 1432' 4°00' 4.00" | 5730' 1°00' 2.00"

#87 50MPH: 2865' 2°00' 3.25"

#88 50MPH: 2546' 2°15' 3.50"

#83 30MPH: 5730' 1°00' 1.50" | 1637' 3°30' 3.00" | 3274' 1°45' 1.50"

SIDING CURVE INFO: 5730' 1°00' 0.50" | 3820' 1°30' 0.50"

GRADIENT: 0.00 | -0.45 | -0.36 | -0.50 | V.C. | 0.24 | V.C. | 0.09

DIRECTION NORTHBOUND

SINGLE

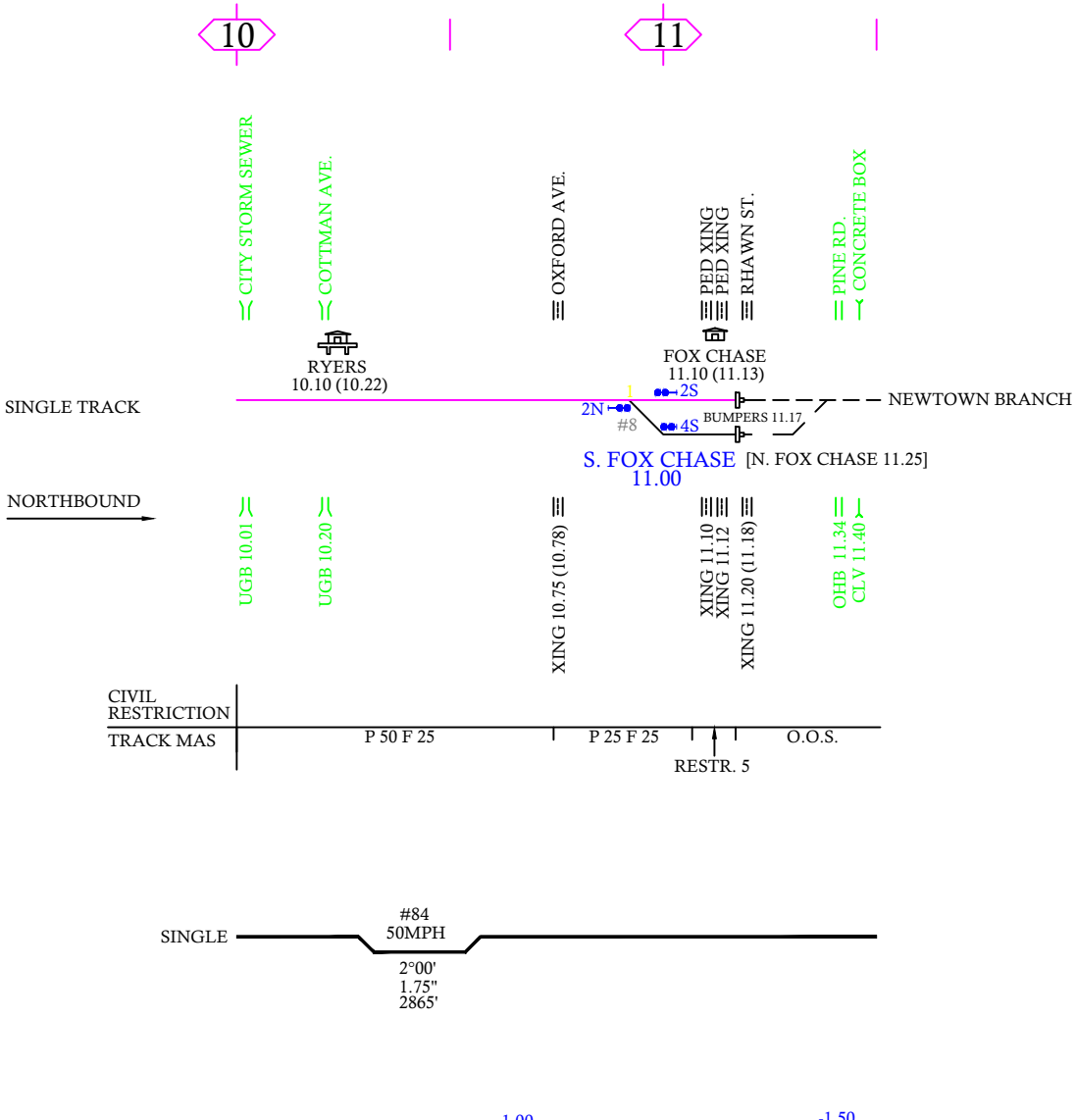
TIES	22	22	O.O.S.
SURFACING	22	22	O.O.S.
ADJ. RAIL TEMP	110°-02		O.O.S.
RAIL	15 R-02 L-02		O.O.S.
BRUSH CUTTING	11	11	O.O.S.

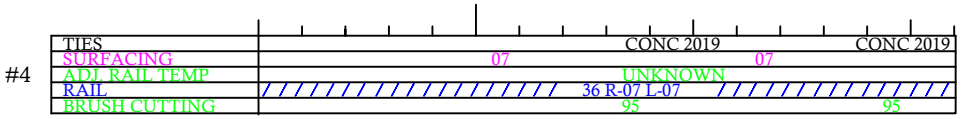
SIDING

TIES	22	O.O.S.
SURFACING	22	O.O.S.
ADJ. RAIL TEMP	110° - 02	O.O.S.
RAIL	15 R-02 L-02	O.O.S.
BRUSH CUTTING	11	O.O.S.

FOX CHASE LINE

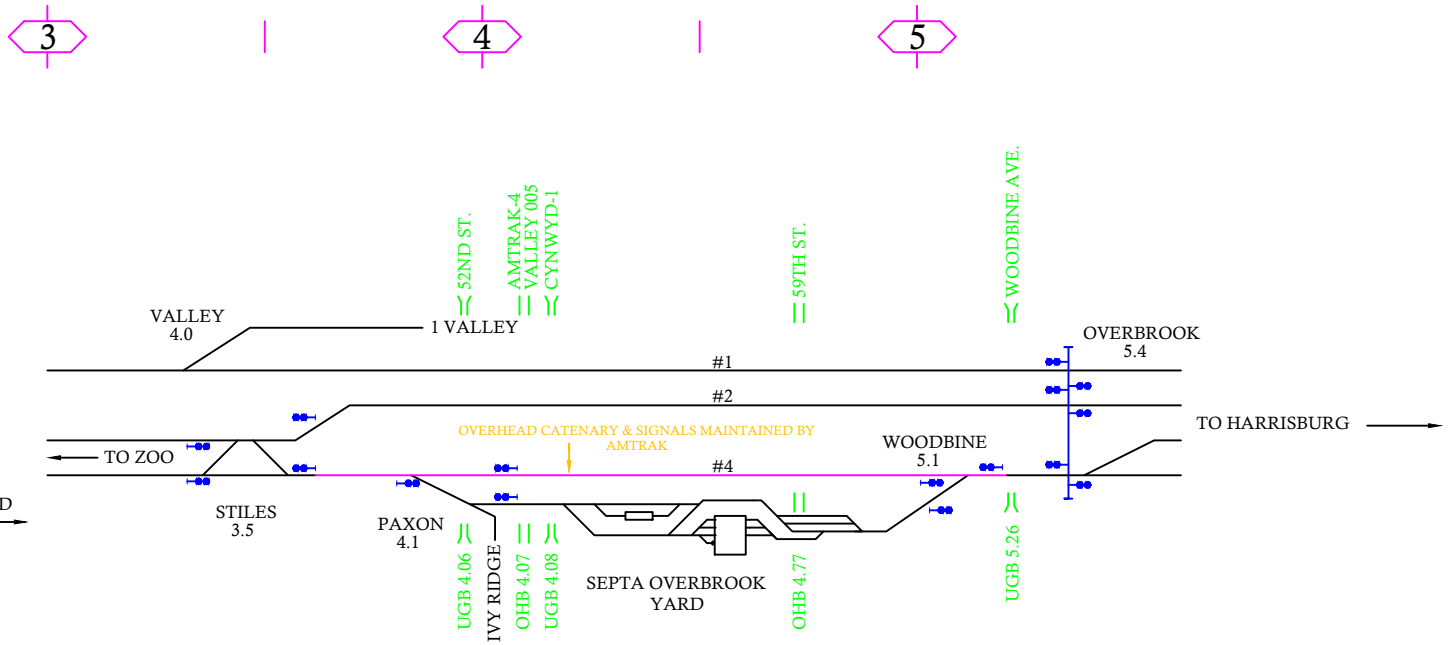
GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 8/2023 BY B. WASZENA

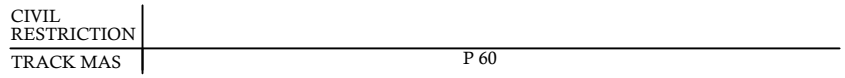


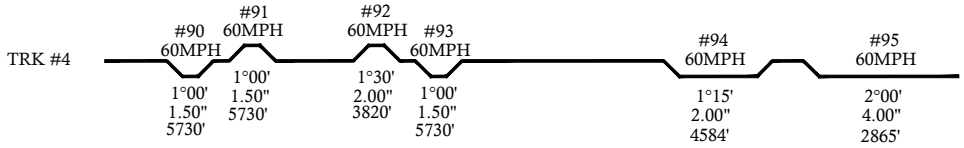


HARRISBURG LINE

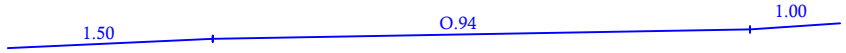
GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 6/2022 BY L. McGRATH







GRADIENT
DIRECTION WESTBOUND



#1

SINGLE TRACK

TIES	2019	2019	2019	2019
SURFACING	2019	2019	2019	
ADJ. RAIL TEMP	110°	110°	110°	
RAIL	30 R-56 L-03	30 R-56 L-03	30 R-56 L-03	30 R-56 L-03
BRUSH CUTTING	06	06	06	06
	15 R-? L-19	15 R-? L-21	15 R-? L-19	

#2

TIES	2019
SURFACING	2019
ADJ. RAIL TEMP	110° - 2017
RAIL	30 R-56 L-03 — 15 R-? L-17
BRUSH CUTTING	06
	15 R-? L-19

IVY RIDGE LINE

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 8/2021 BY C. RITZER

4 5 6 7 8

NOTE: ALL SIGNALS AT JEFF AND 62 SIGNAL AT CP CYN ARE AUTOMATICALLY CONTROLLED BUT HAVE NO NUMBER PLATE AND ARE ABSOLUTE SIGNALS.

VALLEY 4.00
CONNECTION TO AMTRAK HARRISBURG LINE
TUNNEL ON #1 TRACK
JEFFERSON ST.
JEFF 4.50
TRUCK XING
BRYN MAWR AVE.
PED XING
WYNNEFIELD AVE.
WOODBINE AVE.
CITY LINE AVE
PED XING
UNION AVE.
MONTGOMERY AVE.
PED XING
CP CYN 6.00
CONCRETE PIPE
BRICK ARCH
BELMONT AVE.
CLEGGS CREEK
CLEGGS CREEK
CLEGGS CREEK
NS HARRISBURG LINE
SCHUYLKILL EXPRESSWAY & SCHUYLKILL RIVER
SEPTA NORRISTOWN LINE
PASSENGER TUNNEL
LEVERINGTON ST.
WRIGHT ST.
GATES ST.
FOOT TUNNEL (FOUNTAIN ST.)
STREAM
PARKER AVE.
(MAN 8.20)
END SEPTA OWNERSHIP 200' N OF PARKER AVE.

NO. 1 TRACK — 64R — 2W — 2E — TRACK REMOVED FOR CYNWYD TRAIL
NO. 2 TRACK — 68RB — 4W
68L
PAXON 4.00

WYNNEFIELD AVE. 4.90
BALA 5.70
CYNWYD 6.10
(BARMOUTH) 6.80
(MANAYUNK WEST) 7.80
(IVY RIDGE) 8.40

WESTBOUND

TUN 4.18 TO 4.26
UGB 4.32 (TK 1) UGB 4.37 (TK 2)
XING
UGB 4.75
XING
UGB 4.98
UGB 5.29
OHB 5.64 XING
OHB 5.90
OHB 6.11 XING
UGB 6.55
UGB 6.64
OHB 6.75
UGB 6.88
UGB 7.00
UGB 7.24
UGB 7.70
UGB 7.70
UGB 7.70
UGB 7.90
UGB 8.01
XING 8.10
XING 8.20
UGB 8.27
UGB 8.50
UGB 8.52

CIVIL RESTRICTION	P 25 F 10 #1 TRK P 20 F 10 #2 TRK	P 10 F 10	
TRACK MAS	P 25 F 10		RESTR. 10

TRK #1

#99 25MPH 11°30' 0.50"
#100 25MPH 10°30' 3.50"
#101 25MPH 1°30' 0.75"
#102 25MPH 0°45' 0.75"
#96 25MPH 1°45' 2.25"
1°15' 2.25"
#97 25MPH 1°45' 2.75"
#98 25MPH 3°15' 2.75"
4°40' 5.50"
5°40' 5.50"
5°30' 4.50"
5°30' 4.50"
3°15' 3.00"

TRK #2

#103A 20MPH 10°00' 3.25"
#103B 25MPH
#104A 25MPH 1°00' 0.00"
#104B 25MPH
#105 25MPH 0°30' 0.00"
0°15' 0.00"
2°00' 1.00"
START SINGLE TRACK

(CURVE INFO FROM THIS POINT WEST FROM OLD TRACK CHARTS

GRADIENT
DIRECTION WESTBOUND

3.25" -0.53 0.65 0.91 1.23 1.27 1.78 1.22 -0.55 -0.95 -2.19 -2.28 -2.39 -2.06 -0.99 -0.30 0.17 0.10

MAIN LINE

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 11/2024 BY B. BRINSON

#4

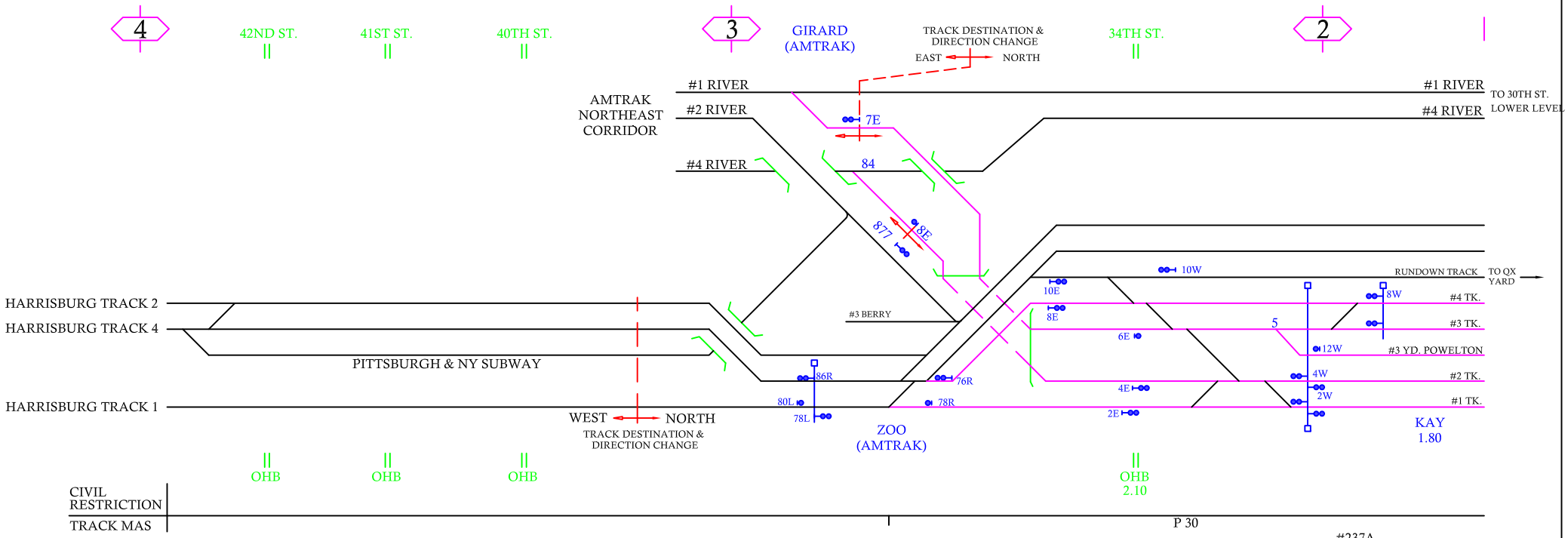
TIES	AMTRAK		AMTRAK		AMTRAK	24		24	
SURFACING		AMTRAK		AMTRAK			24		24
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		32 R-07 L-08			
BRUSH CUTTING	AMTRAK		AMTRAK			08		08	

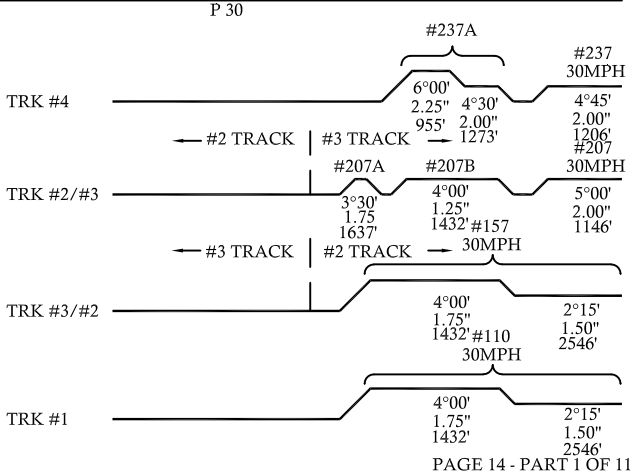
#2/#3

						← #2 TRACK		#3 TRACK →	
TIES	AMTRAK		24		24		24		
SURFACING		AMTRAK		24		24		24	
ADJ. RAIL TEMP									
RAIL		AMTRAK		32 R-07 L-08			32 R-07 L-08		
BRUSH CUTTING	AMTRAK		08		08		08		

						← #3 TRACK		#2 TRACK →	
TIES	24		24		24		24		
SURFACING		24		24					
ADJ. RAIL TEMP									
RAIL		32 R-07 L-08			32 R-07 L-08				
BRUSH CUTTING	08		08		08				

TIES	24		24						
SURFACING		24		24					
ADJ. RAIL TEMP									
RAIL		32 R-07 L-08							
BRUSH CUTTING	08		08						



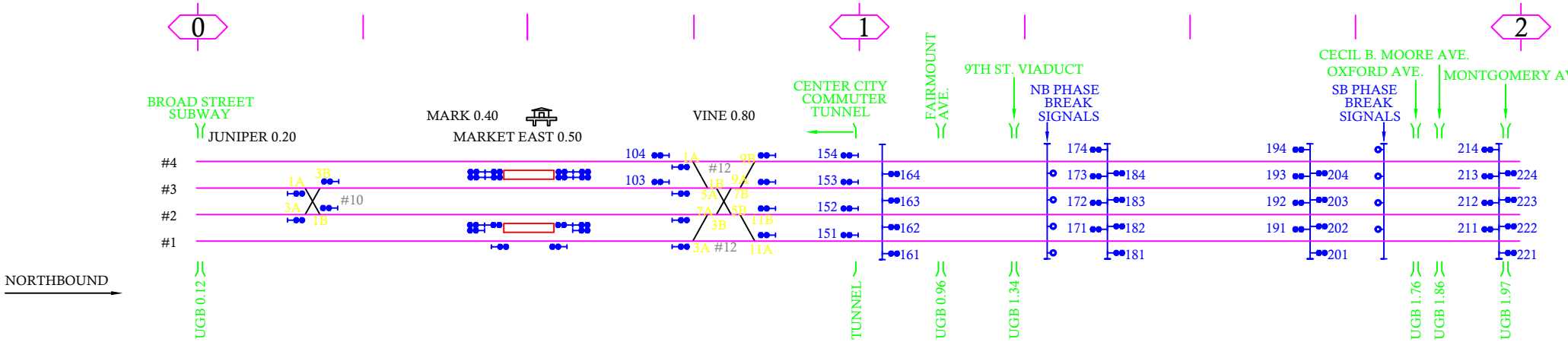


| | | |

#4	TIES	CONCRETE 1980	CONCRETE 1980		16	2017	2017
	SURFACING	DIRECT FIXATION	DIRECT FIXATION	DIRECT FIXATION		2017	2017	2017
	ADJ. RAIL TEMP	85° - 1981	110° - 2014	85° - 1980		90° - 1992	
	RAIL	32 R-13 L-89	32 R-80 L-81	32 2014	32 R-80 L-81	32 2015	32 R-92 L-92
	BRUSH CUTTING	N/A	N/A		2008	2008	2008
#3	TIES	CONCRETE 1980	CONCRETE 1980		16	2017	2017
	SURFACING	DIRECT FIXATION	DIRECT FIXATION	DIRECT FIXATION		2017	2017	2017
	ADJ. RAIL TEMP	85° - 1981	110° - 2012	85° - 1980		90° - 1992	
	RAIL	32 R-13 L-89	32 R-89 L-89	32 R-? L-20	32 R-80 L-81	32 2015	32 R-92 L-92
	BRUSH CUTTING	N/A	N/A		2008	2008	2008
#2	TIES	CONCRETE 1980	CONCRETE 1980		16	2017	2017
	SURFACING	DIRECT FIXATION	DIRECT FIXATION	DIRECT FIXATION		2017	2017	2017
	ADJ. RAIL TEMP	85° - 1981	110° - 2012	85° - 1980		90° - 1992	
	RAIL	32 R-13 L-89	32 R-80 L-81	32 R-? L-21	32 R-80 L-81	32 2015	32 R-92 L-92
	BRUSH CUTTING	N/A	N/A		2008	2008	2008
#1	TIES	CONCRETE 1980	CONCRETE 1980		15	2017	2017
	SURFACING	DIRECT FIXATION	DIRECT FIXATION	DIRECT FIXATION		2017	2017	2017
	ADJ. RAIL TEMP	85° - 1981	110° - 2014	85° - 1980		90° - 1992	
	RAIL	32 R-80 L-81	32 2014	32 R-80 L-81	32 2015	32 R-92 L-92	
	BRUSH CUTTING	N/A	N/A		2008	2008	2008

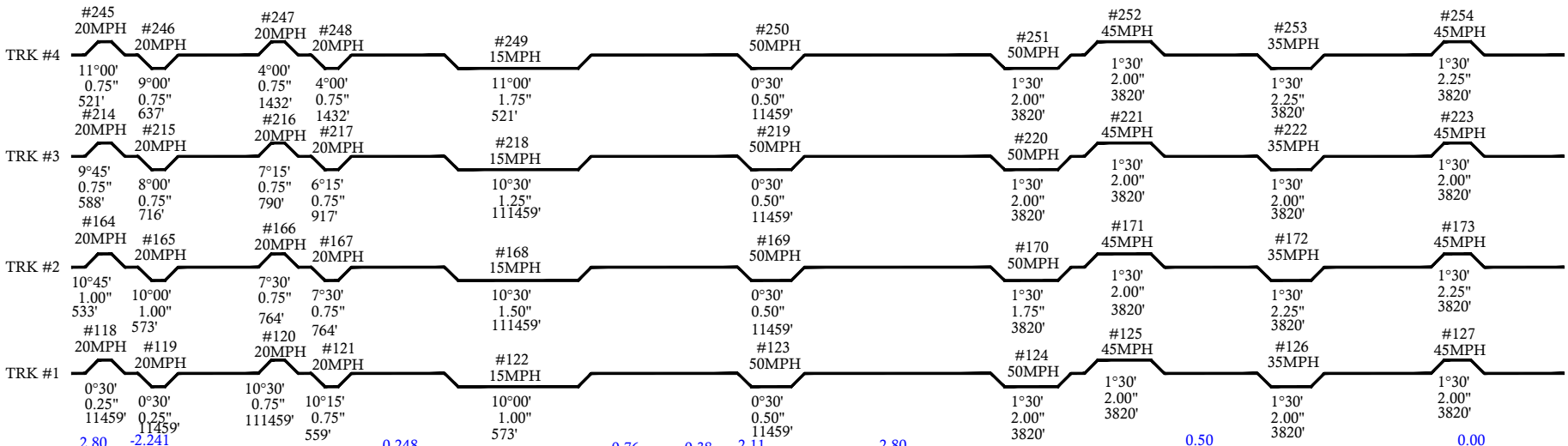
MAIN LINE

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 10/2023 BY B. BRINSON



CIVIL RESTRICTION
TRACK MAS

P 20 F 10 | P 15 F 10 | P 50 F 25 NB, P 35 F 10 SB | P 45 F 25 | P 45 F 25 NB, P 35 F 10 SB | P 45 F 25



| | | |

| | | |

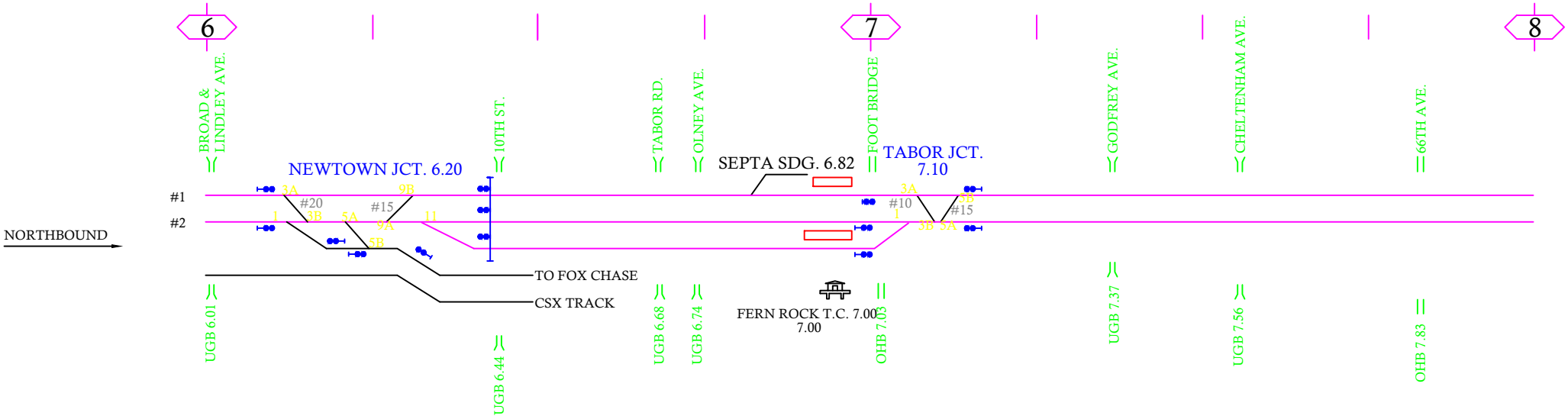
#1							
TIES	2017	2017	2017	2017	2017	2017	2017
SURFACING	2017	2017	2017	2017	2017	2017	2017
ADJ. RAIL TEMP	87° - 1984	87° - 1984	87° - 1984	87° - 1984	110° - 2016	87° - 1984	
RAIL	32 R-79 L-84	32 R-79 L-84	32 R-78 L-84	32 R-78 L-84	32 R-? L-16	32 R-78 L-84	
BRUSH CUTTING	2008	2008	2008	10	10	10	

#2							
TIES	2017	2017	2017	2017	2017	2017	2017
SURFACING	2017	2017	2017	2017	2017	2017	2017
ADJ. RAIL TEMP	87° - 1984	87° - 1984	87° - 1984	87° - 1984	110° - 2016	87° - 1984	
RAIL	32 R-83 L-84	32 R-83 L-84	32 R-78 L-84	32 R-83 L-84	32 R-? L-16	32 R-83 L-84	
BRUSH CUTTING	2008	2008	2008	10	10	10	

#0			
TIES	2017	2017	2017
SURFACING	2017	2017	2017
ADJ. RAIL TEMP	90° - 1991		
RAIL	32 R-90 L-91		
BRUSH CUTTING	92	92	10

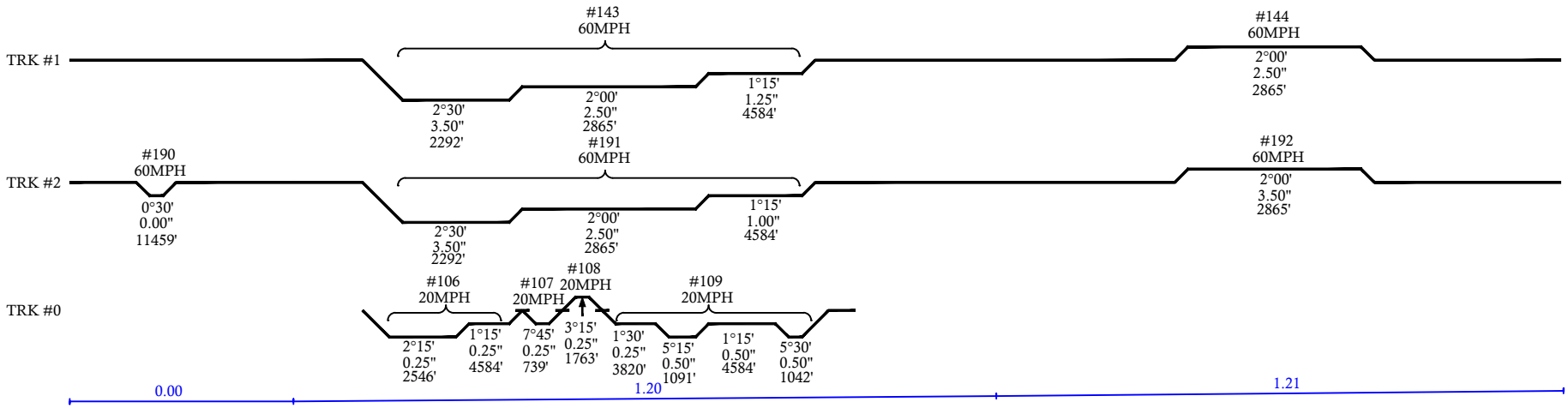
MAIN LINE

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 10/2023 BY B. BRINSON

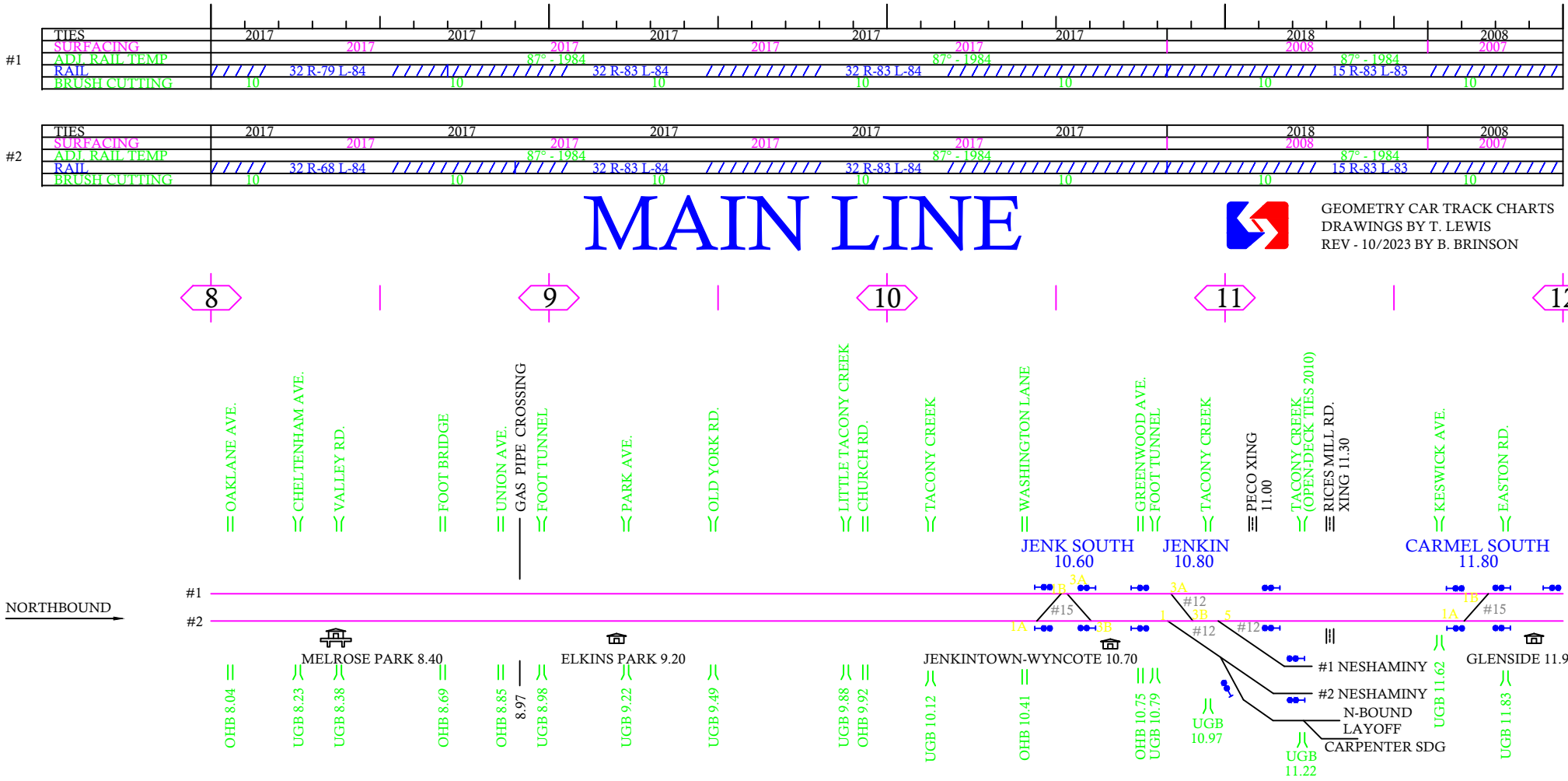


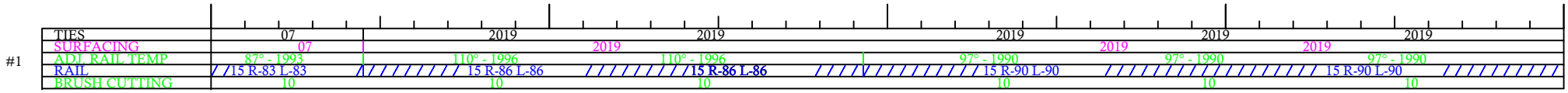
CIVIL RESTRICTION

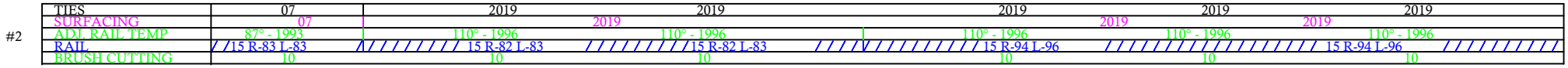
TRACK MAS: P 60 F 25 | P 60 F 25 (#1 & #2), P 20 F 10 (SIDING) | P 60 F 25



GRADIENT
DIRECTION NORTHBOUND

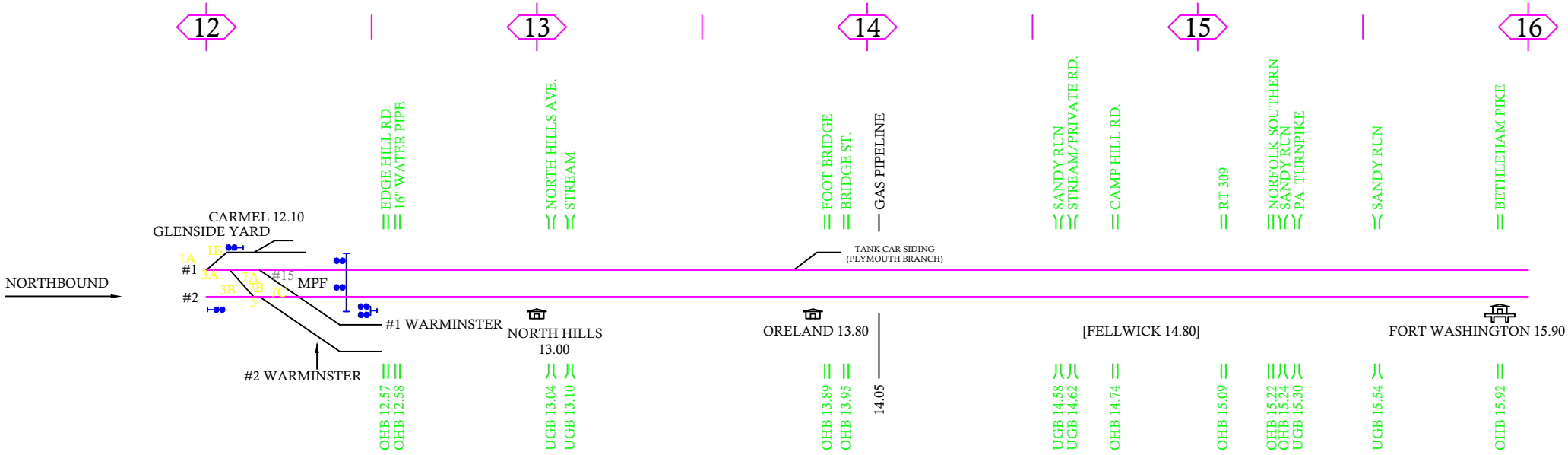

#1
TIES 2017 2017 2017 2017 2017 2017 2018 2008
SURFACING 2017 2017 2017 2017 2017 2008 2007
ADJ RAIL TEMP 87° - 1984 87° - 1984 87° - 1984
RAIL 32 R-79 L-84 32 R-83 L-84 32 R-83 L-84 15 R-83 L-83
BRUSH CUTTING 10 10 10 10 10 10 10
#2
TIES 2017 2017 2017 2017 2017 2017 2018 2008
SURFACING 2017 2017 2017 2017 2017 2008 2007
ADJ RAIL TEMP 87° - 1984 87° - 1984 87° - 1984
RAIL 32 R-68 L-84 32 R-83 L-84 32 R-83 L-84 15 R-83 L-83
BRUSH CUTTING 10 10 10 10 10 10 10
MAIN LINE
GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 10/2023 BY B. BRINSON
8
9
10
11
12
OAKLANE AVE.
CHELTENHAM AVE.
VALLEY RD.
FOOT BRIDGE
UNION AVE.
GAS PIPE CROSSING
FOOT TUNNEL
PARK AVE.
OLD YORK RD.
LITTLE TACONY CREEK
CHURCH RD.
TACONY CREEK
WASHINGTON LANE
GREENWOOD AVE.
FOOT TUNNEL
TACONY CREEK
PECO XING 11.00
TACONY CREEK (OPEN-DECK TIES 2010)
RICES MILL RD. XING 11.30
KESWICK AVE.
EASTON RD.
JENK SOUTH 10.60
JENKIN 10.80
CARMEL SOUTH 11.80
NORTHBOUND
#1
#2
MELROSE PARK 8.40
ELKINS PARK 9.20
JENKINTOWN-WYNCOTE 10.70
#1 NESHAMINY
#2 NESHAMINY
N-BOUND LAYOFF
CARPENTER SDG
GLENSIDE 11.90
OHB 8.04
UGB 8.23
UGB 8.38
OHB 8.69
OHB 8.85
8.97
UGB 8.98
UGB 9.22
UGB 9.49
UGB 9.88
OHB 9.92
UGB 10.12
OHB 10.41
OHB 10.75
UGB 10.79
UGB 10.97
UGB 11.22
UGB 11.62
UGB 11.83
CIVIL RESTRICTION
TRACK MAS
P 60 F 25
P 45 F 10 (#1)
P 30 F 10 (#2)
P 60 F 30
TRK #1
TRK #2
#145 60MPH
#146 60MPH
#147 60MPH
#148 60MPH
#193 60MPH
#194 60MPH
#195 60MPH
#196 60MPH
#197 60MPH
#198 60MPH
2°00' 3.50" 2865'
1°00' 1.00" 5730'
2°00' 2.50" 2865'
0°45' 0.50" 7639'
0°45' 0.25" 7639'
1°00' 1.00" 5730'
GRADIENT DIRECTION NORTHBOUND
-0.13
-0.32
0.00
-0.10
0.36
0.85
1.00

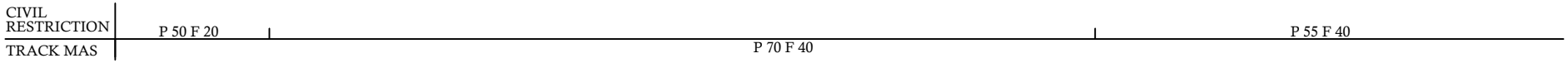


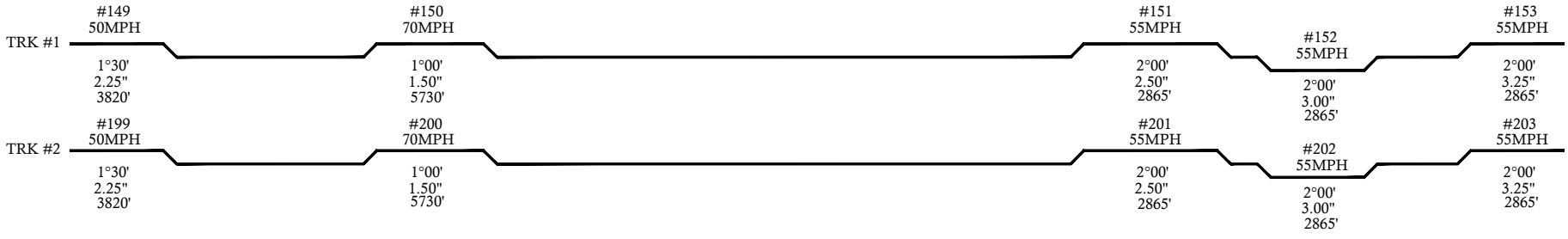


MAIN LINE

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 10/2023 BY B. BRINSON

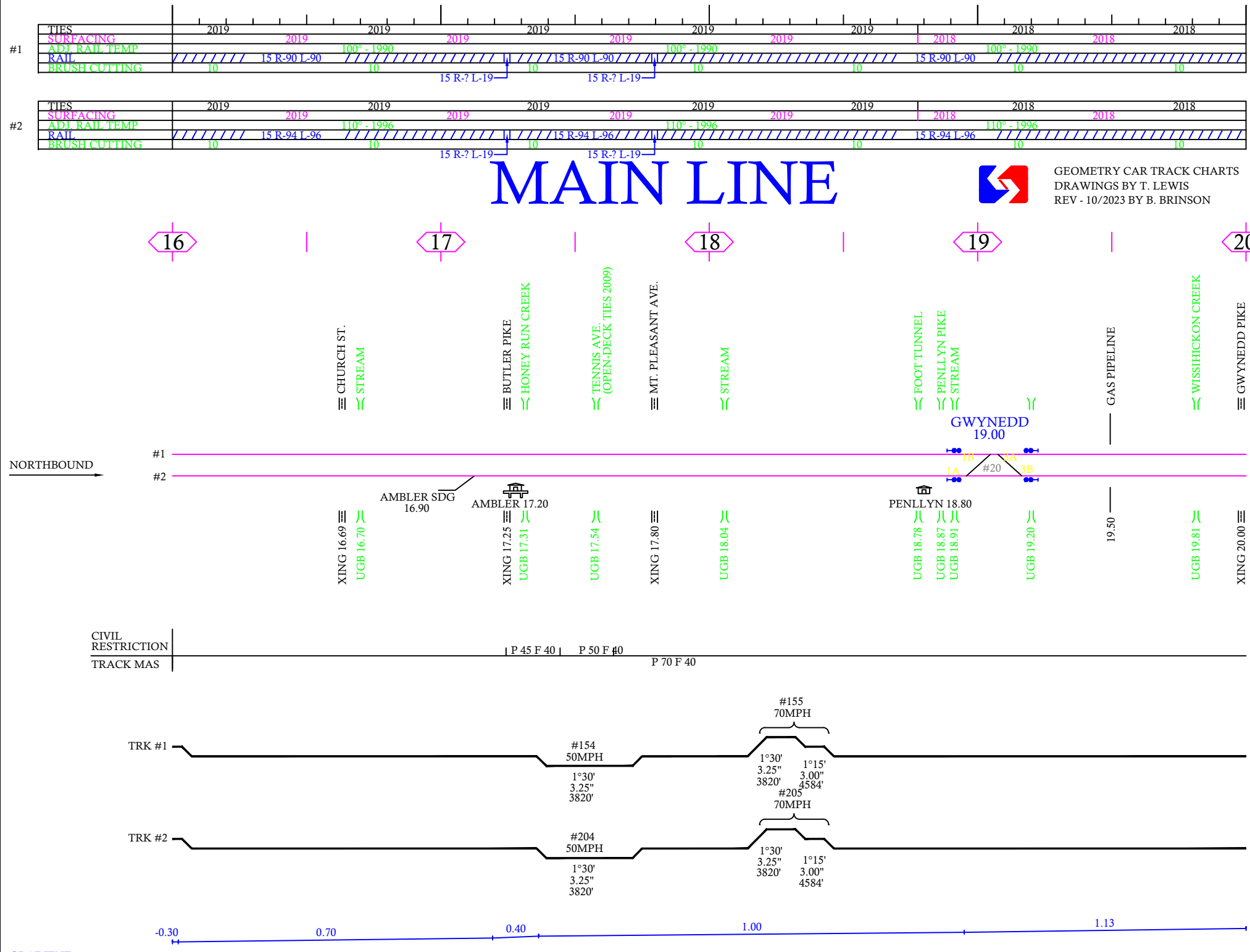


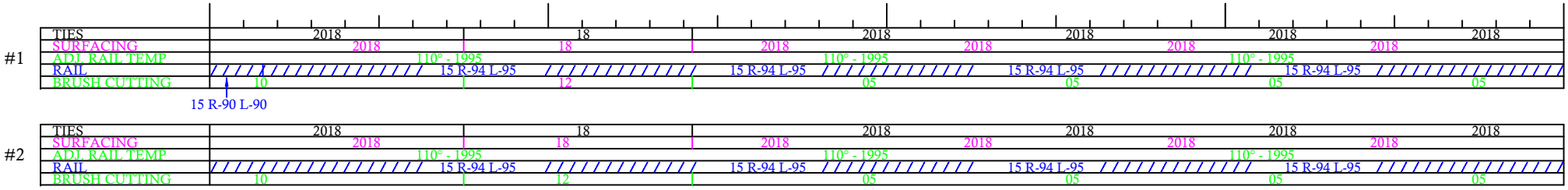






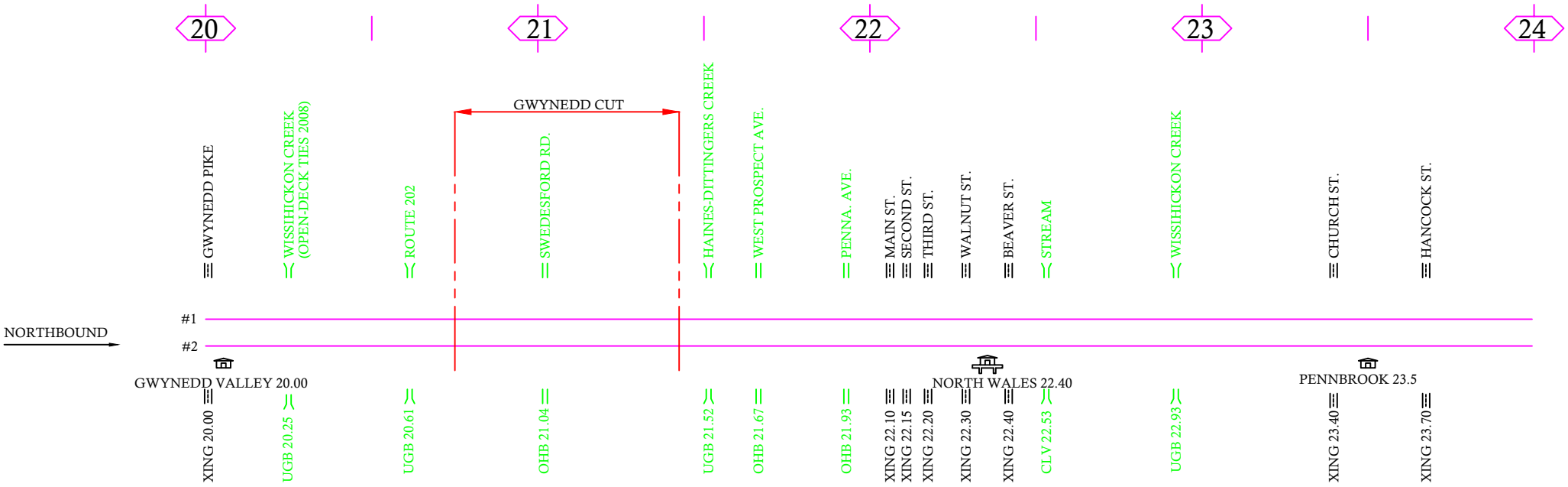
GRADIENT
DIRECTION NORTHBOUND

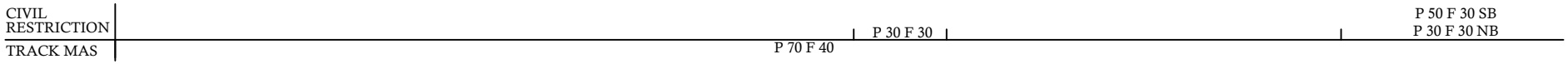

#1
TIES 2019 2019 2019 2019 2019 2018 2018
SURFACING 2019 2019 2019 2019 2018 2018
ADJ. RAIL TEMP 100° - 1990 100° - 1990 100° - 1990
RAIL 15 R-90 L-90 15 R-90 L-90 15 R-90 L-90
BRUSH CUTTING 10 10 10 10 10 10 10
15 R-? L-19
15 R-? L-19
#2
TIES 2019 2019 2019 2019 2019 2018 2018
SURFACING 2019 2019 2019 2019 2018 2018
ADJ. RAIL TEMP 110° - 1996 110° - 1996 110° - 1996
RAIL 15 R-94 L-96 15 R-94 L-96 15 R-94 L-96
BRUSH CUTTING 10 10 10 10 10 10 10
15 R-? L-19
15 R-? L-19
MAIN LINE
GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 10/2023 BY B. BRINSON
16
17
18
19
20
CHURCH ST.
STREAM
BUTLER PIKE
HONEY RUN CREEK
TENNIS AVE. (OPEN-DECK TIES 2009)
MT. PLEASANT AVE.
STREAM
FOOT TUNNEL
PENLLYN PIKE
STREAM
GAS PIPELINE
WISSIHICKON CREEK
GWYNEDD PIKE
GWYNEDD
19.00
NORTHBOUND
#1
#2
1B
3A
1A
#20
3B
AMBLER SDG
16.90
AMBLER 17.20
PENLLYN 18.80
XING 16.69
UGB 16.70
XING 17.25
UGB 17.31
UGB 17.54
XING 17.80
UGB 18.04
UGB 18.78
UGB 18.87
UGB 18.91
UGB 19.20
19.50
UGB 19.81
XING 20.00
CIVIL RESTRICTION
TRACK MAS
P 45 F 40
P 50 F 40
P 70 F 40
TRK #1
#154
50MPH
1°30'
3.25"
3820'
#155
70MPH
1°30'
3.25"
3820'
1°15'
3.00"
4584'
TRK #2
#204
50MPH
1°30'
3.25"
3820'
#205
70MPH
1°30'
3.25"
3820'
1°15'
3.00"
4584'
-0.30
0.70
0.40
1.00
1.13
GRADIENT
DIRECTION NORTHBOUND

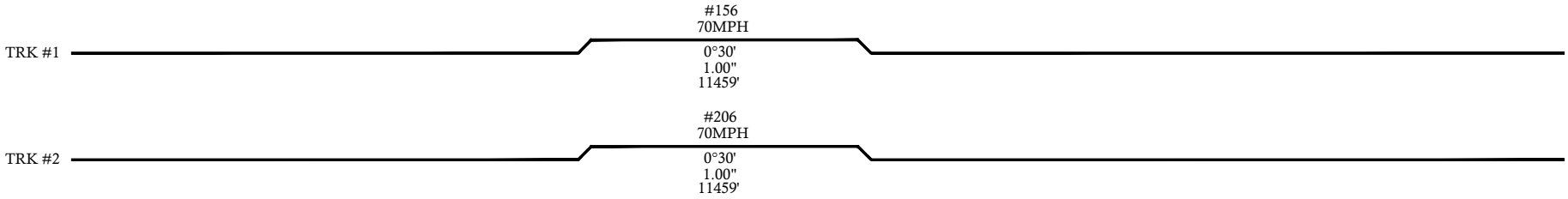


MAIN LINE

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 10/2023 BY B. BRINSON









#1

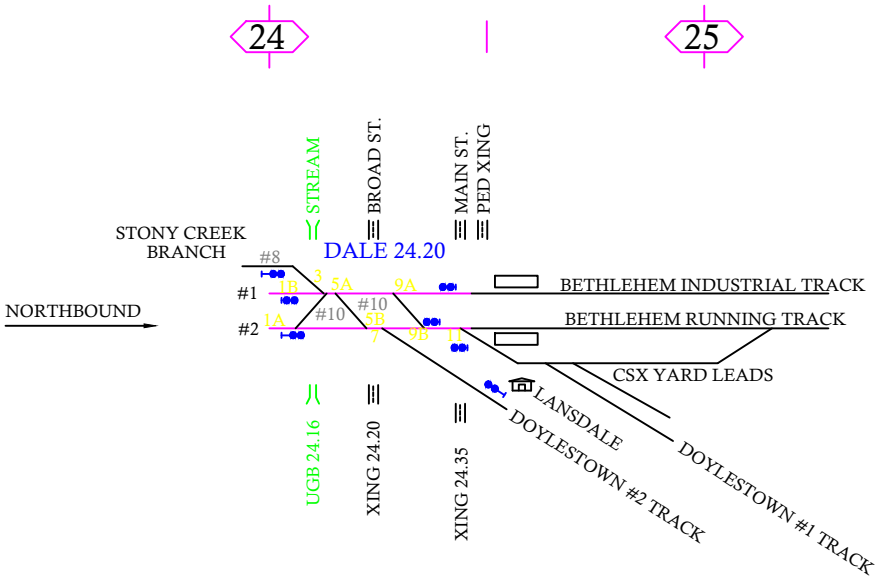
TIES	2018	07
SURFACING	2018	07
ADJ RAIL TEMP		110°-07
RAIL	15 R-07 L-07	30 R-30 L-30
BRUSH CUTTING	05	05

#2

TIES	2018	07
SURFACING	2018	07
ADJ RAIL TEMP		110°-07
RAIL	15 R-07 L-07	15 R-07 L-07
BRUSH CUTTING	05	05

MAIN LINE

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 6/2021 BY C. RITZER



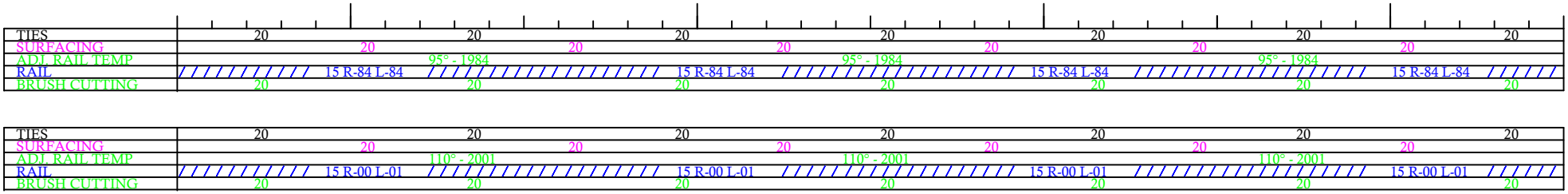
CIVIL RESTRICTION	P 15 F 15
TRACK MAS	

TRK #1

TRK #2

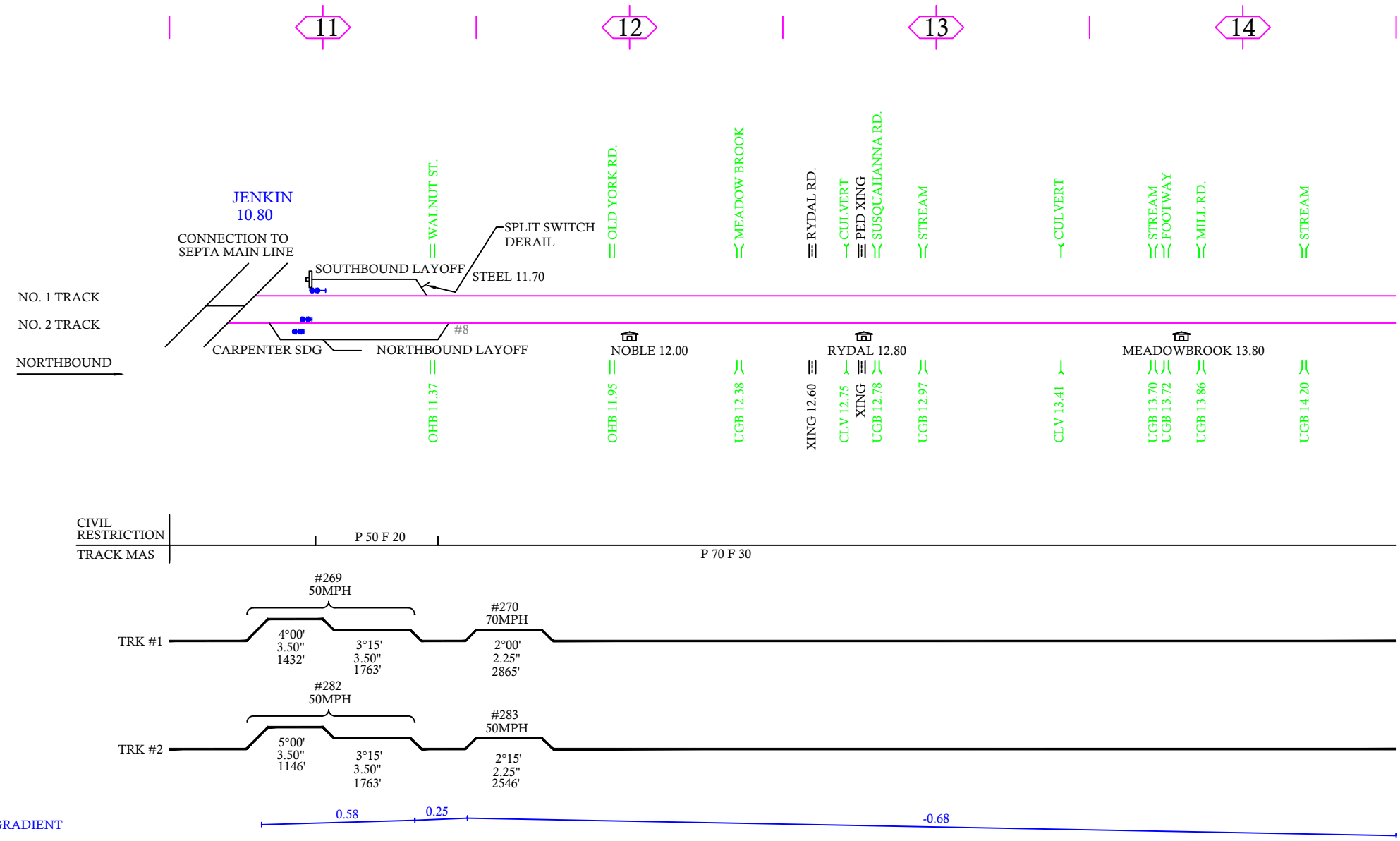
-0.76 -0.50 -1.00

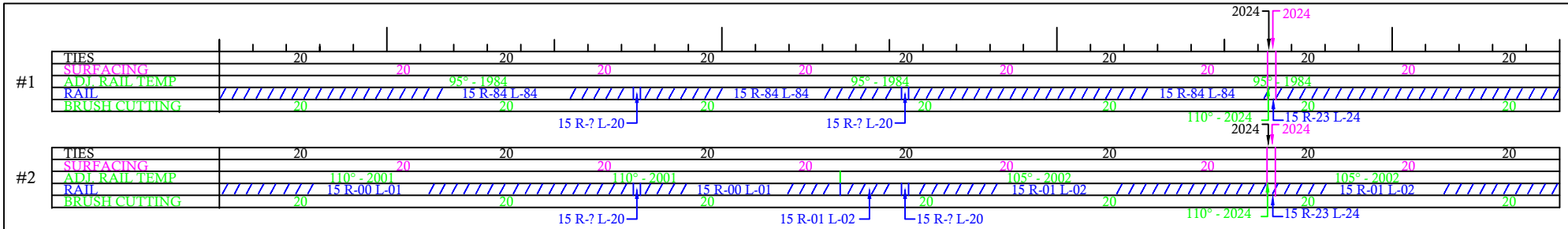
GRADIENT
DIRECTION NORTHBOUND



NESHAMINY LINE

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 10/2023 BY B. BRINSON





NESHAMINY LINE

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 11/2024 BY B. BRINSON

15 16 17 18

MEADOW BROOK
PENNYPACK TRAIL
STREAM
PENNYPACK CREEK
HUNTINGDON PIKE
PED XING
CULVERT
RED LION RD.
PED XING
STREAM
STREAM
PINE RD.
FOOTWAY
TOMLINSON RD.
STREAM
STREAM
STREAM
BYBERRY RD.
PED XING
BUSTLETON AVE.
PED XING

NO. 1 TRACK
NO. 2 TRACK
NORTHBOUND

BETHAYRES 15.10
PHILMONT 16.40
#8
PHILMONT YARD
FOREST HILLS 17.70
SOMERTON 18.20

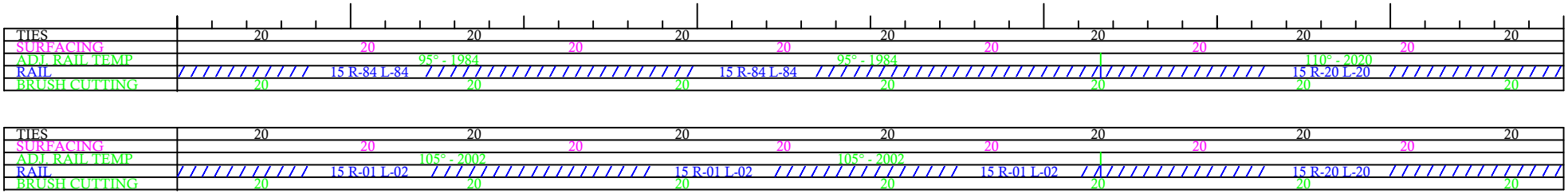
UGB 14.59
XING 14.80
CLV 14.85
UGB 14.96
OHB 15.01
XING
CLV 15.15
XING 15.75
XING 15.76
UGB 15.95
UGB 16.25
XING 16.35
UGB 16.44
XING 16.55
UGB 16.67
UGB 16.85
UGB 17.57
XING 17.65
XING
OHB 18.17
XING

CIVIL RESTRICTION
TRACK MAS
P 70 F 30

TRK #1
#271
70MPH
1°00'
2.25"
5730'

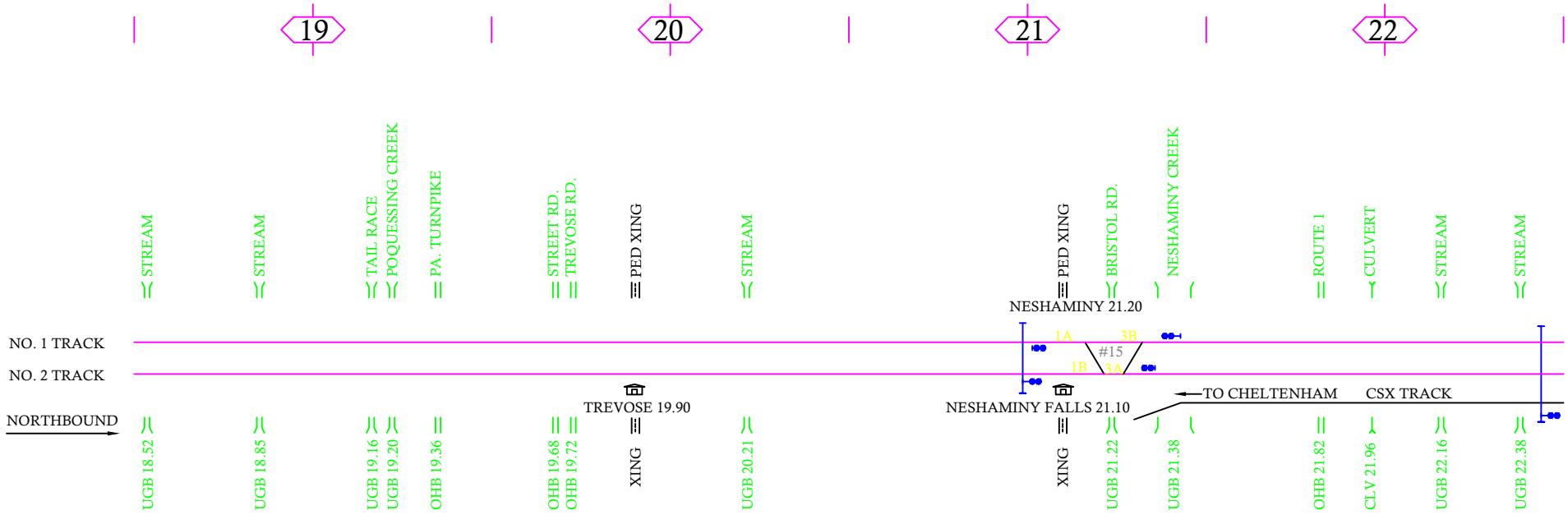
TRK #2
#284
70MPH
1°00'
2.25"
5730'

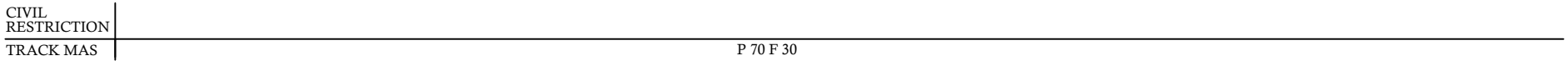
GRADIENT
DIRECTION NORTHBOUND
0.06
0.65
-0.43

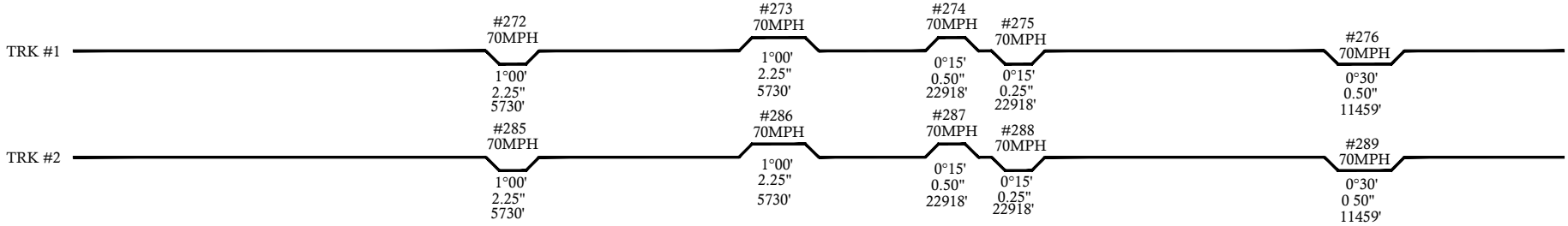


NESHAMINY LINE

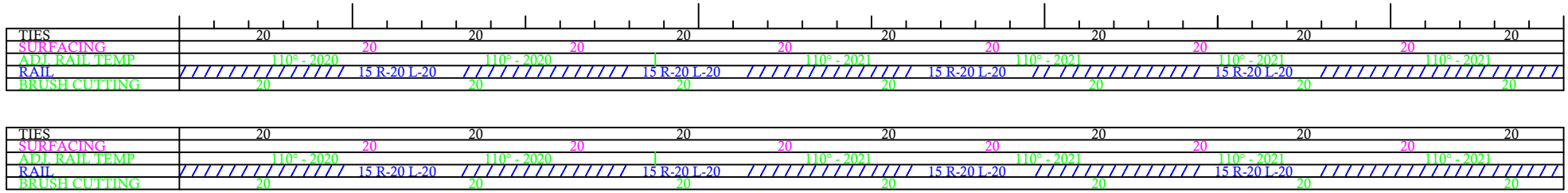
GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 10/2023 BY B. BRINSON





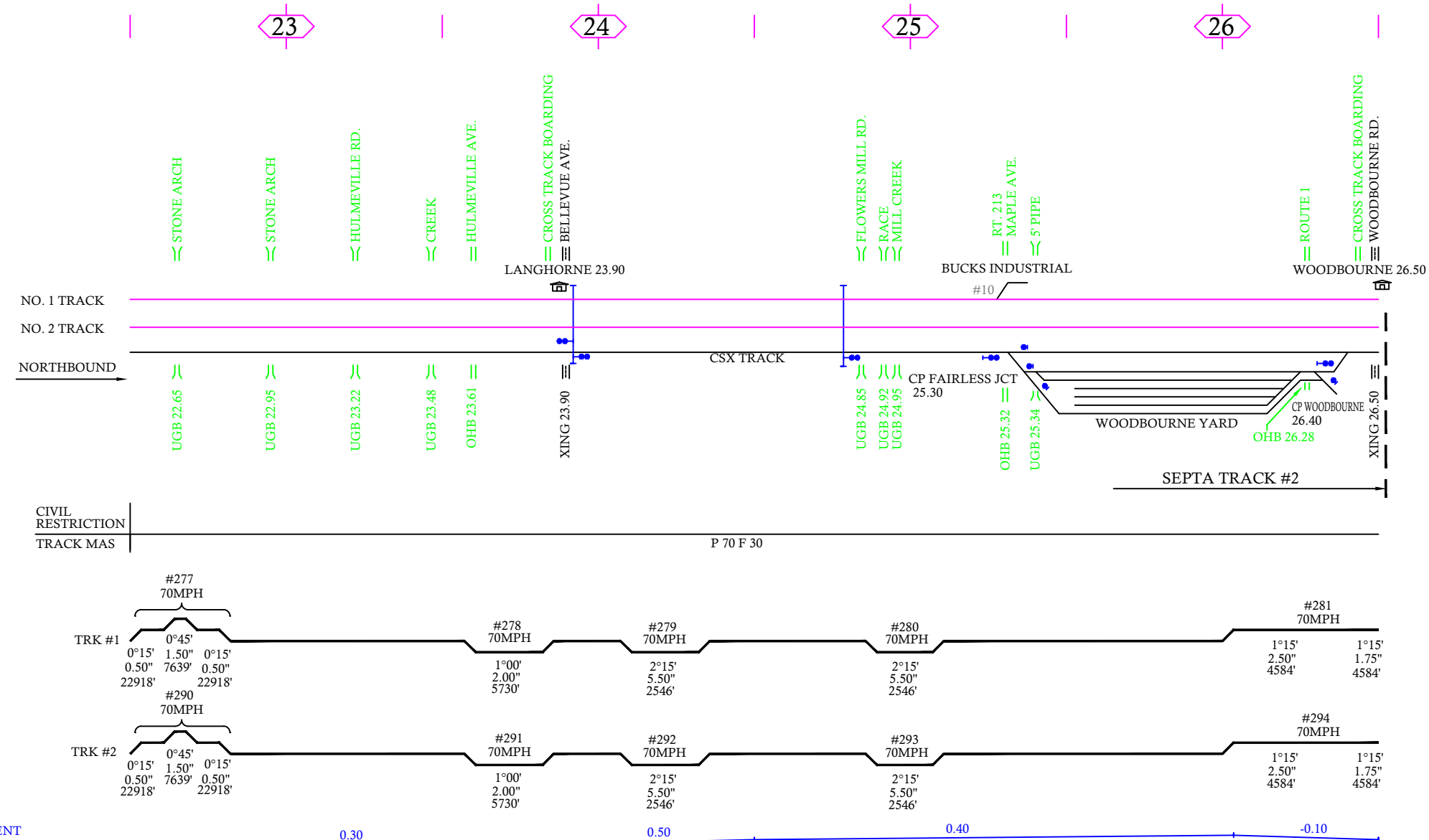






NESHAMINY LINE

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 10/202 BY B. BRINSON



#1

TIES	2020		2015		CONCRETE		2015		2015		2015		2015
SURFACING	2020		2015		2015		2015		2015		2015		
ADJ. RAIL TEMP	110° - 2021				110° - 2021				110° - 2021			110° - 2021	
RAIL	15 R-20 L-20				15 R-15 L-15				15 R-15 L-15			15 R-15 L-15	
BRUSH CUTTING	20		20		20		20		20		20		20

#2

TIES	2020				2020				2020				2020
SURFACING	2020				2020			2020			2020		
ADJ. RAIL TEMP	110° - 2022				110° - 2022				110° - 2022			110° - 2022	
RAIL	15 R-22 L-22				15 R-22 L-22				15 R-22 L-22			15 R-22 L-22	
BRUSH CUTTING	20												

NESHAMINY LINE

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 10/2023 BY B. BRINSON

27 28 29 30

NS TRENTON BRANCH
STREAM
WOOD 26.90
TOWNSHIP LINE RD.
I 95 SOUTH
I 95 NORTH
HEACOCK RD.
BROCK CREEK
STREAM
STONEY HILL RD.
BROCK CREEK
EDGEWOOD RD.
READING AVE. (OPEN-DECK TIES 2015 - TRK NO. 1)

NO. 1 TRACK
NO. 2 TRACK
CSX NORTHBOUND

47B 49A
47A #20 49B

OHB 26.53
UGB 26.69
XING 27.50
OHB 27.57
OHB 27.59
XING 28.20
UGB 28.31
UGB 28.56
XING 28.70
UGB 29.38
XING 29.70
UGB 30.47

CIVIL RESTRICTION
TRACK MAS

P 70 F 30

TRK #1

#415 70MPH
0°45' 0.75" 7639'
#416 70MPH
0°45' 0.75" 7639'
#417 70MPH
1°00' 0.75" 5730'

TRK #2

#421 70MPH
0°45' 0.75" 7639'
#422 70MPH
0°45' 0.75" 7639'
#423 70MPH
1°00' 1.00" 5730'

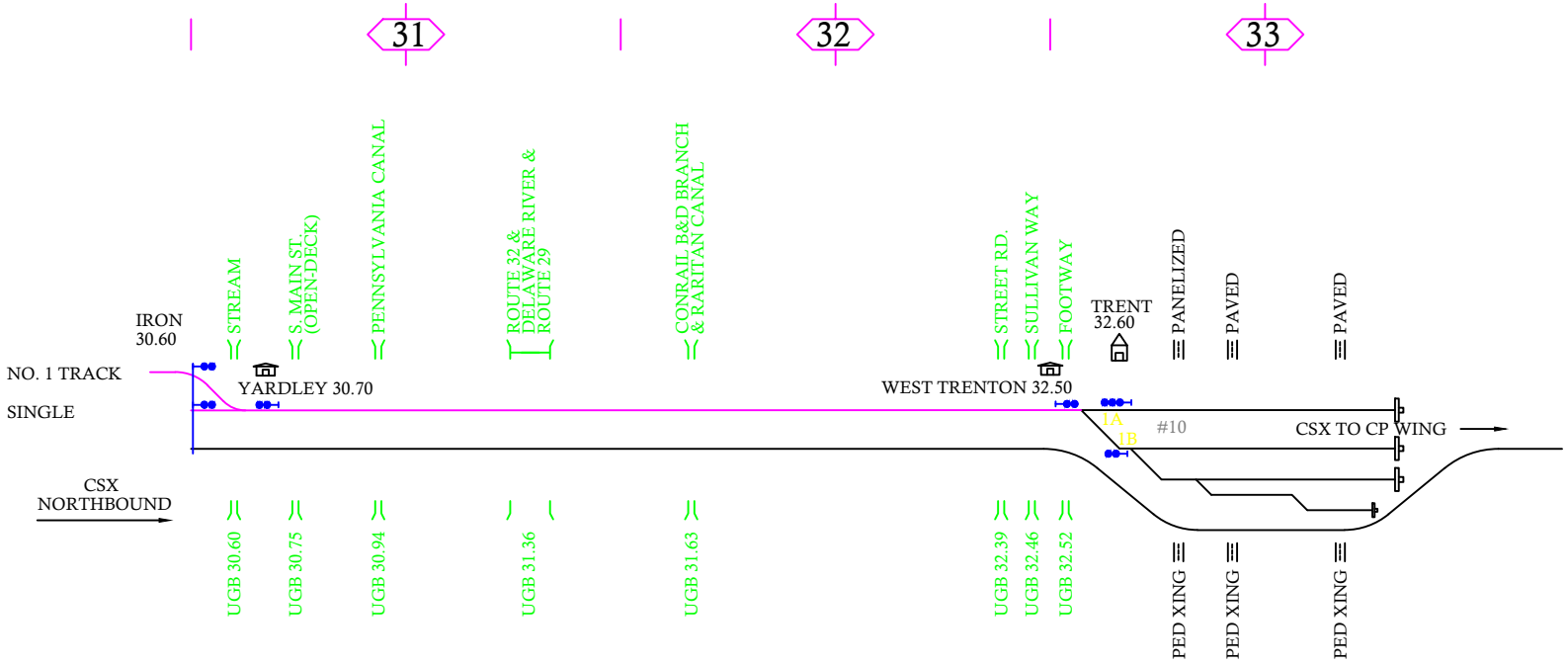
GRADIENT
DIRECTION NORTHBOUND

-0.10 V.C. 0.15 -0.53 -0.20 0.00 -0.73 -0.35 -0.53

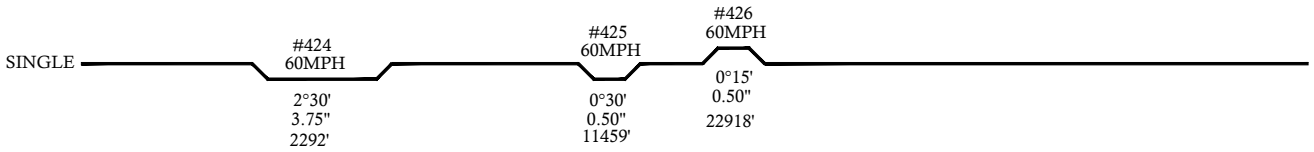
#1	TIES	'15 CONC.		
	SURFACING	'15		
	ADJ. RAIL TEMP	110°		
	RAIL	15 R-'15		
	BRUSH CUTTING	'20		
			SINGLE	YARD
#2	TIES	'20	'20	'20
	SURFACING	'20	'20	'20
	ADJ. RAIL TEMP	110° '23	110° '23	110° '23
	RAIL	15 R-'23 L-'23	15 R-'23 L-'23	15 R-'23 L-'23
	BRUSH CUTTING	'20		

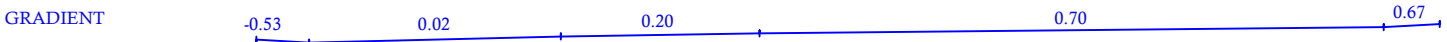
NESHAMINY LINE

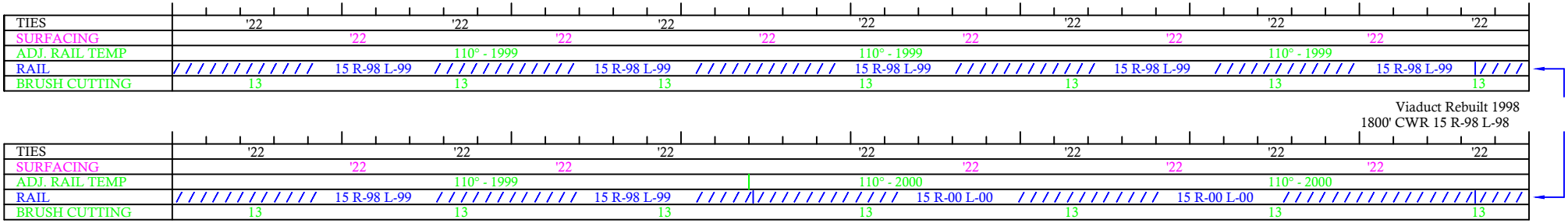
GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 10/2023 BY B. BRINSON



CIVIL RESTRICTION	
TRACK MAS	P 60 F 30

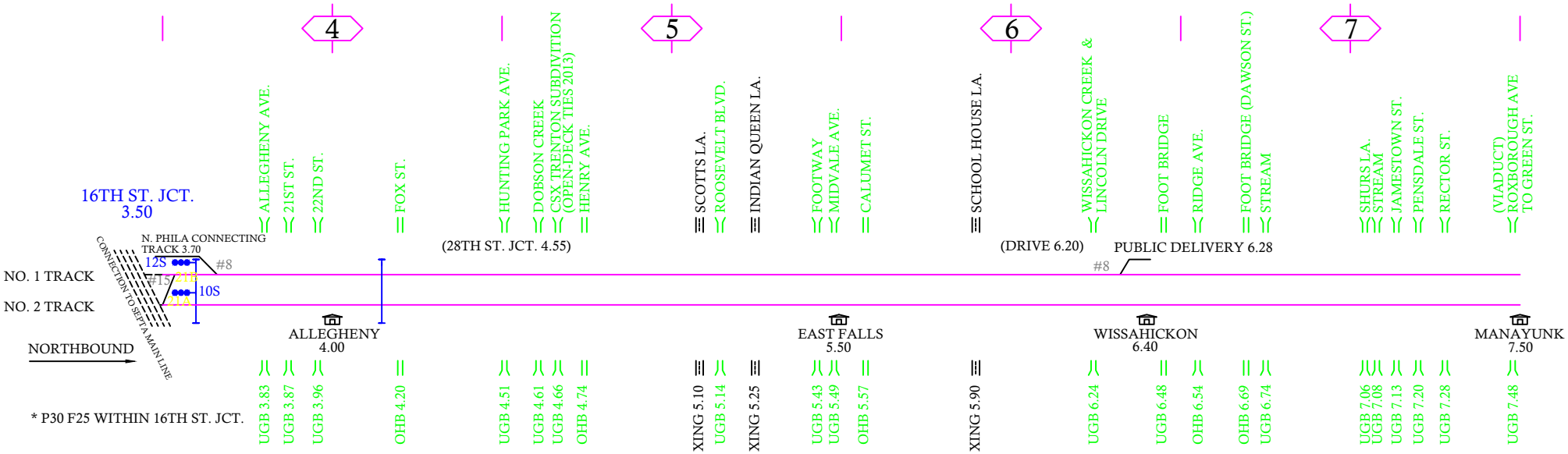




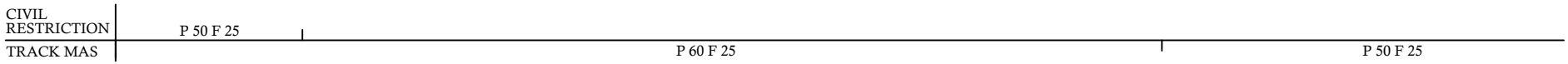


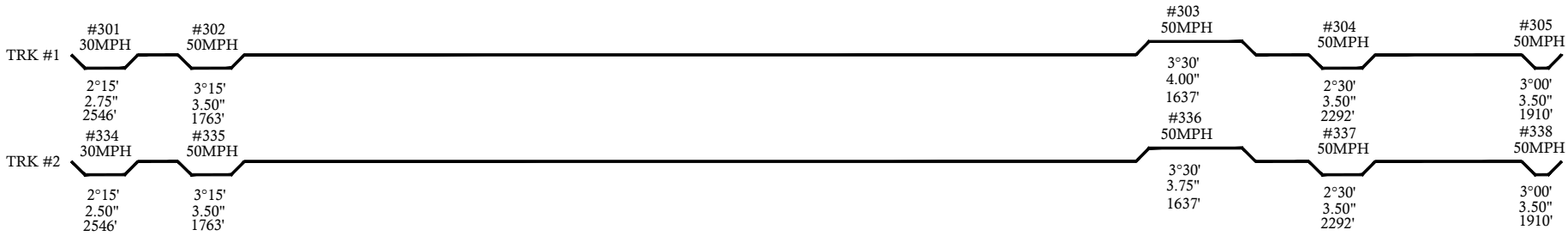
NORRISTOWN LINE

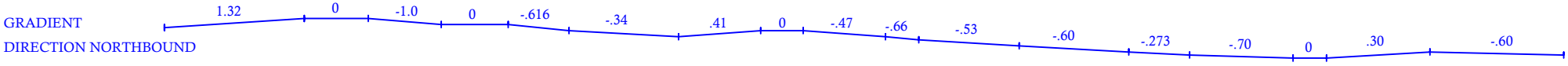
GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 8/2023 BY B. WASZENA



* P30 F25 WITHIN 16TH ST. JCT.







#1

| | | |

#1 TIES	22	22	22	22	22	22	22	22	22	22
SURFACING		22	22	22	22	22	22	22	22	
ADJ. RAIL TEMP	100° - 1993			105° - 1992				100° - 1991		
RAIL	15 R-92 L-93		15 R-91 L-92		15 R-91 L-92		15 R-90 L-91		15 R-90 L-91	
BRUSH CUTTING	14	14	14	14	14	14	14	14	14	14

Viaduct Rebuilt 1998
1800' CWR 15 R-98 L-98

#2 TIES	22	22	22	22	22	22	22	22	22	22
SURFACING		22	22	22	22	22	22	22	22	
ADJ. RAIL TEMP	100° - 1993			105° - 1992				100° - 1991		
RAIL	15 R-92 L-93		15 R-91 L-92		15 R-91 L-92		15 R-90 L-91		15 R-90 L-91	15 R-89 L-90
BRUSH CUTTING	14	14	14	14	14	14	14	14	14	14

CWR

NORRISTOWN LINE

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 10/2023 BY B. BRINSON

12 13 14 15

CREEK
SPRING MILL CREEK
SPRING MILL RD.
PED XING
END ST.
CAST IRON PIPE
CORRUGATED PIPES
CHERRY ST.
STREAM
POPLAR ST.
ASH ST.
HARRY ST
FAYETTE ST.
PLYMOUTH CREEK
I-476 NORTH
I-476 SOUTH
STONE BOX
STONE BOX
CONCRETE PIPE
STONE BOX &
CORRUGATED PIPE
WATERWAY & DRIVE
UPPER MERION &
PLYMOUTH RR

NEVE
13.74
(CREEK 13.88)
(PLYMOUTH JCT. 14.20)
(IVY ROCK 15.30)
#8

NO. 1 TRACK
NO. 2 TRACK
NORTHBOUND

SPRING MILL
12.30
CONSHOHOCKEN
13.50

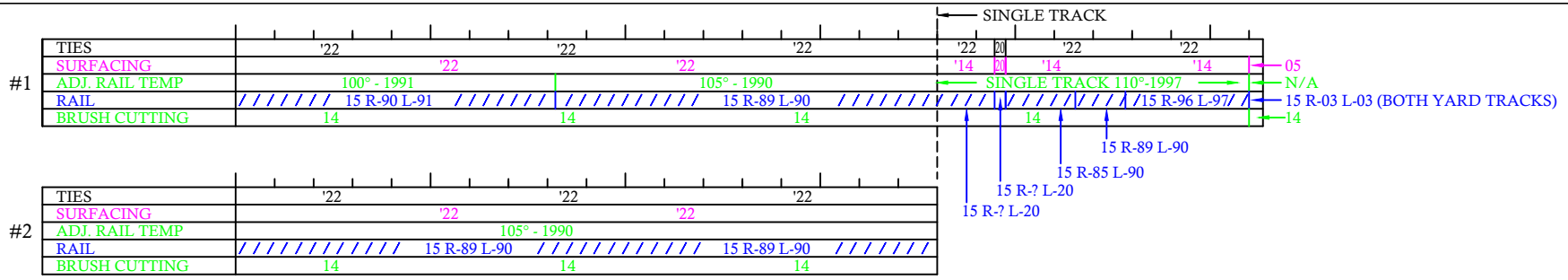
UGB 12.07
UGB 12.25
XING 12.25
XING
XING 12.35
CLV 12.70
CLV 12.90
XING 12.95
UGB 12.96
XING 13.15
XING 13.30
XING 13.40
OHB 13.48
UGB 13.73
OHB 14.16
OHB 14.18
CLV 14.22
CLV 14.34
CLV 14.65
CLV 14.81
UGB 14.95
OHB 15.03

CIVIL RESTRICTION: P 50 F 25 | P 40 F 25 | P 60 F 25 | P 50 F 25 SB / P 40 F 25 NB
TRACK MAS

TRK #1
#320 50MPH: 2°30' 3.50" 2292' | 2°00' 3.50" 2865' | 3°00' 3.50" 1910' | 1°15' 2.50" 4584' | 2°00' 2.50" 2865'
#321 40MPH: 4°00' 2.50" 1432' | 2°15' 2.50" 2546' | 1°00' 2.75" 5730' | 3°45' 2.75" 1528'
#322 60MPH: 1°45' 2.00" 3274' | 1°15' 2.00" 4584' | 0°45' 1.50" 7639' | 2°30' 3.50" 2292'
#323 60MPH: 1°30' 2.00" 3820'
#324 60MPH: 2°15' 2.75" 2546'
#325 50MPH: 3°45' 4.00" 1528'
#326 50MPH: 1°00' 0.50" 5730'

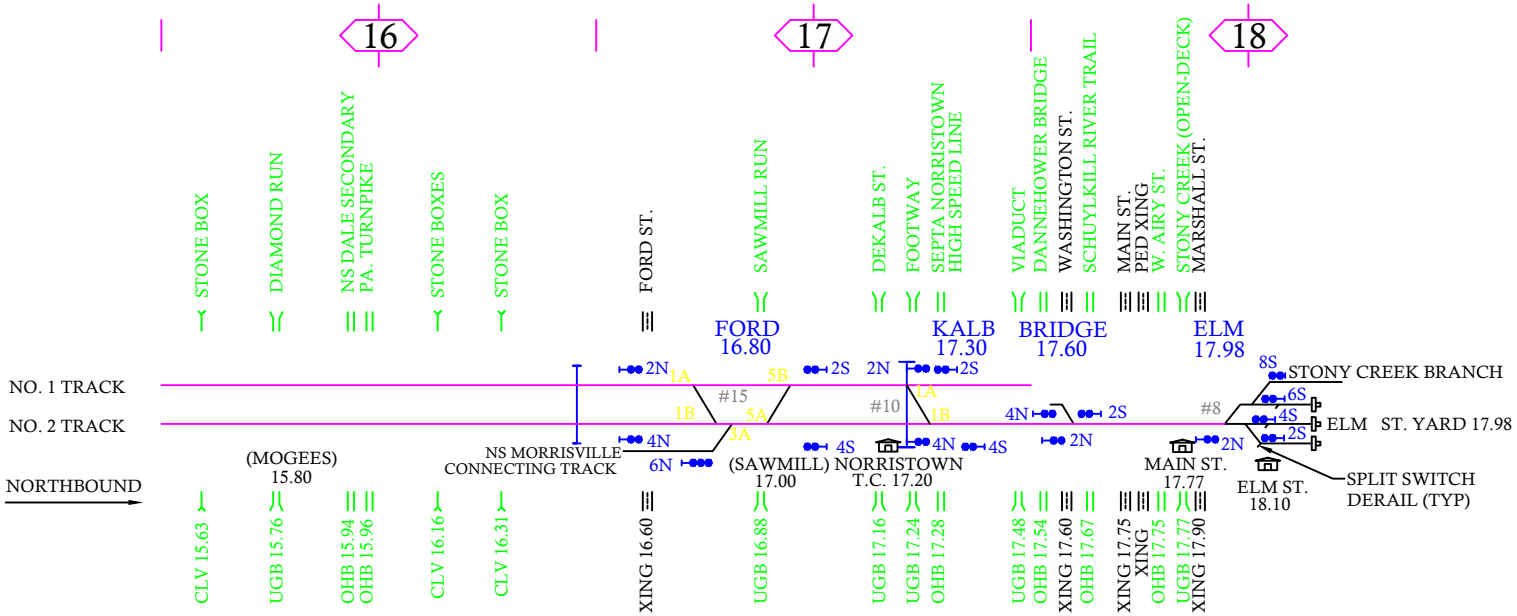
TRK #2
#353 50MPH: 2°30' 3.50" 2292' | 1°45' 3.50" 3274' | 3°00' 3.50" 1910' | 1°45' 2.25" 3274'
#354 40MPH: 3°00' 2.75" 1910' | 2°15' 2.75" 2546' | 1°15' 3.00" 4584' | 3°45' 3.00" 1528'
#355 60MPH: 1°45' 1.50" 3274' | 1°15' 1.50" 4584' | 1°15' 1.50" 4584' | 2°30' 3.75" 2292'
#356 60MPH: 1°30' 1.75" 3820'
#357 60MPH: 2°15' 2.75" 2546'
#358 40MPH: 4°00' 3.75" 1432'
#359 40MPH: 1°30' 1.00" 3820'

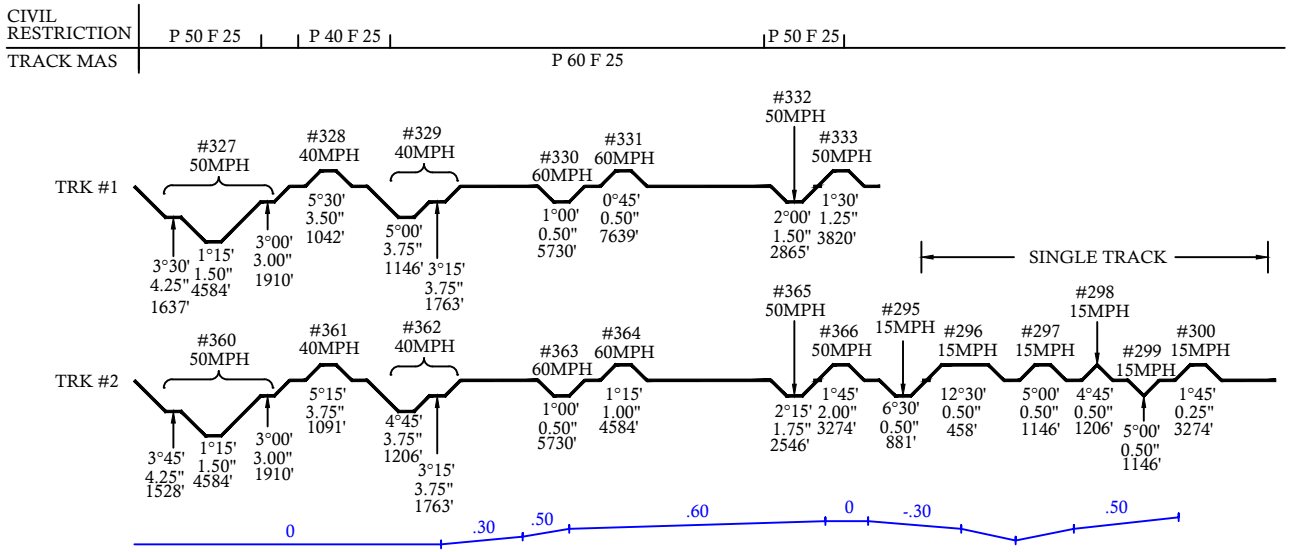
GRADIENT: 0 | .244 | -.14 | 0 | -.24 | 0
DIRECTION NORTHBOUND

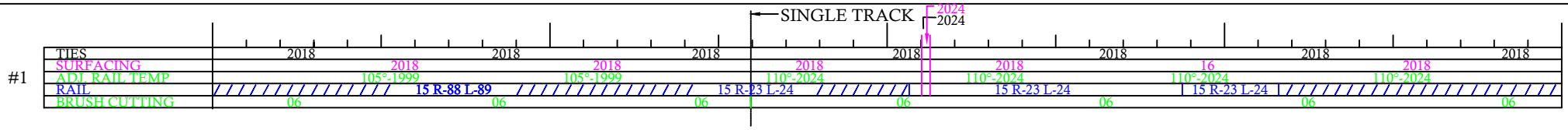


NORRISTOWN LINE

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 10/2023 BY B.BRINSON

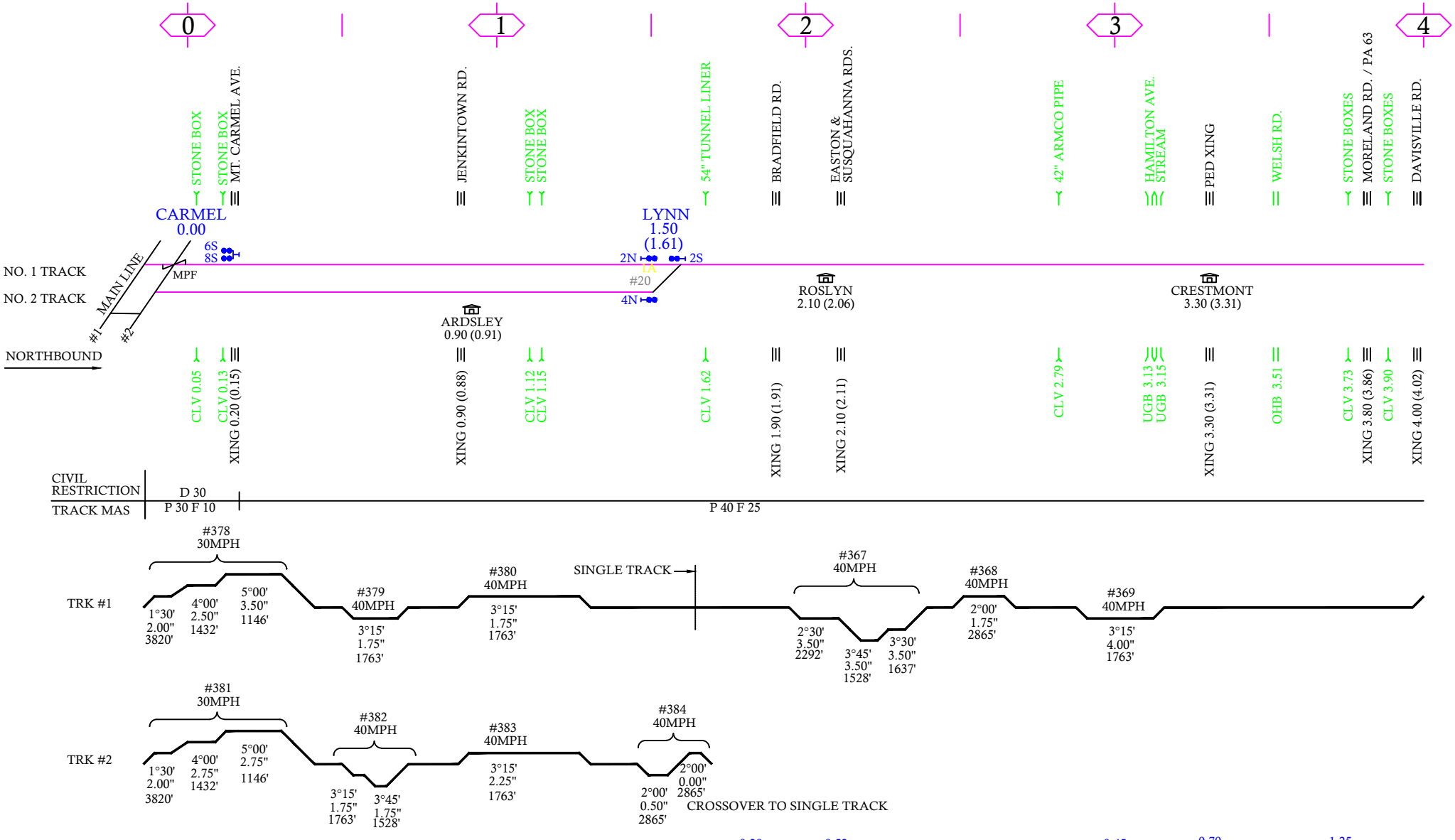






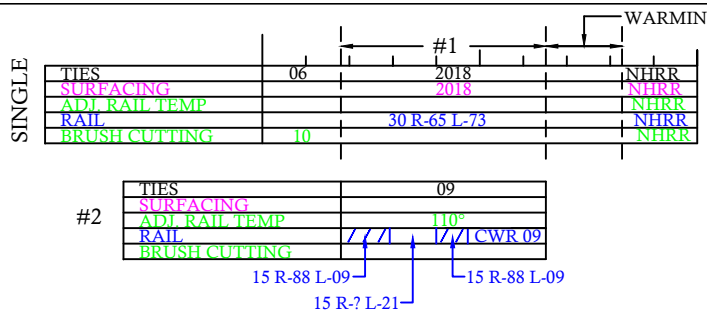
WARMINSTER LINE

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 11/2024 BY B. BRINSON



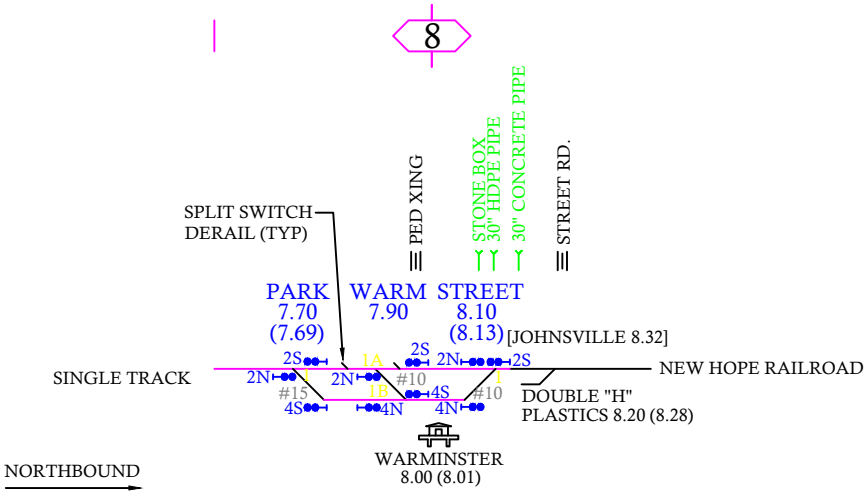
SINGLE

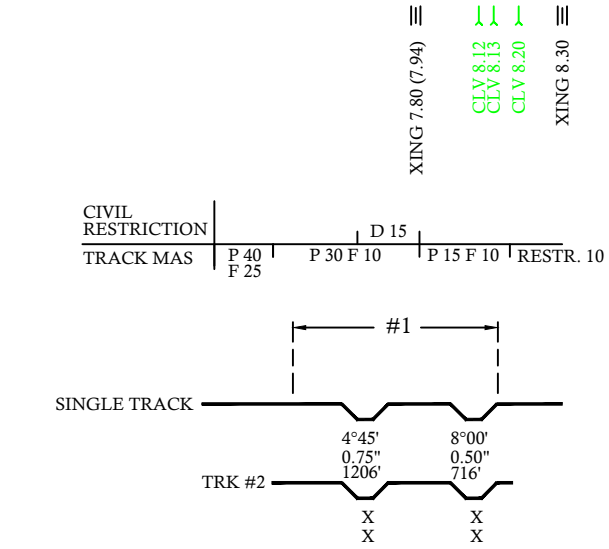
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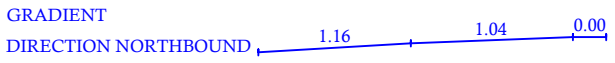


WARMINSTER LINE

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 10/2023 BY B. BRINSON

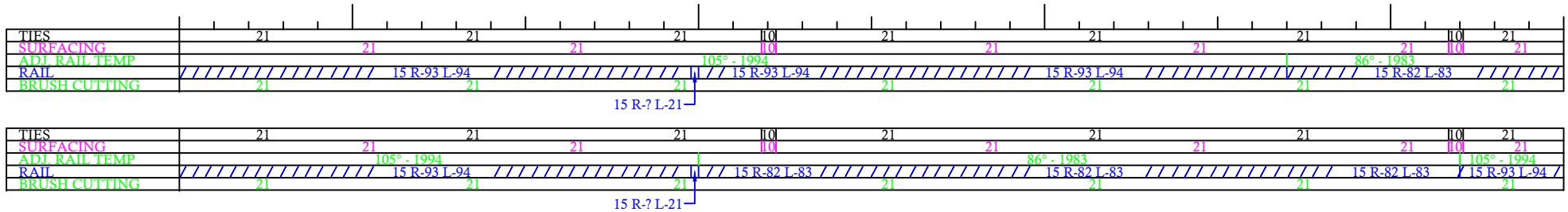






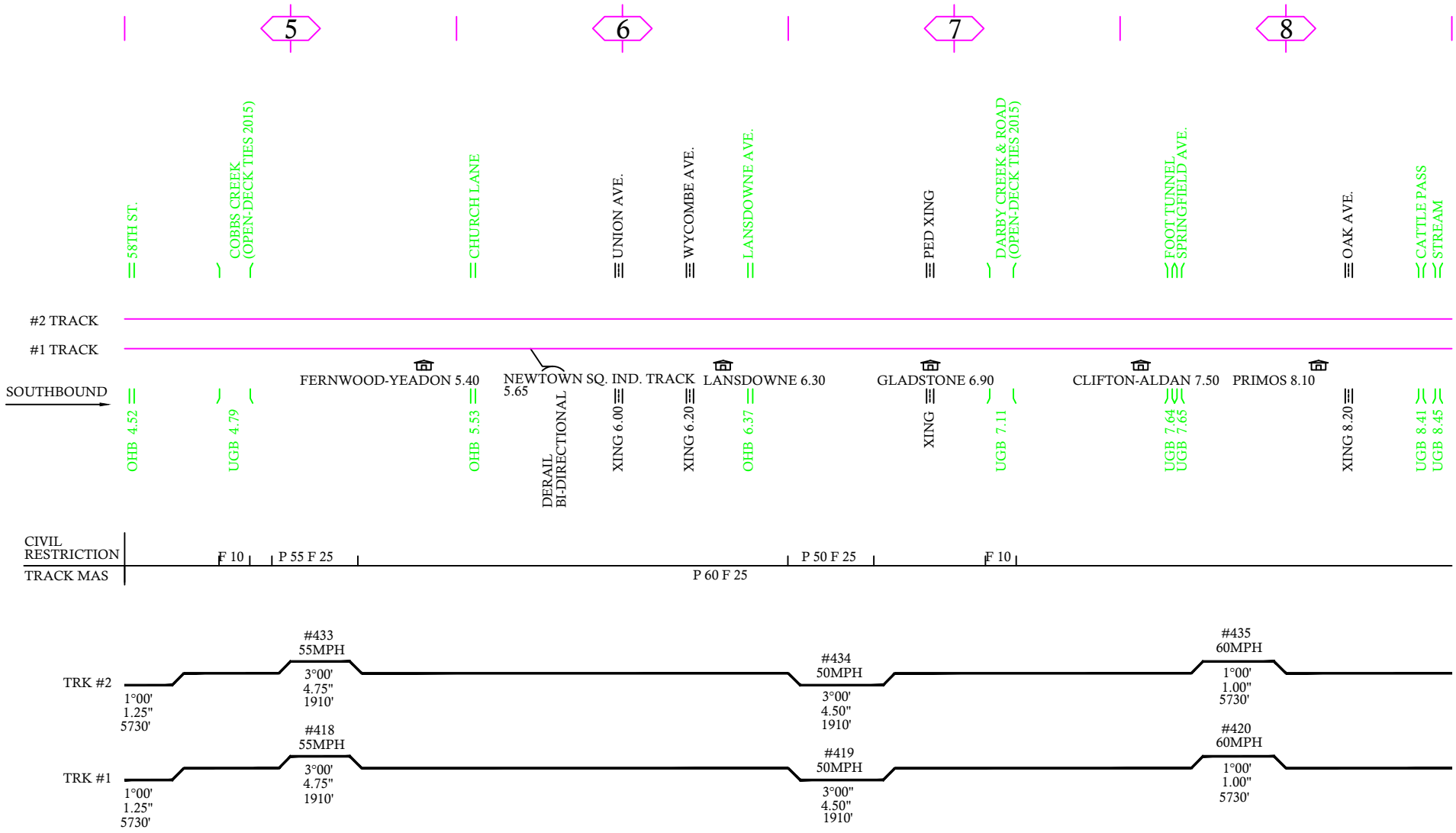
#2 TRACK

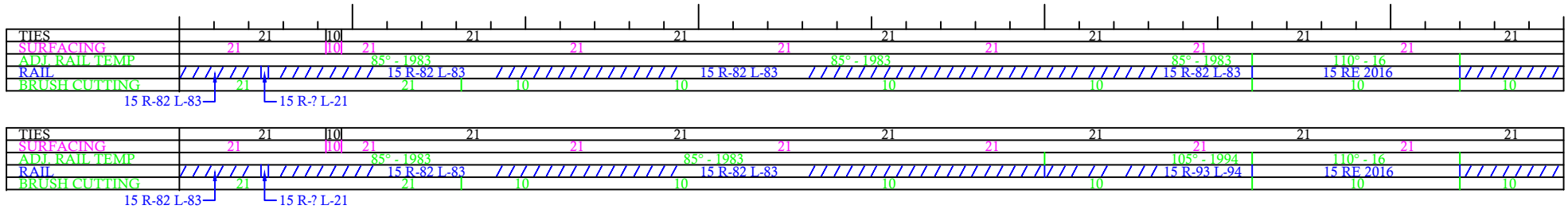
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WEST CHESTER LINE

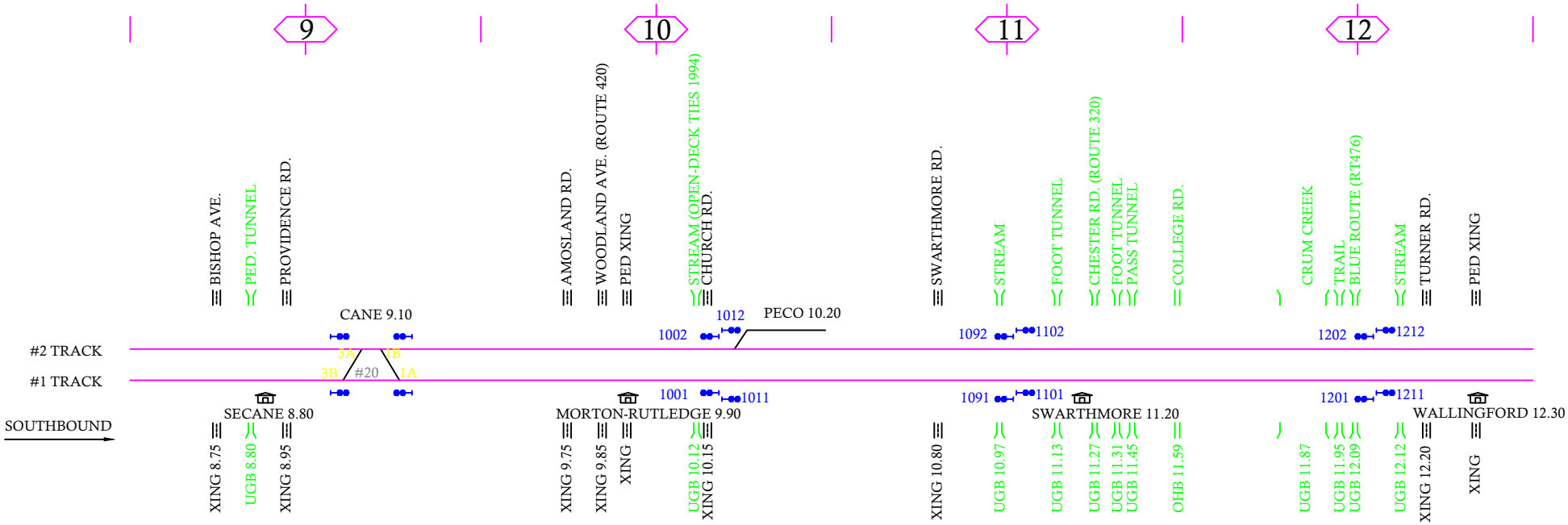
GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 10/2023 BY B. BRINSON





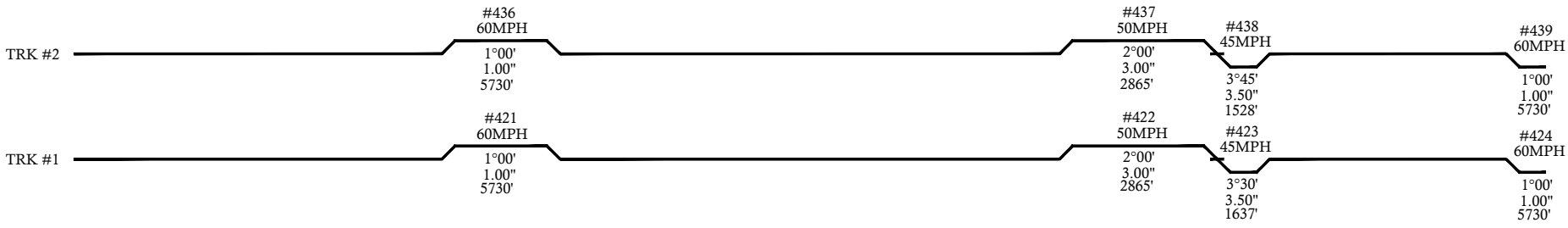
WEST CHESTER LINE

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 9/2021 BY C. RITZER



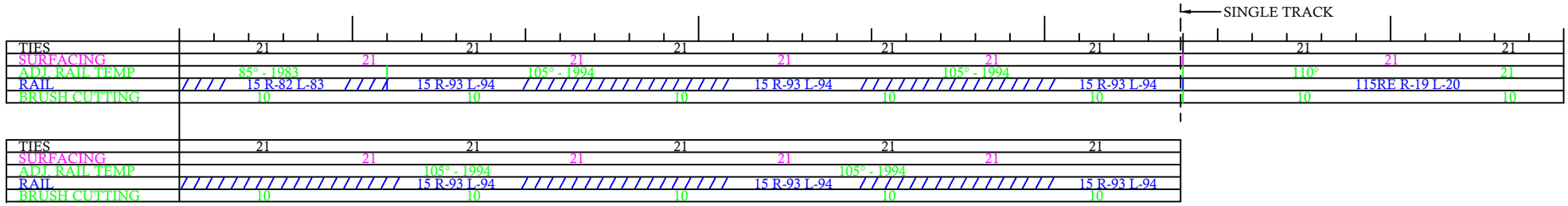
CIVIL RESTRICTION
TRACK MAS

P 60 F 25
P 50 F 25 NB
P 45 F 25
F 10



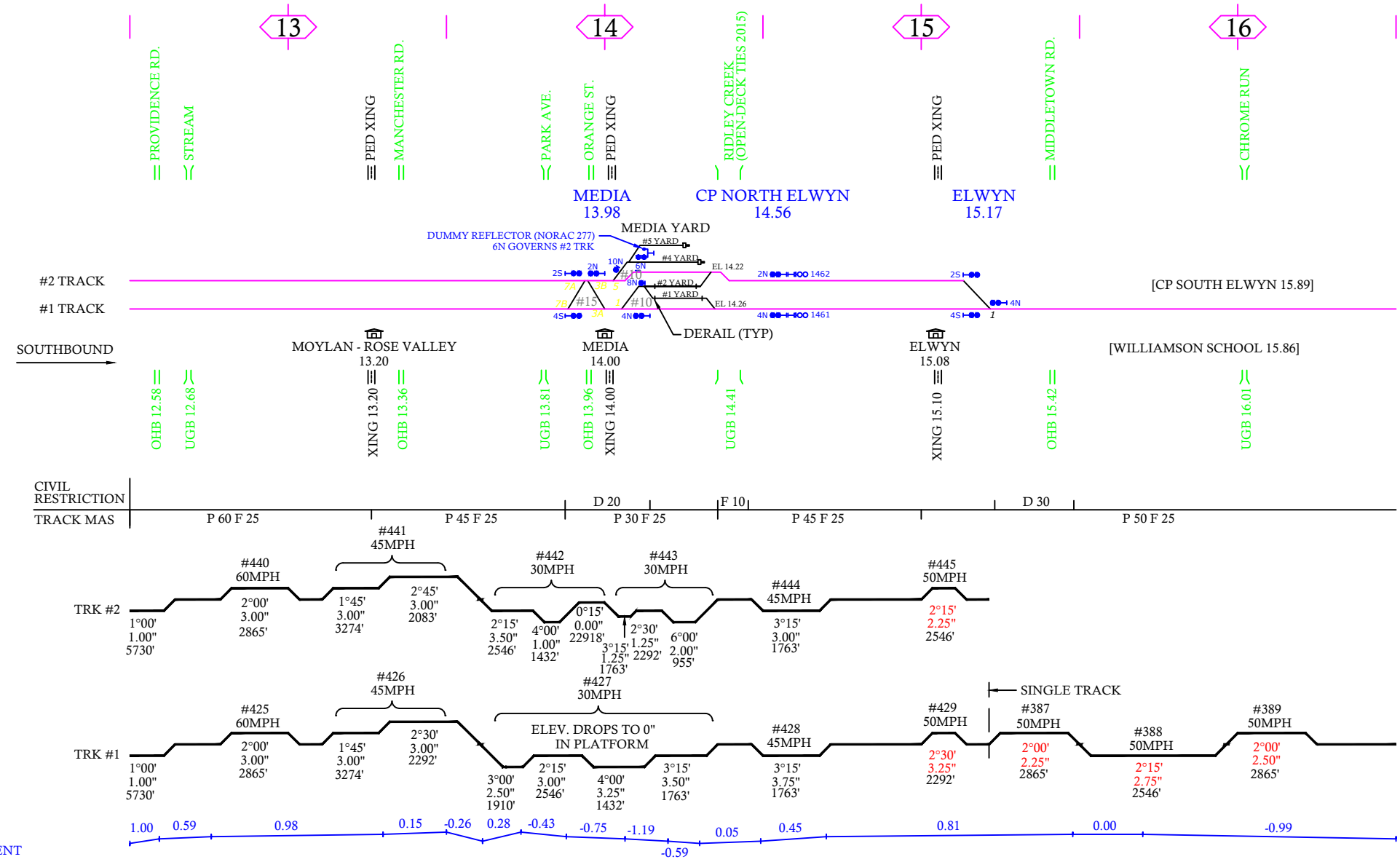


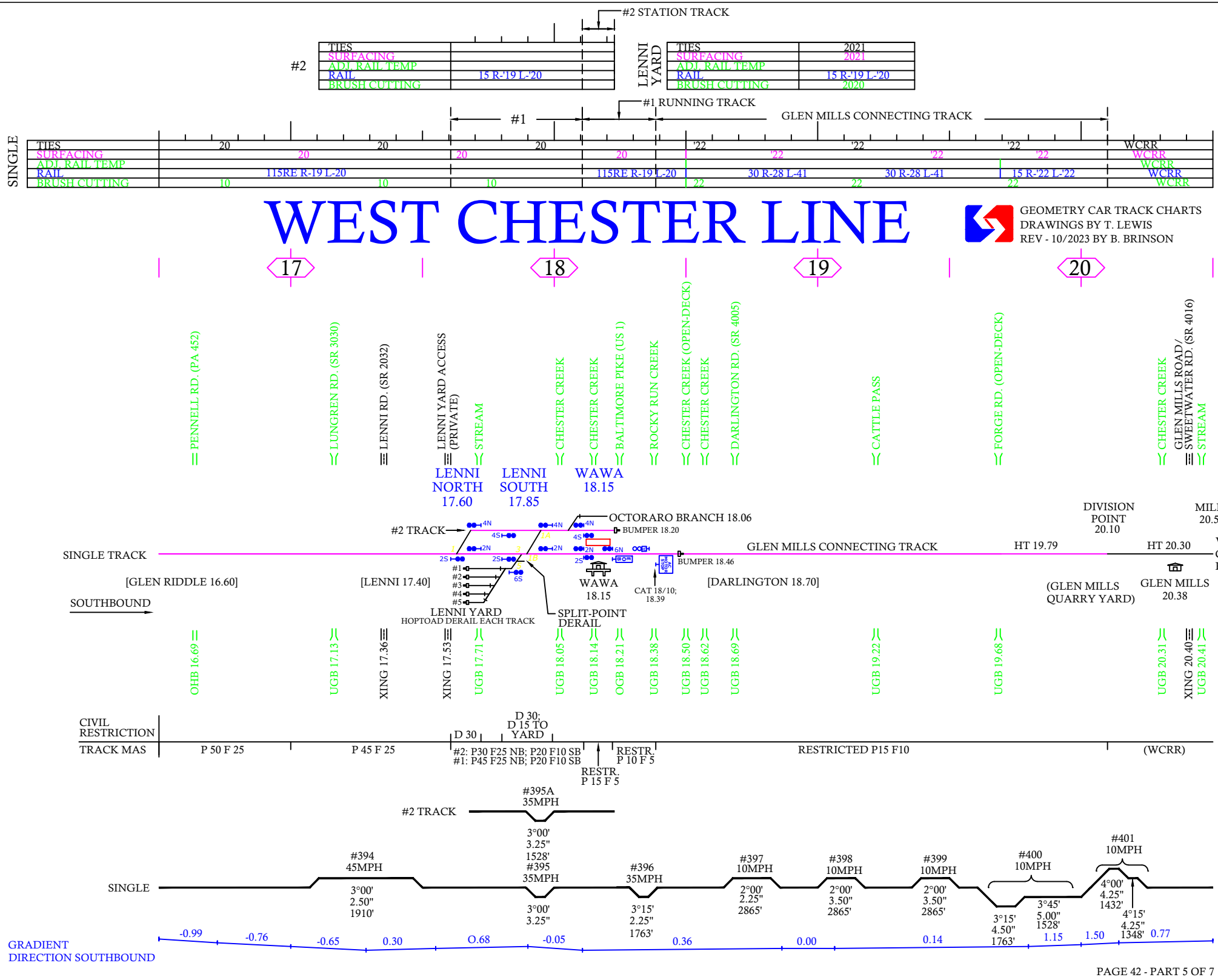
GRADIENT
DIRECTION SOUTHBOUND



WEST CHESTER LINE

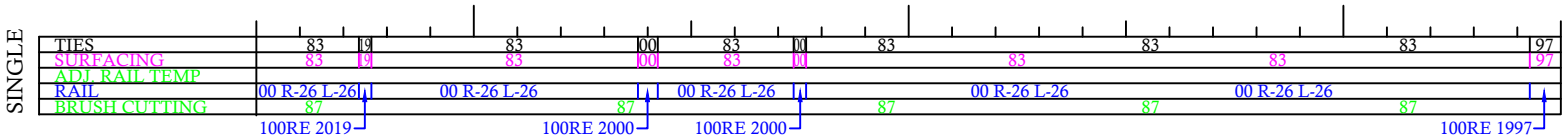
GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 10/2023 BY B. BRINSON




#2 STATION TRACK
#2
TIES
SURFACING
ADJ. RAIL TEMP
RAIL
BRUSH CUTTING
15 R-'19 L-'20
LENNI YARD
TIES
SURFACING
ADJ. RAIL TEMP
RAIL
BRUSH CUTTING
2021
2021
15 R-'19 L-'20
2020
#1 RUNNING TRACK
#1
GLEN MILLS CONNECTING TRACK
SINGLE
TIES
SURFACING
ADJ. RAIL TEMP
RAIL
BRUSH CUTTING
115RE R-19 L-20
115RE R-19 L-20
30 R-28 L-41
30 R-28 L-41
15 R-'22 L-'22
WCRR
WEST CHESTER LINE
GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 10/2023 BY B. BRINSON
17
18
19
20
PENNELL RD. (PA 452)
LUNGREN RD. (SR 3030)
LENNI RD. (SR 2032)
LENNI YARD ACCESS (PRIVATE)
STREAM
CHESTER CREEK
CHESTER CREEK
BALTIMORE PIKE (US 1)
ROCKY RUN CREEK
CHESTER CREEK (OPEN-DECK)
CHESTER CREEK
DARLINGTON RD. (SR 4005)
CATTLE PASS
FORGE RD. (OPEN-DECK)
CHESTER CREEK
GLEN MILLS ROAD/ SWEETWATER RD. (SR 4016)
STREAM
LENNI NORTH 17.60
LENNI SOUTH 17.85
WAWA 18.15
#2 TRACK
OCTORARO BRANCH 18.06
BUMPER 18.20
SINGLE TRACK
GLEN MILLS CONNECTING TRACK
DIVISION POINT 20.10
MILLS 20.50
HT 19.79
HT 20.30
WEST CHESTER RR
BUMPER 18.46
[GLEN RIDDLE 16.60]
[LENNI 17.40]
WAWA 18.15
CAT 18/10; 18.39
[DARLINGTON 18.70]
(GLEN MILLS QUARRY YARD)
GLEN MILLS 20.38
SOUTHBOUND
LENNI YARD
HOPTOAD DERAIL EACH TRACK
SPLIT-POINT DERAIL
OHB 16.69
UGB 17.13
XING 17.36
XING 17.53
UGB 17.71
UGB 18.05
UGB 18.14
OGB 18.21
UGB 18.38
UGB 18.50
UGB 18.62
UGB 18.69
UGB 19.22
UGB 19.68
UGB 20.31
XING 20.40
UGB 20.41
CIVIL RESTRICTION
TRACK MAS
P 50 F 25
P 45 F 25
D 30
D 30; D 15 TO YARD
#2: P30 F25 NB; P20 F10 SB
#1: P45 F25 NB; P20 F10 SB
RESTR. P 10 F 5
RESTR. P 15 F 5
RESTRICTED P15 F10
(WCRR)
#2 TRACK
#395A 35MPH
3°00' 3.25" 1528'
SINGLE
#394 45MPH
3°00' 2.50" 1910'
#395 35MPH
3°00' 3.25"
#396 35MPH
3°15' 2.25" 1763'
#397 10MPH
2°00' 2.25" 2865'
#398 10MPH
2°00' 3.50" 2865'
#399 10MPH
2°00' 3.50" 2865'
#400 10MPH
3°15' 4.50" 1763'
3°45' 5.00" 1528'
#401 10MPH
4°00' 4.25" 1432'
4°15' 4.25" 1348'
GRADIENT DIRECTION SOUTHBOUND
-0.99
-0.76
-0.65
0.30
O.68
-0.05
0.36
0.00
0.14
1.15
1.50
0.77

SINGLE

| | | |



WEST CHESTER LINE

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 10/2023 BY B. BRINSON

25 26 27

STREAM
OAKBOURNE RD.
CHESTER CREEK
ROUTE 202
EACHUS ST.
PRIVATE XING
PRIVATE XING
NIELDS ST.
UNION ST.
GOOSE CREEK
BARNARD ST.

STATE 27.00

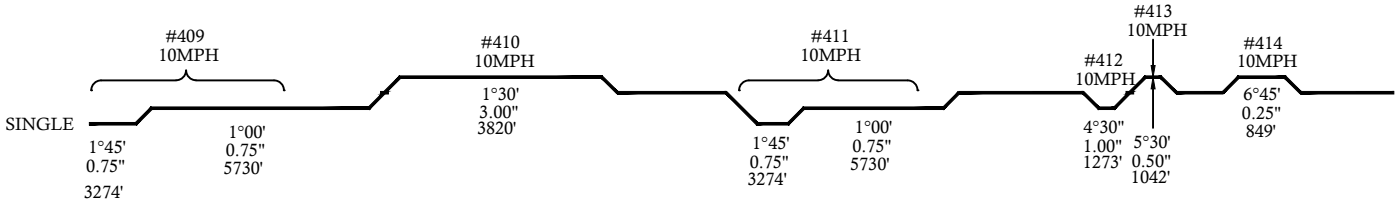
SINGLE TRACK

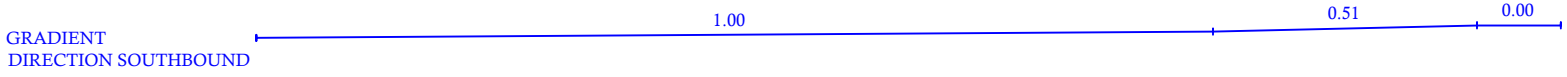
SOUTHBOUND

WEST CHESTER UNIVERSITY 27.10
WEST CHESTER 27.40

UGB 24.75
UGB 25.40
UGB 25.75
OHB 26.22
OHB 26.38
XING 26.65
XING 26.70
XING 27.05
XING 27.35
UGB 27.35
UGB 27.45

CIVIL RESTRICTION
TRACK MAS
RESTR. 10





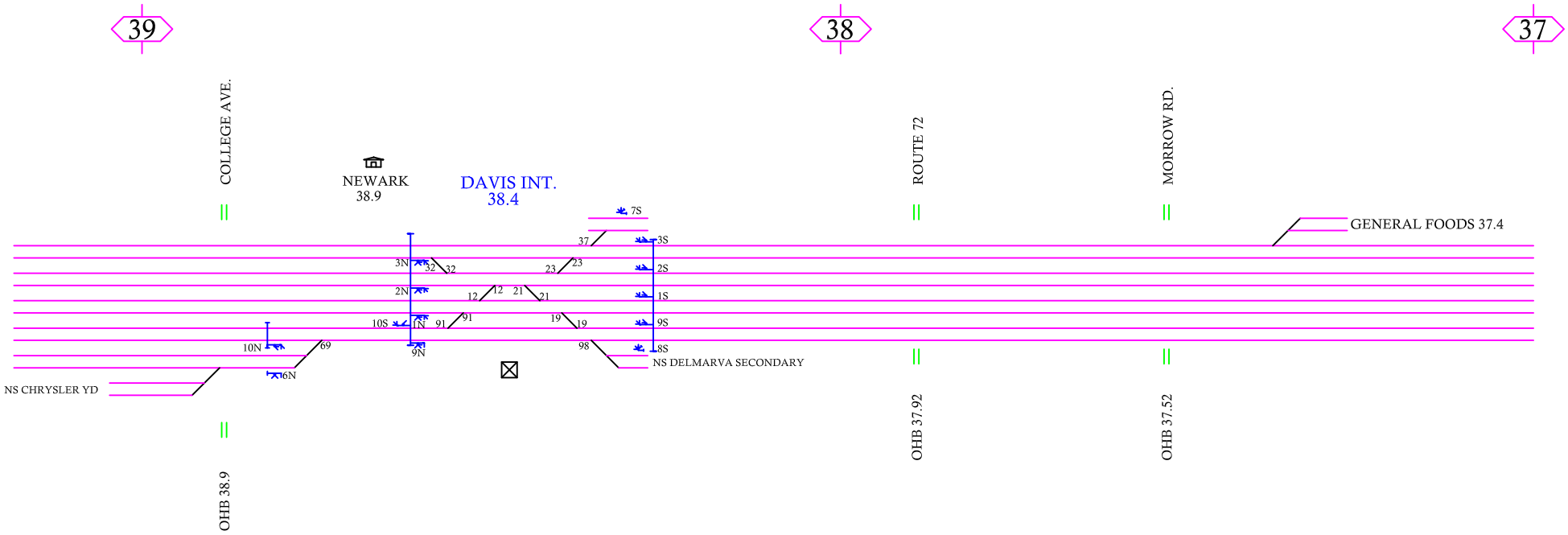
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SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK NORTHEAST CORRIDOR

(SEPTA WILMINGTON/NEWARK LINE)

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 6/2012



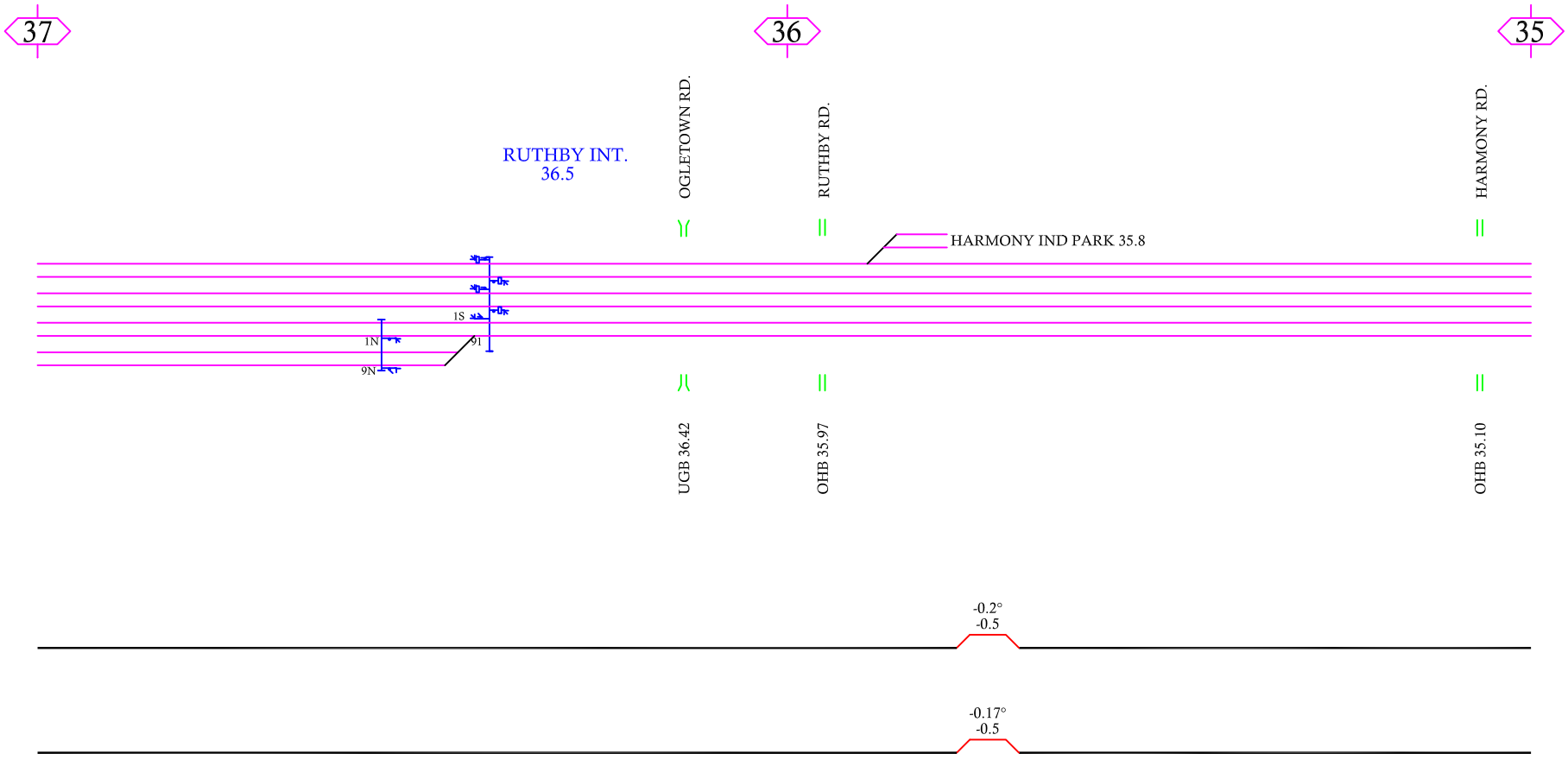
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SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK NORTHEAST CORRIDOR

(SEPTA WILMINGTON/NEWARK LINE)

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 6/2012



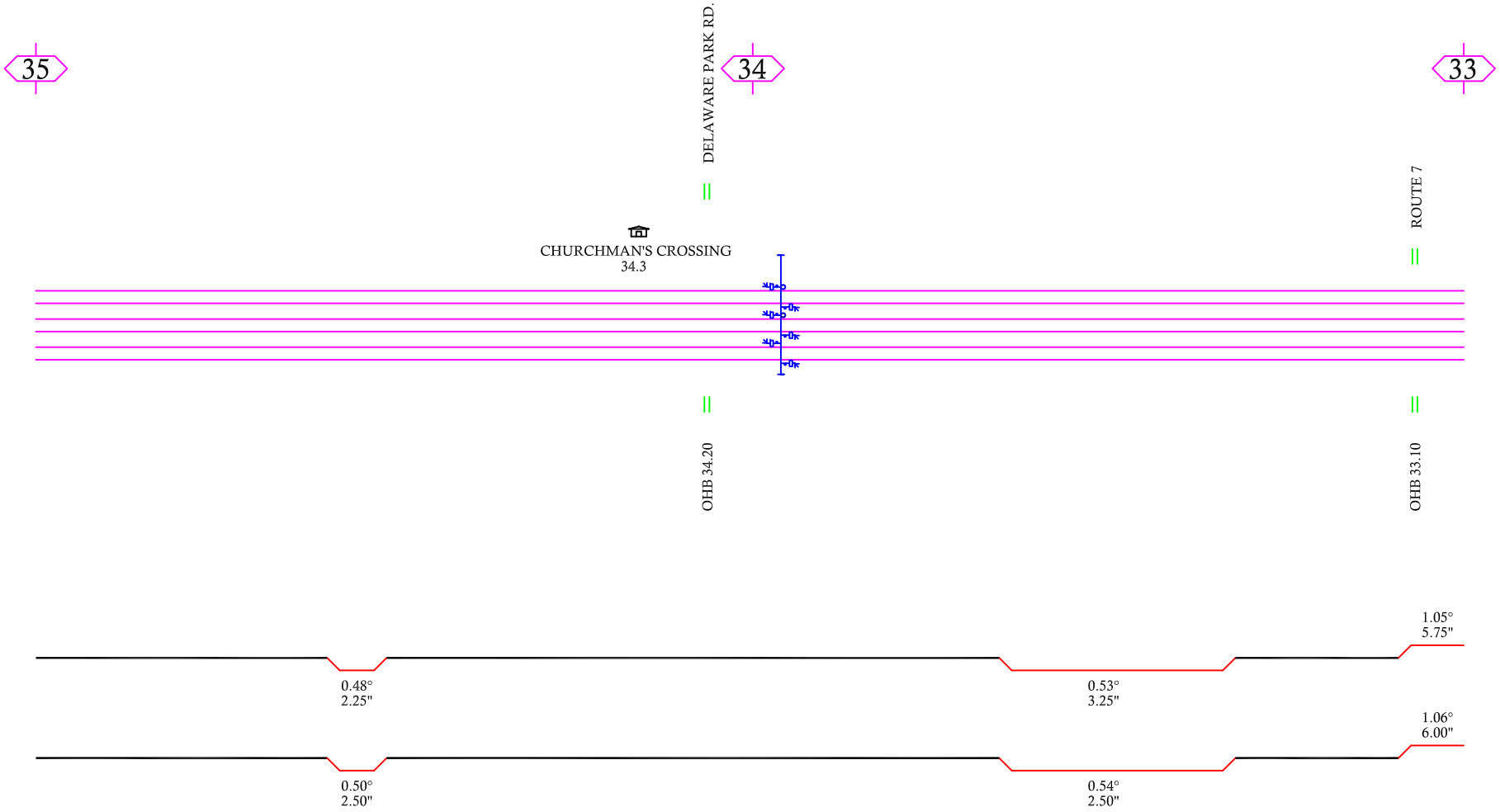
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SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK NORTHEAST CORRIDOR

(SEPTA WILMINGTON/NEWARK LINE)

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 6/2012



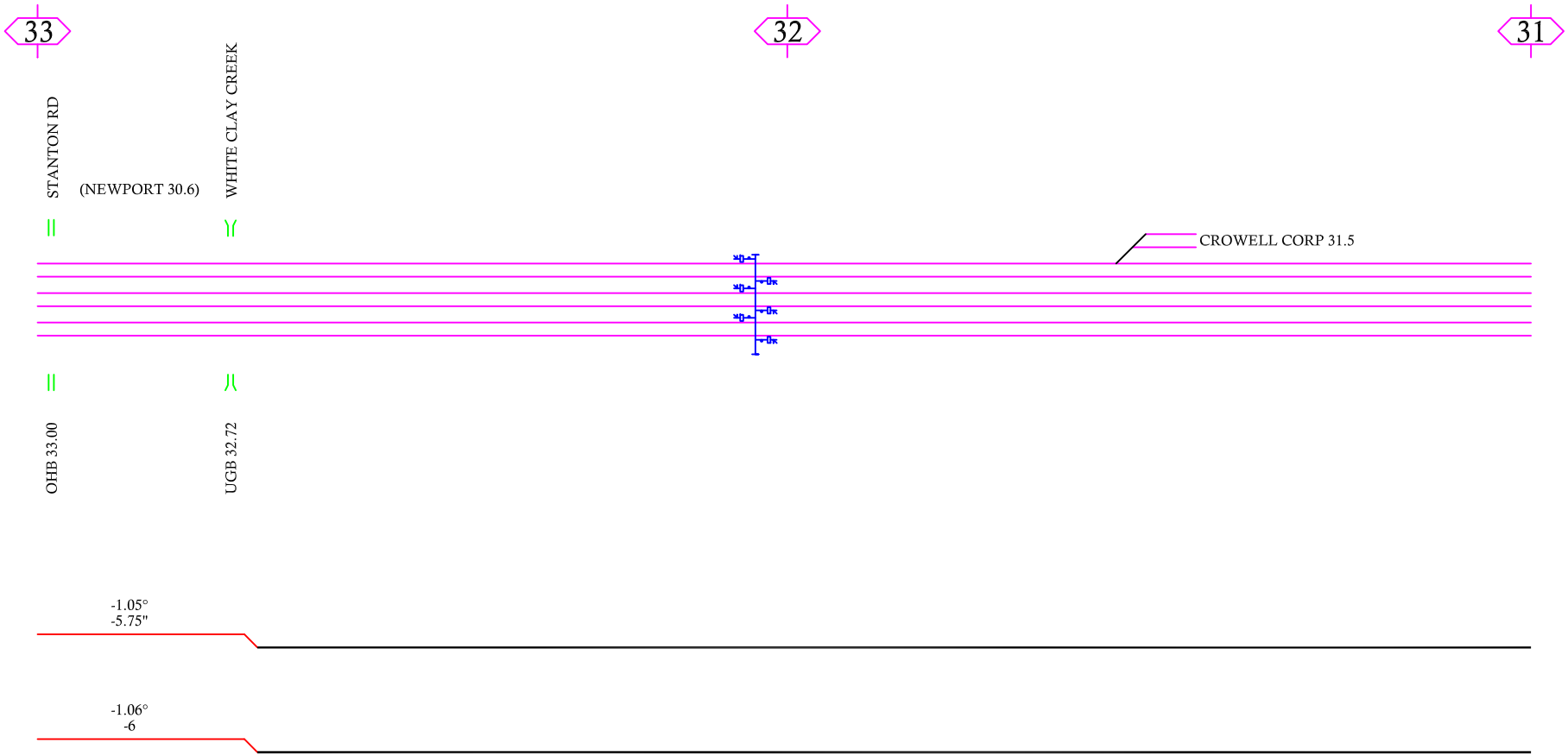
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SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK NORTHEAST CORRIDOR

(SEPTA WILMINGTON/NEWARK LINE)

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 6/2012



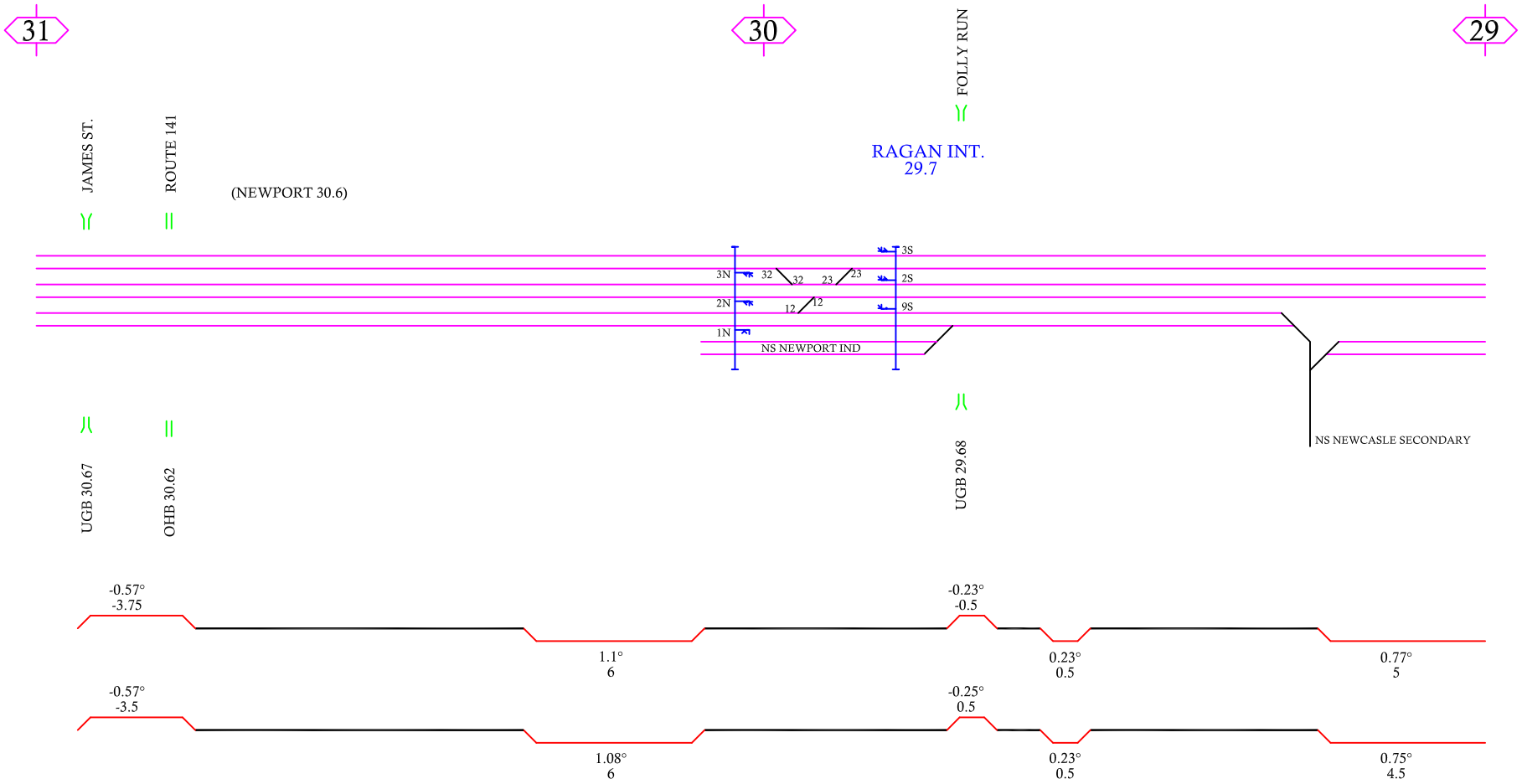
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SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK NORTHEAST CORRIDOR

(SEPTA WILMINGTON/NEWARK LINE)

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 6/2012



TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

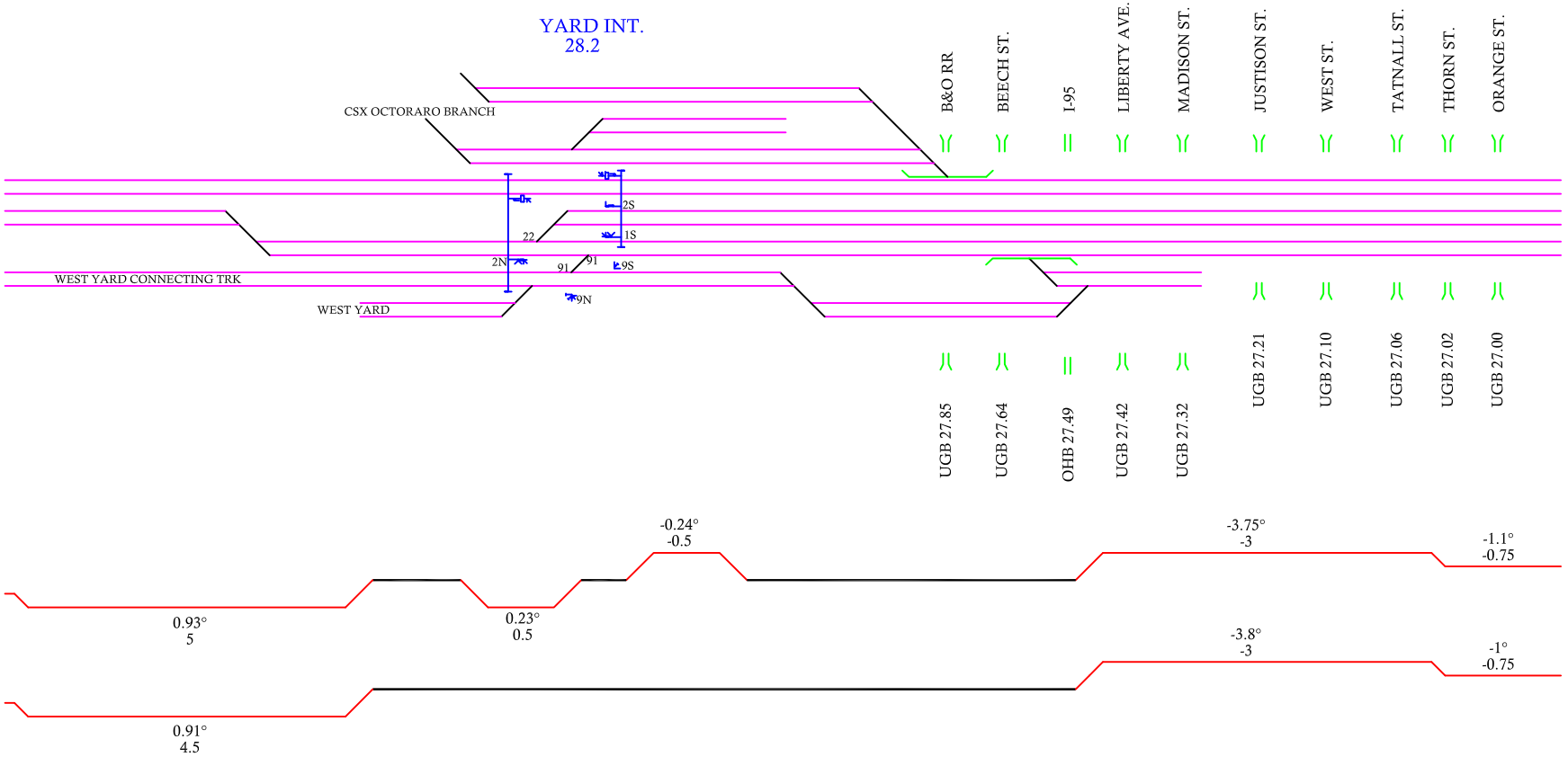
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SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK NORTHEAST CORRIDOR

(SEPTA WILMINGTON/NEWARK LINE)

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 6/2012

29 28 27



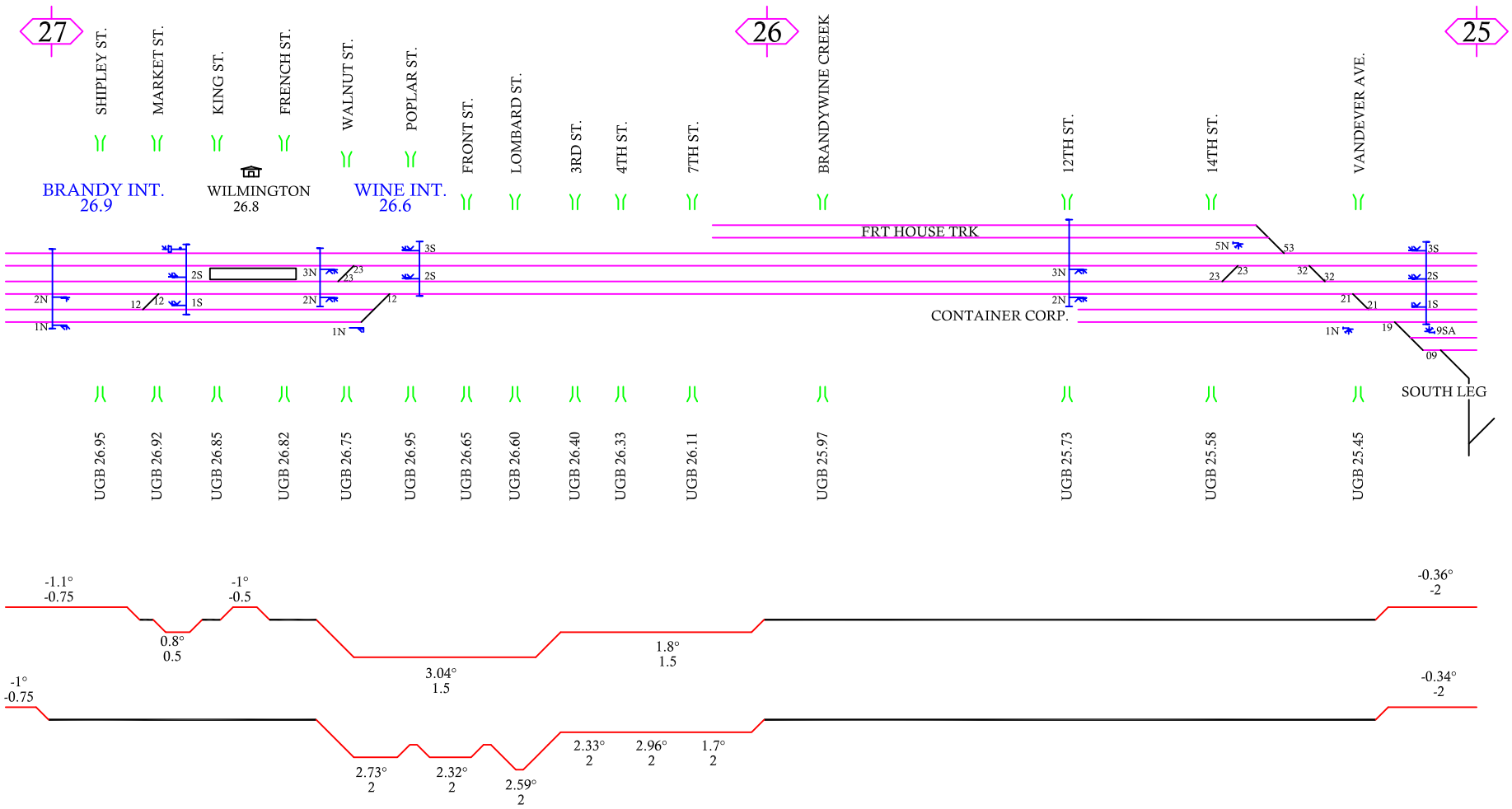
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SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK NORTHEAST CORRIDOR

(SEPTA WILMINGTON/NEWARK LINE)

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 6/2012



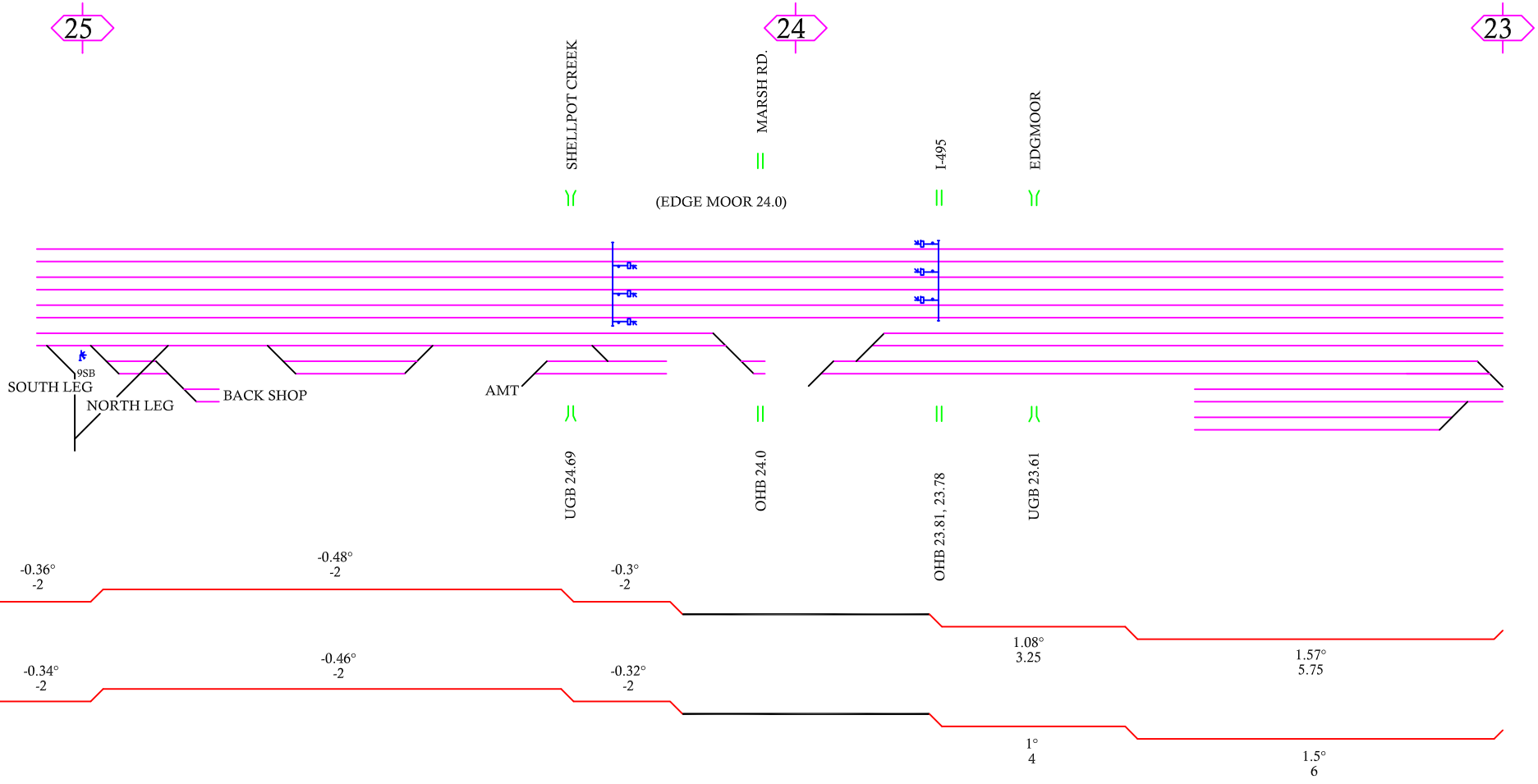
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SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK NORTHEAST CORRIDOR

(SEPTA WILMINGTON/NEWARK LINE)

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 6/2012



TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK NORTHEAST CORRIDOR

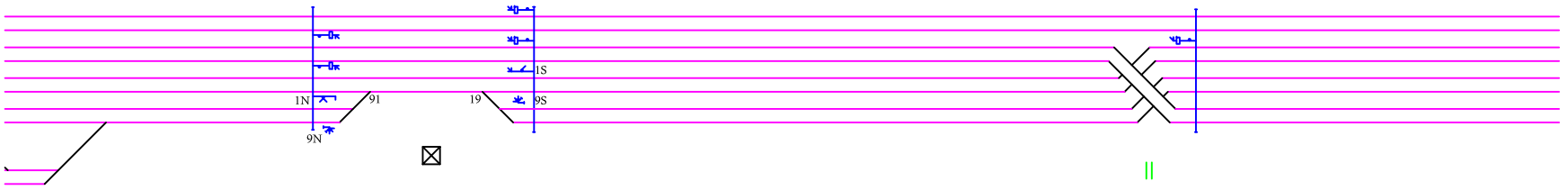
(SEPTA WILMINGTON/NEWARK LINE)

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 6/2012

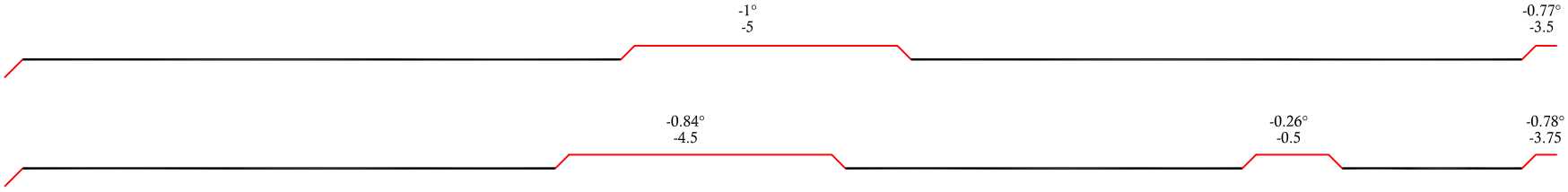
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2 TRK JUMPOVER

BELL INT. 22.5



OHB 21.73



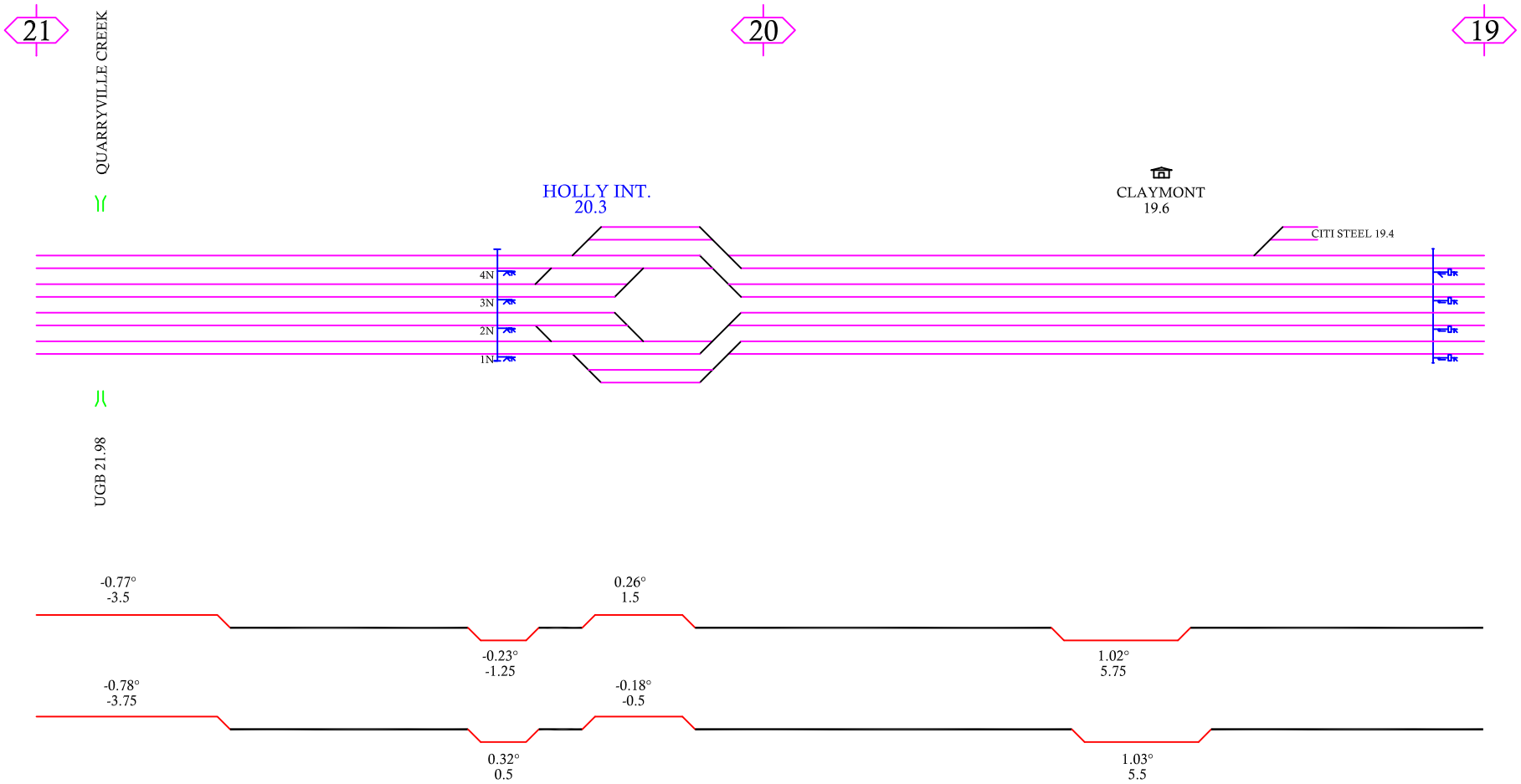
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ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK NORTHEAST CORRIDOR

(SEPTA WILMINGTON/NEWARK LINE)

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
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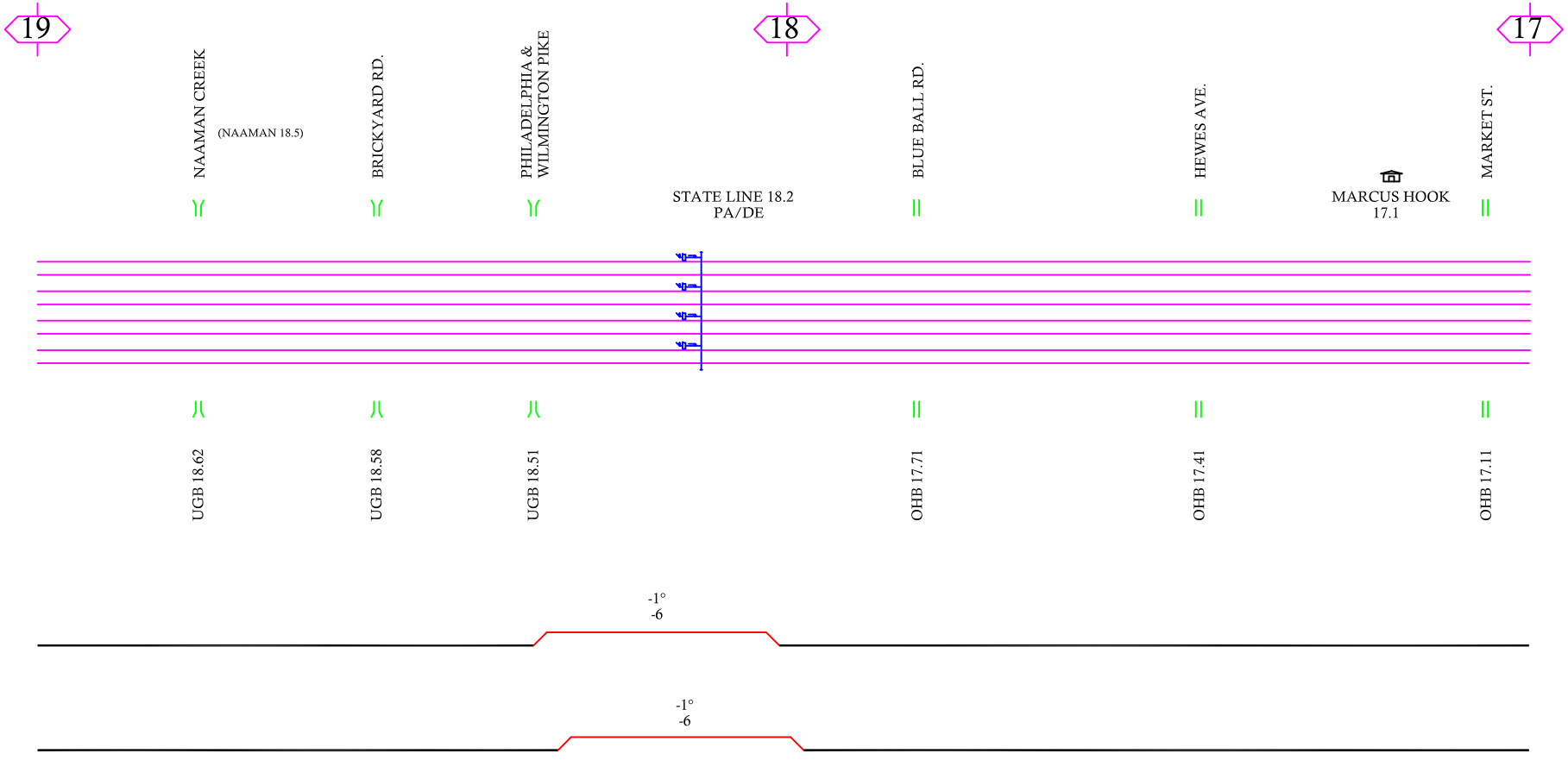
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ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK NORTHEAST CORRIDOR

(SEPTA WILMINGTON/NEWARK LINE)

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 6/2012



TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK NORTHEAST CORRIDOR

(SEPTA WILMINGTON/NEWARK LINE)

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 6/2012

17 16 15

HOOK INT.
16.8

MAIN ST.

(TRAINER 16.3)

BOOTH ST.

HIGHLAND AVE.
15.5

HIGHLAND AVE.

WILSON ST.

ENGLE ST.

JEFFREY ST.

4S
4N 43 43 34 34 3S
3N 32 32 23 23 2S
2N 12 12 21 21 1S
1N 91 91 9SB 19 19
PLUG TRACK
9N 89
8N
9NB

1 TRK TO NAUGHT 15.8

CR LINWOOD BR
TO STONEY CREEK YD

UGB 16.35

UGB 15.70

UGB 15.50

UGB 15.36

UGB 15.09

UGB 15.02

-0.13°
-1

0.11°
1

0.53°
2

0.1°
1

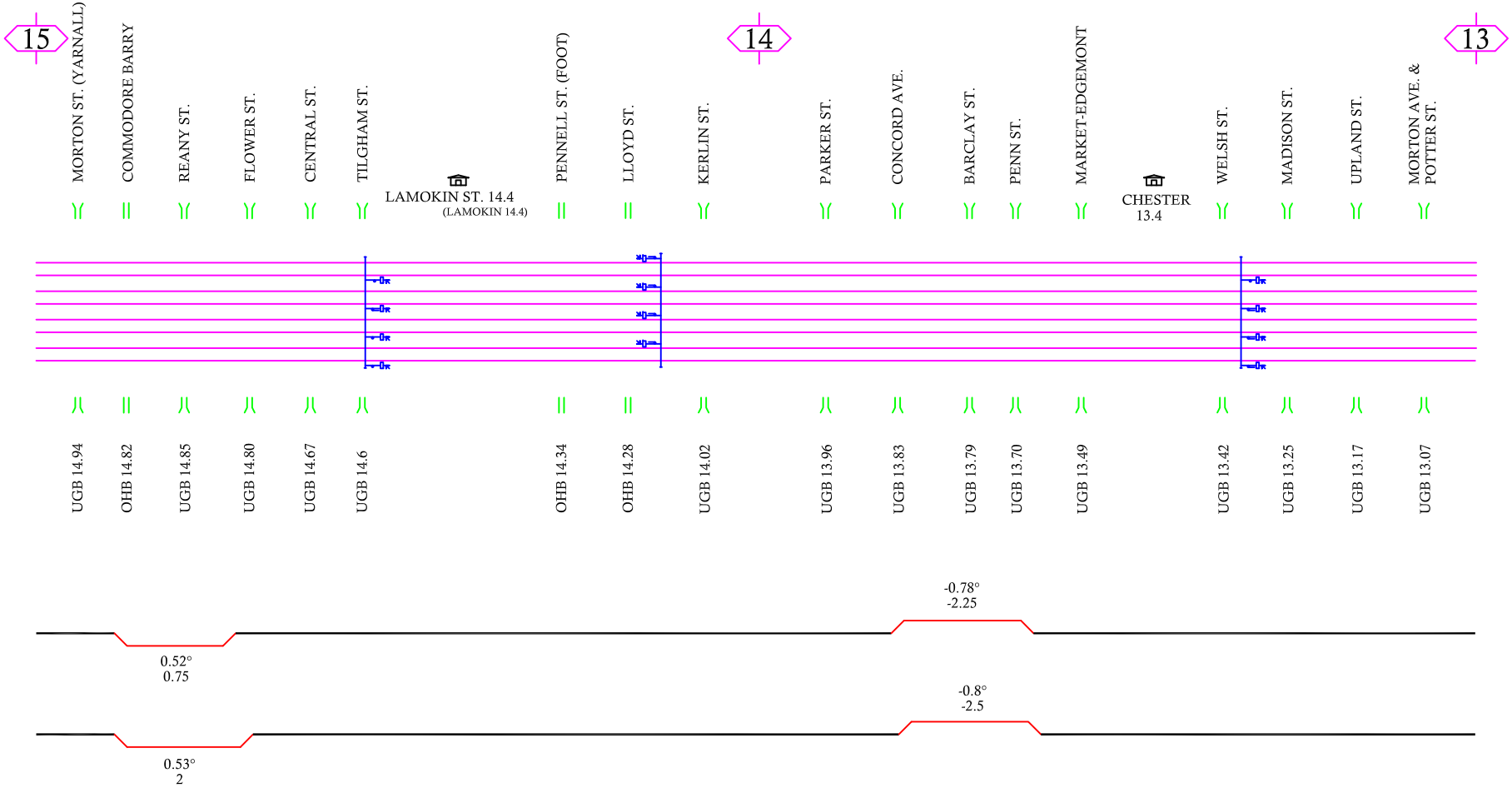
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ADJ. RAIL TEMP										
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK	

TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
ADJ. RAIL TEMP										
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK	

AMTRAK NORTHEAST CORRIDOR

(SEPTA WILMINGTON/NEWARK LINE)

GEOMETRY CAR TRACK CHARTS
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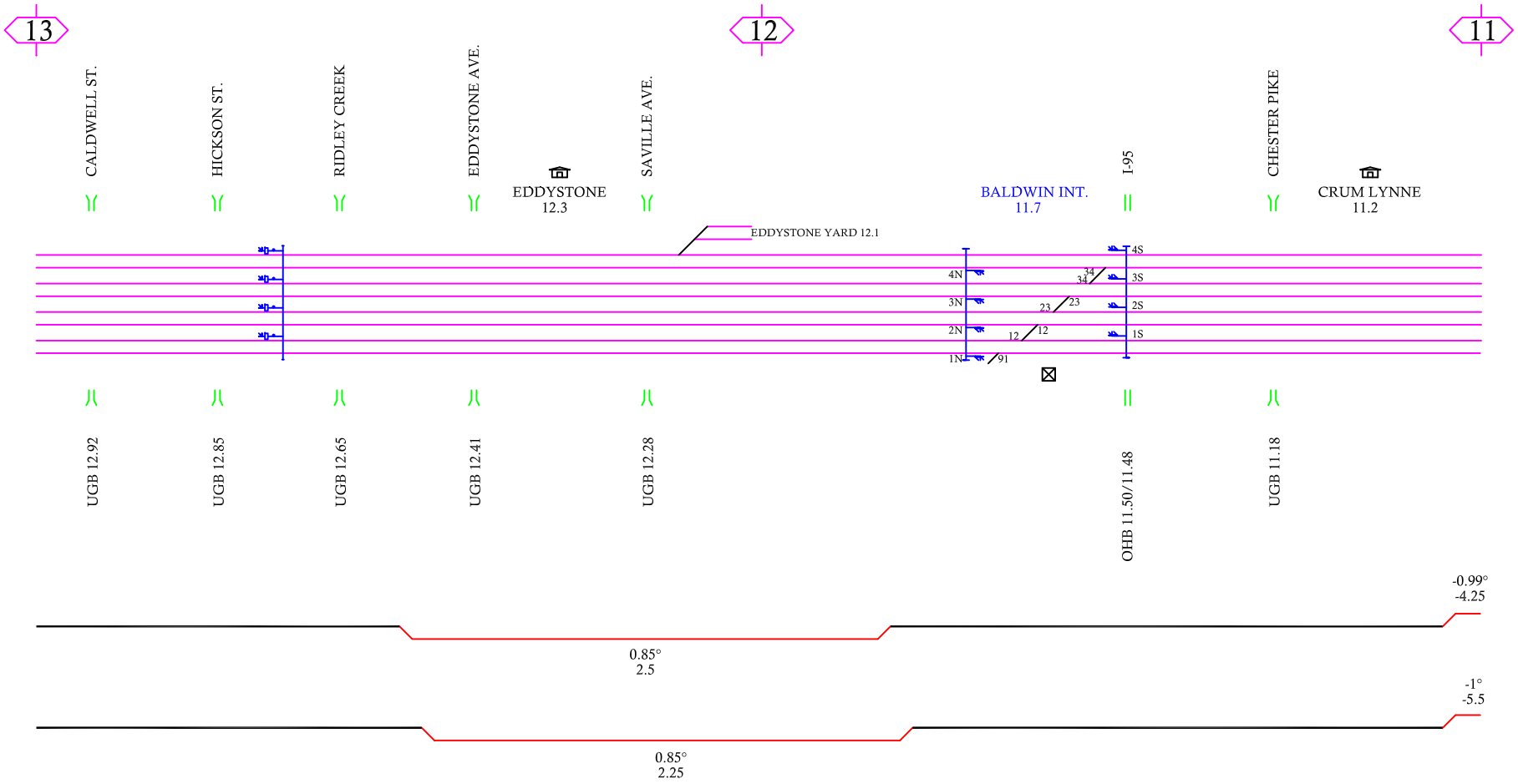
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ADJ. RAIL TEMP									
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BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

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BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK NORTHEAST CORRIDOR

(SEPTA WILMINGTON/NEWARK LINE)

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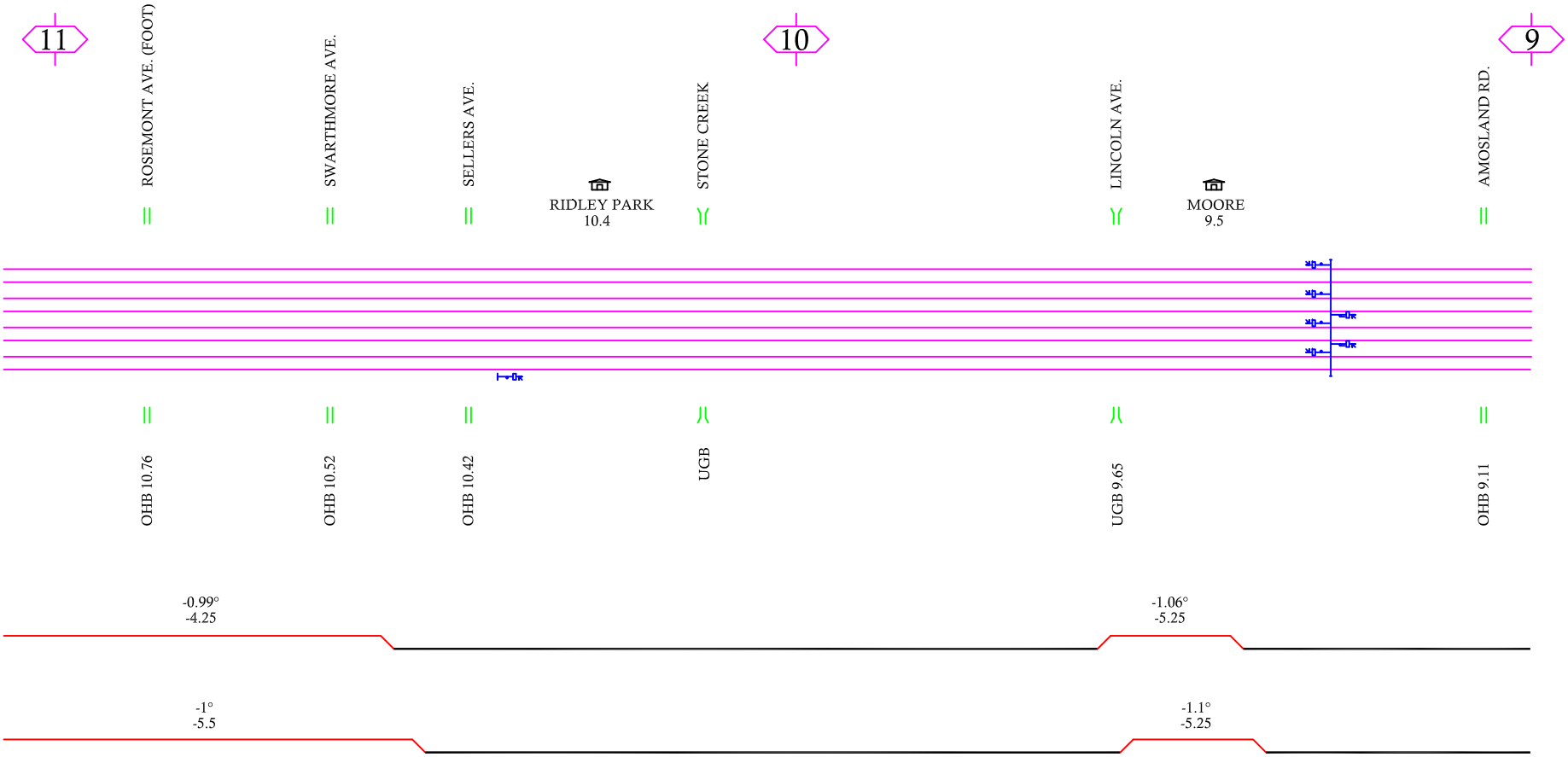
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BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

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BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

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(SEPTA WILMINGTON/NEWARK LINE)

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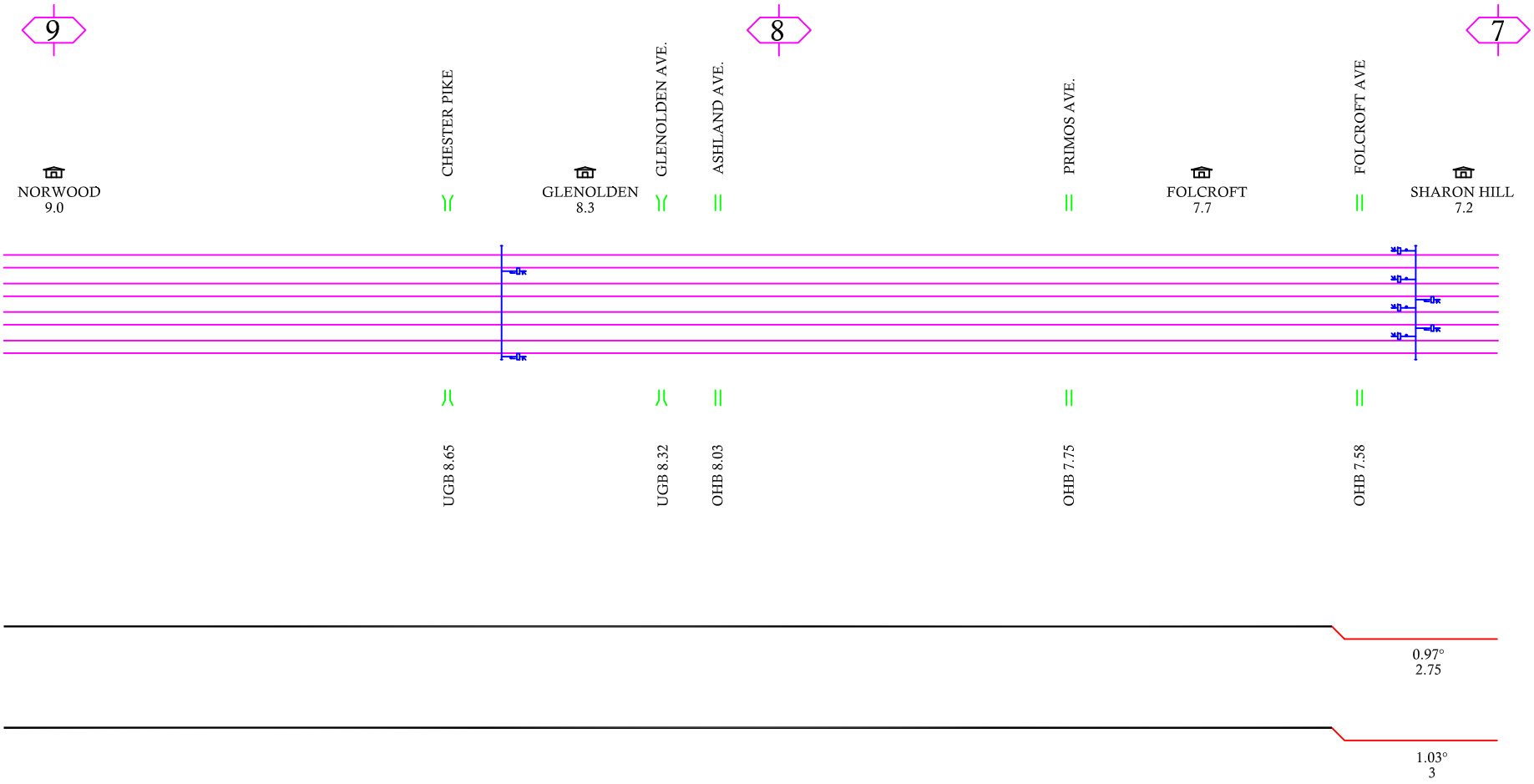
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ADJ. RAIL TEMP									
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BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

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AMTRAK NORTHEAST CORRIDOR

(SEPTA WILMINGTON/NEWARK LINE)

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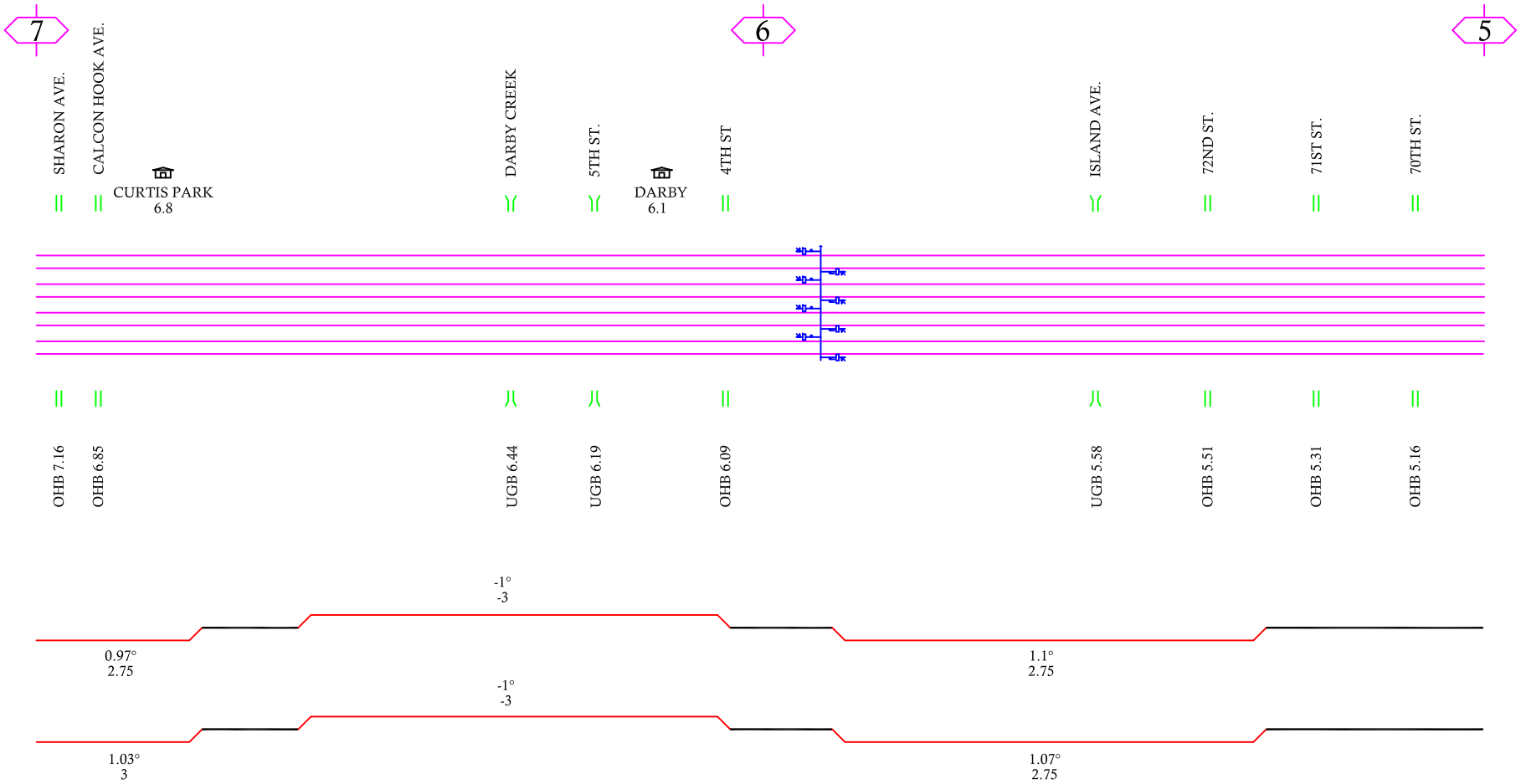
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BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK NORTHEAST CORRIDOR

(SEPTA WILMINGTON/NEWARK LINE)

GEOMETRY CAR TRACK CHARTS
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TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
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BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

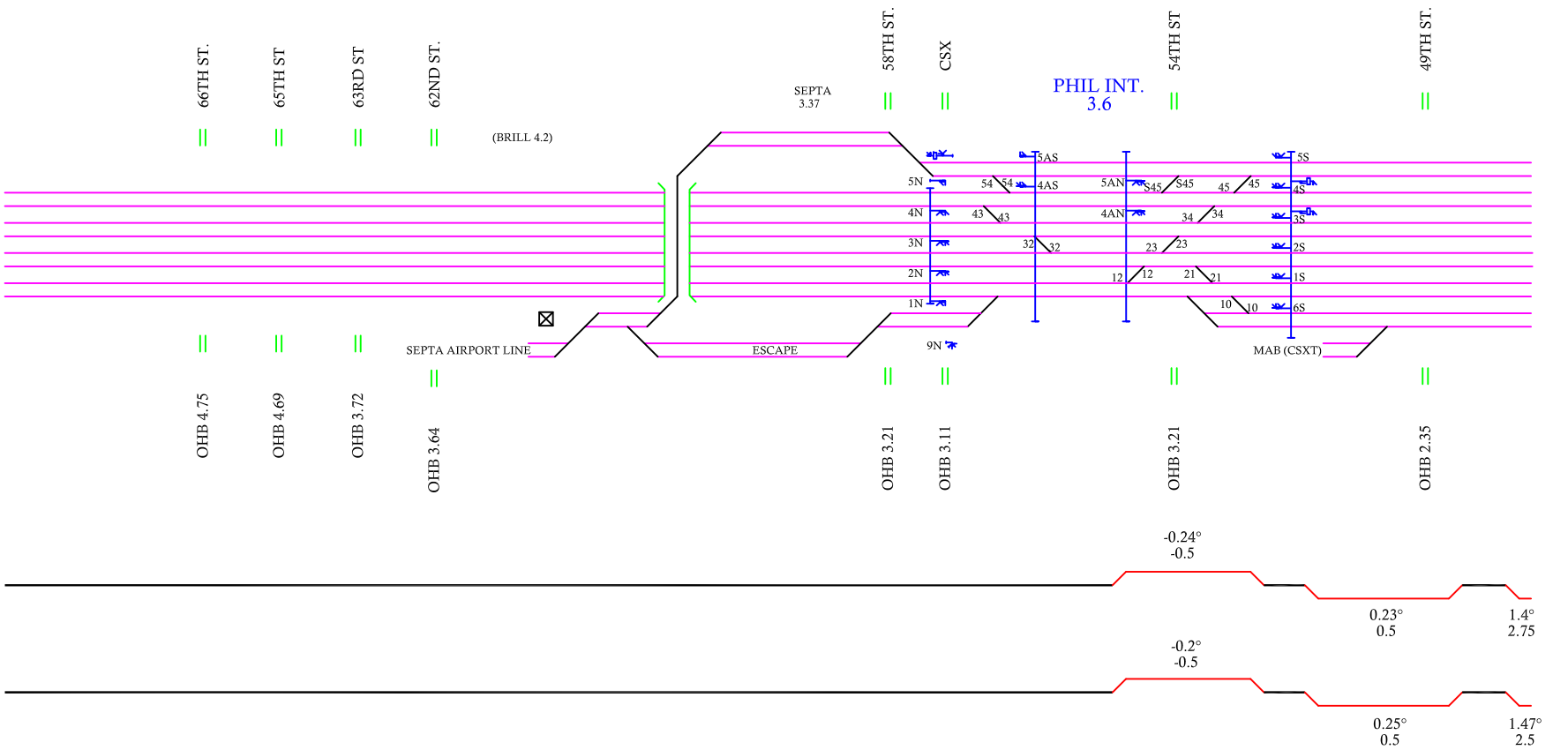
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RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK NORTHEAST CORRIDOR

(SEPTA WILMINGTON/NEWARK LINE)

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
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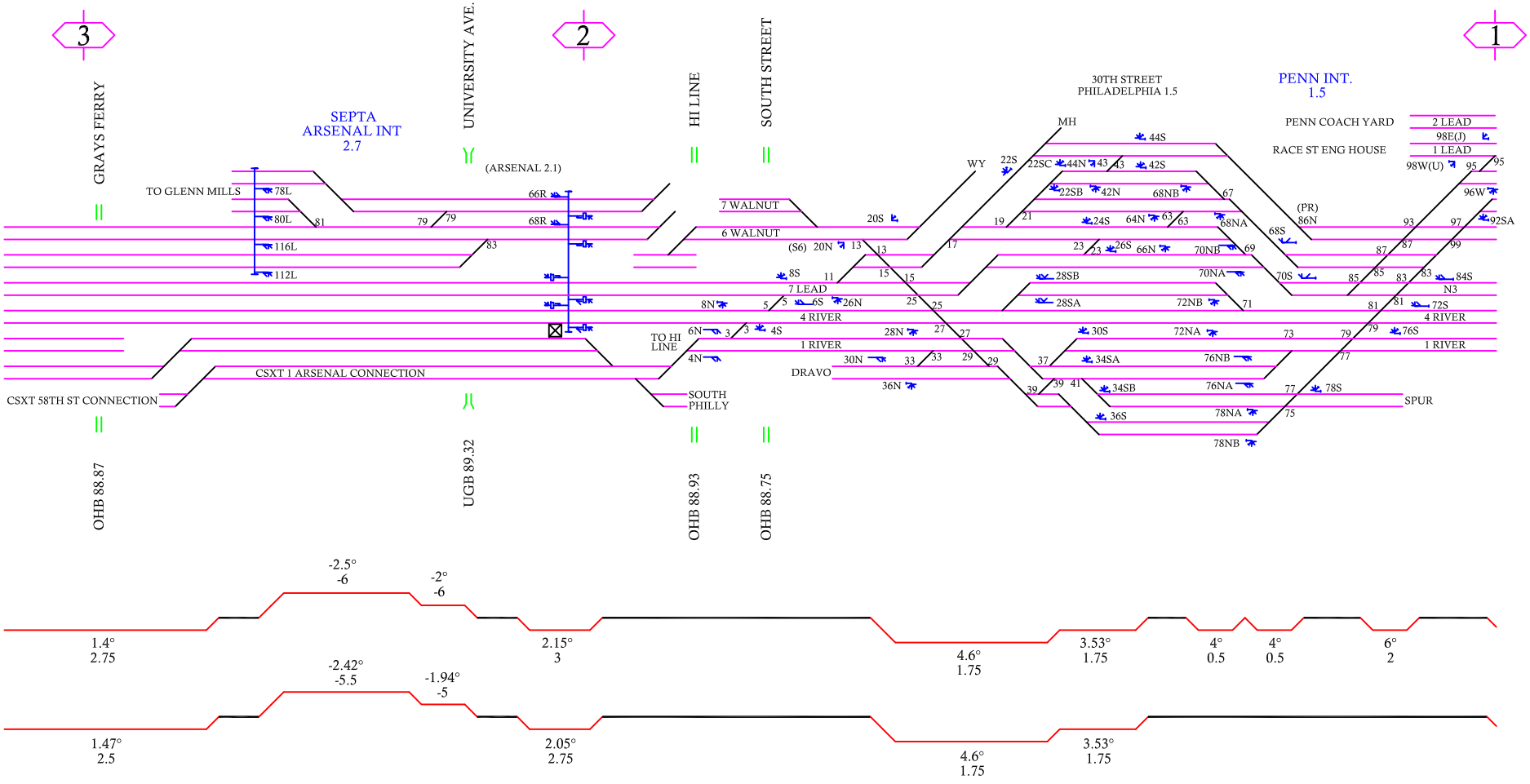
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ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK NORTHEAST CORRIDOR

(SEPTA WILMINGTON/NEWARK LINE)

GEOMETRY CAR TRACK CHARTS
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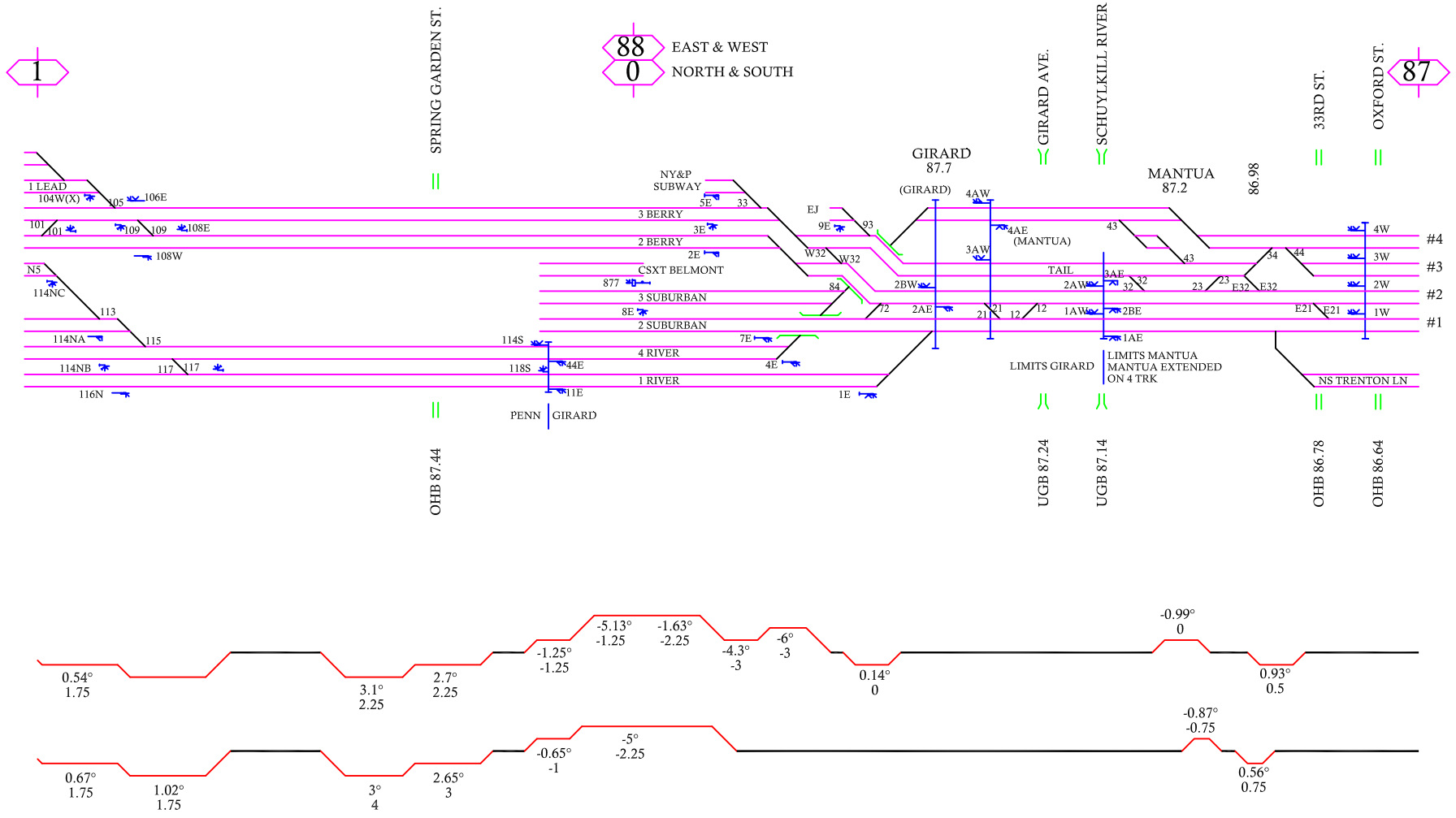
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BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK NORTHEAST CORRIDOR

(SEPTA WILMINGTON/NEWARK LINE)

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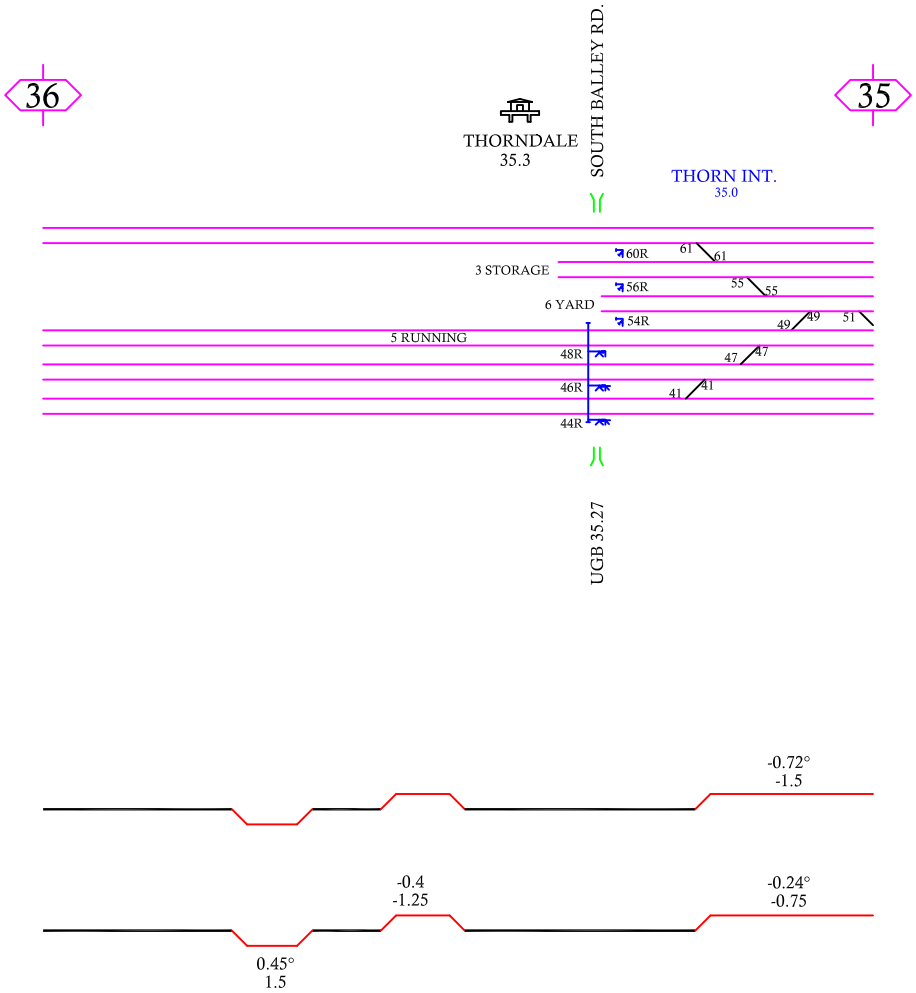
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ADJ. RAIL TEMP					
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BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK

TIES	AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK	
ADJ. RAIL TEMP					
RAIL		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK

AMTRAK HARRISBURG LINE

(SEPTA PAOLI/MALVERN TO THORNDALE)

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
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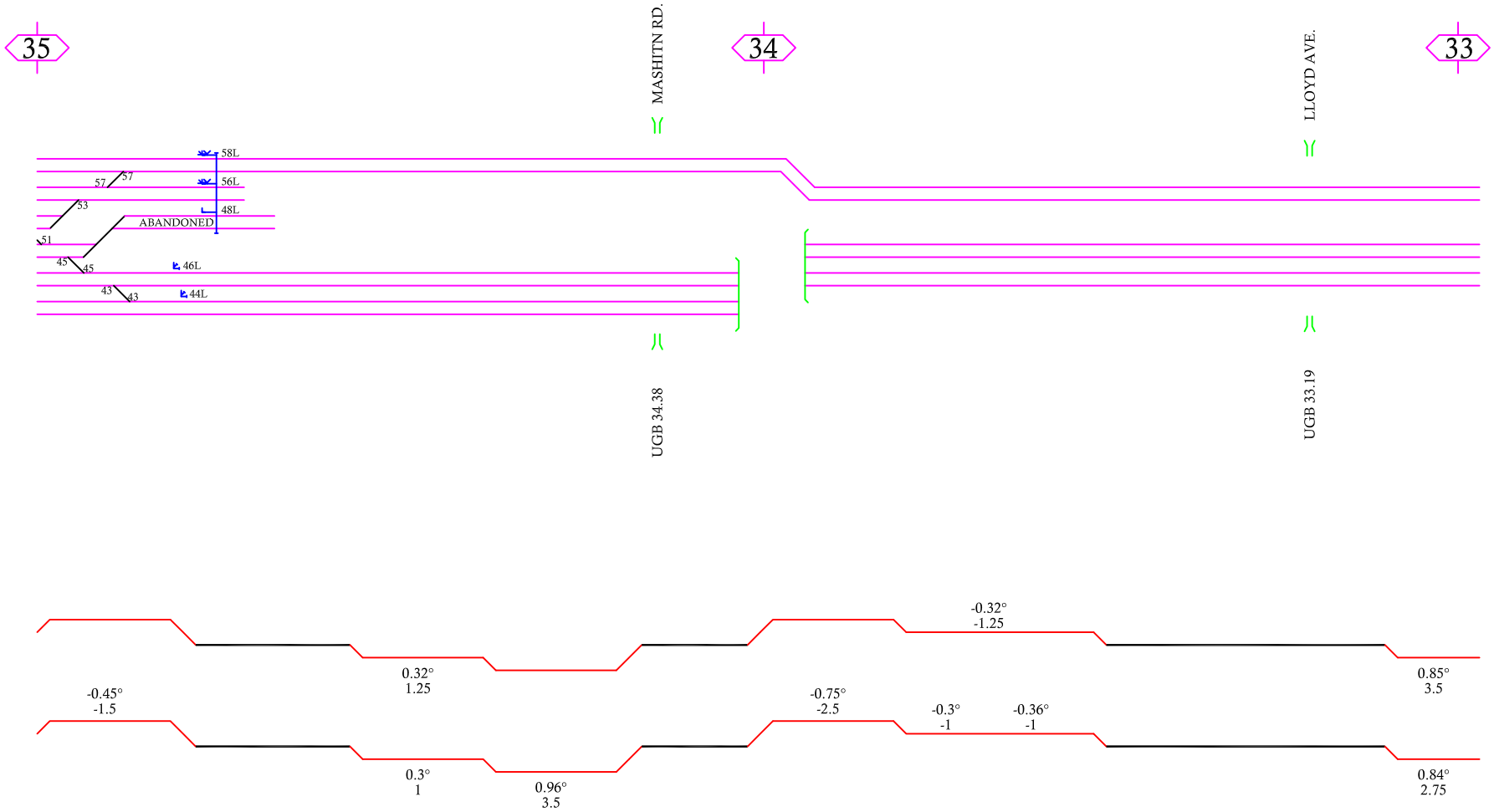
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BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK HARRISBURG LINE

(SEPTA PAOLI/MALVERN TO THORNDALE)

GEOMETRY CAR TRACK CHARTS
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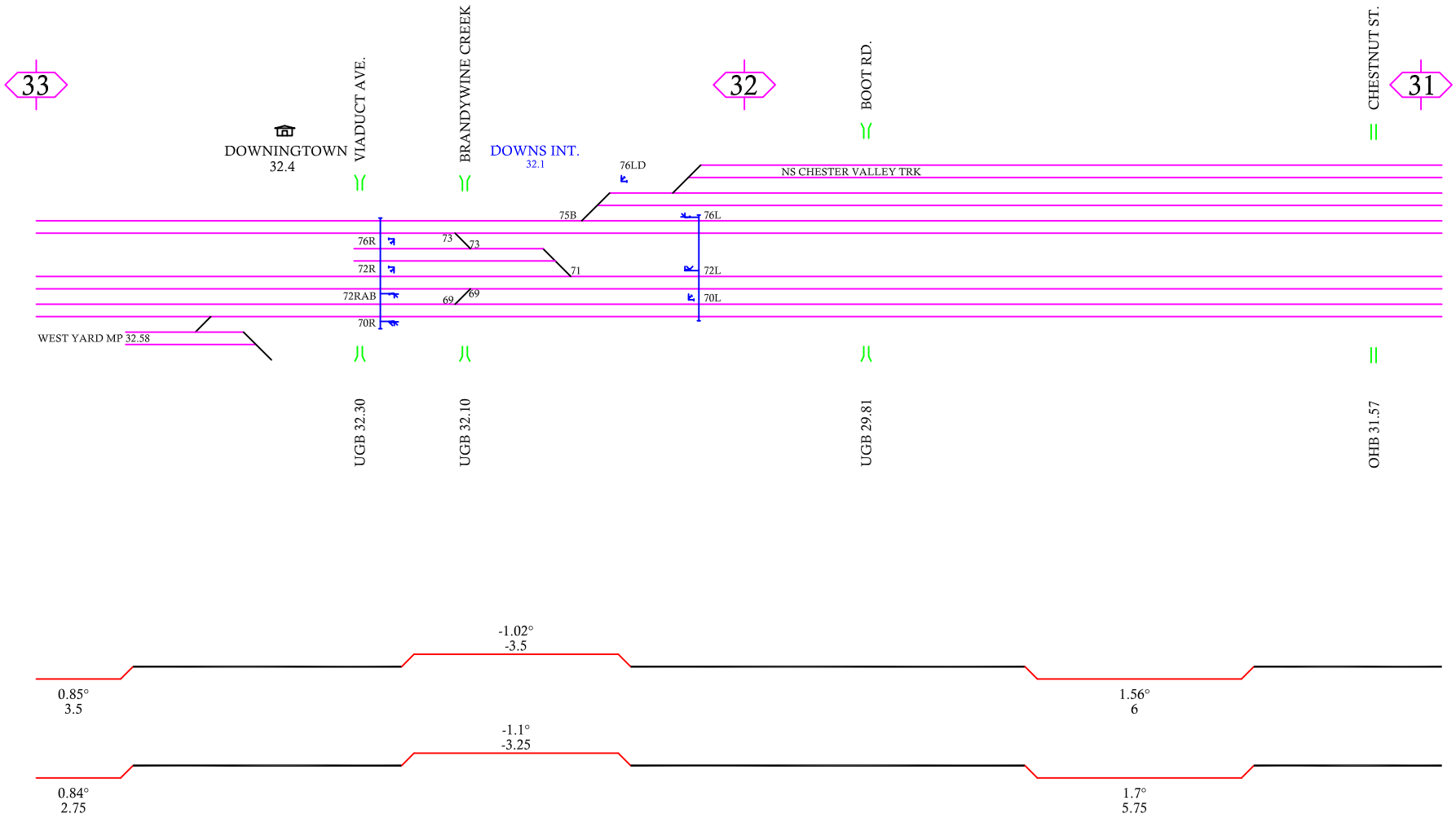
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BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
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BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK HARRISBURG LINE

(SEPTA PAOLI/MALVERN TO THORNDALE)

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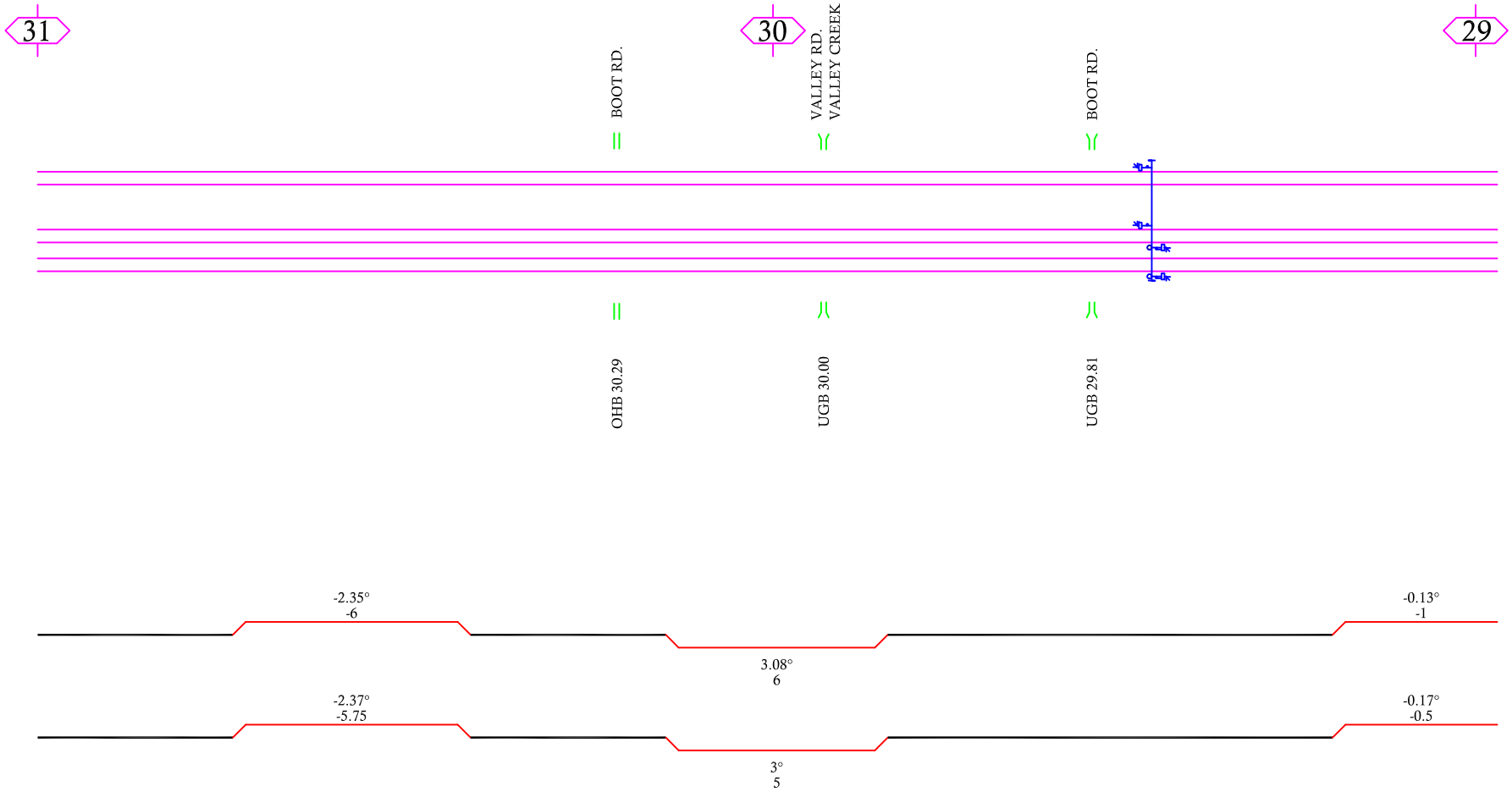
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TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
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BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK HARRISBURG LINE

(SEPTA PAOLI/MALVERN TO THORNDALE)

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DRAWINGS BY T. LEWIS
REV - 6/2012



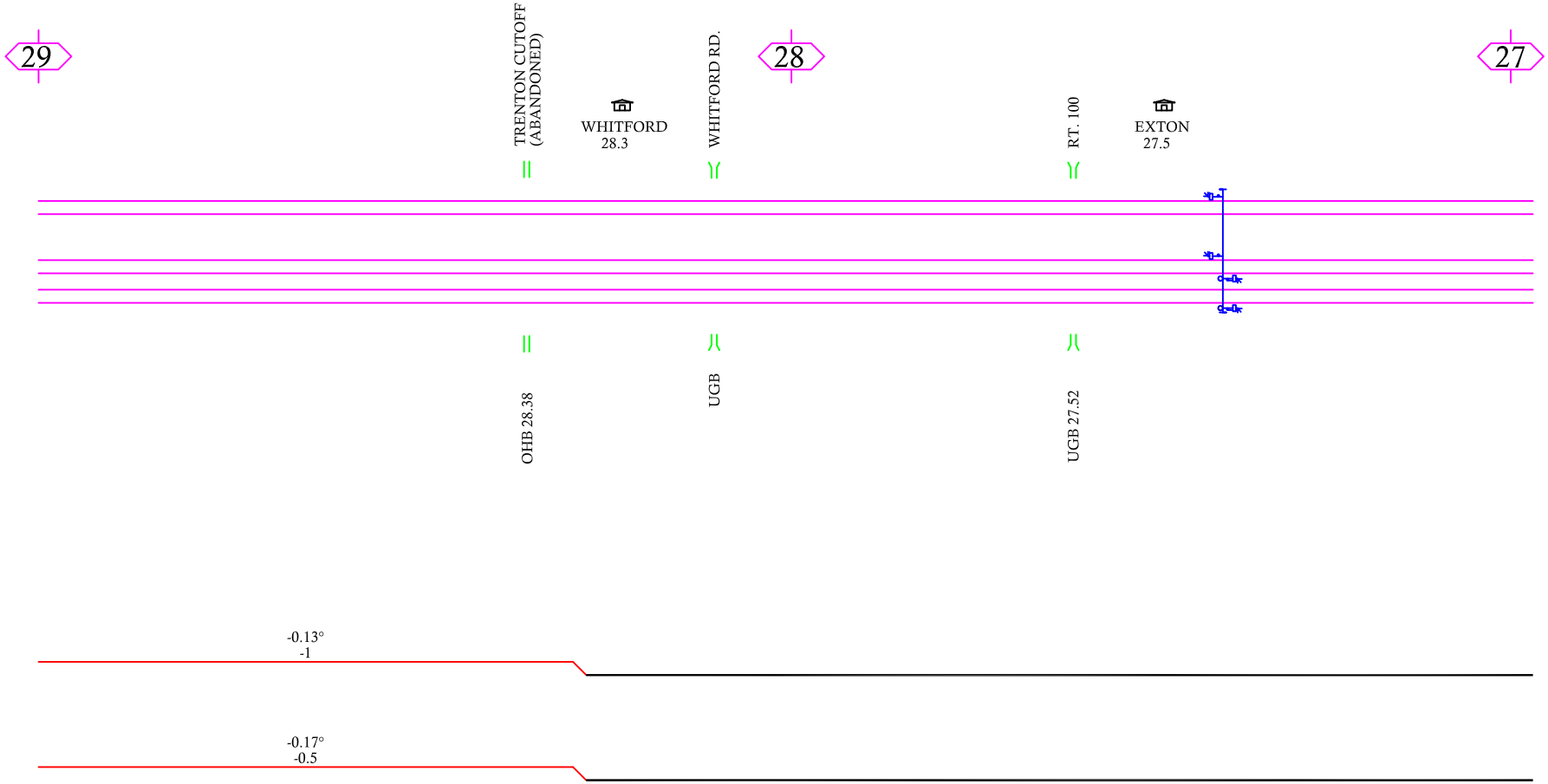
TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK HARRISBURG LINE

(SEPTA PAOLI/MALVERN TO THORNDALE)

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
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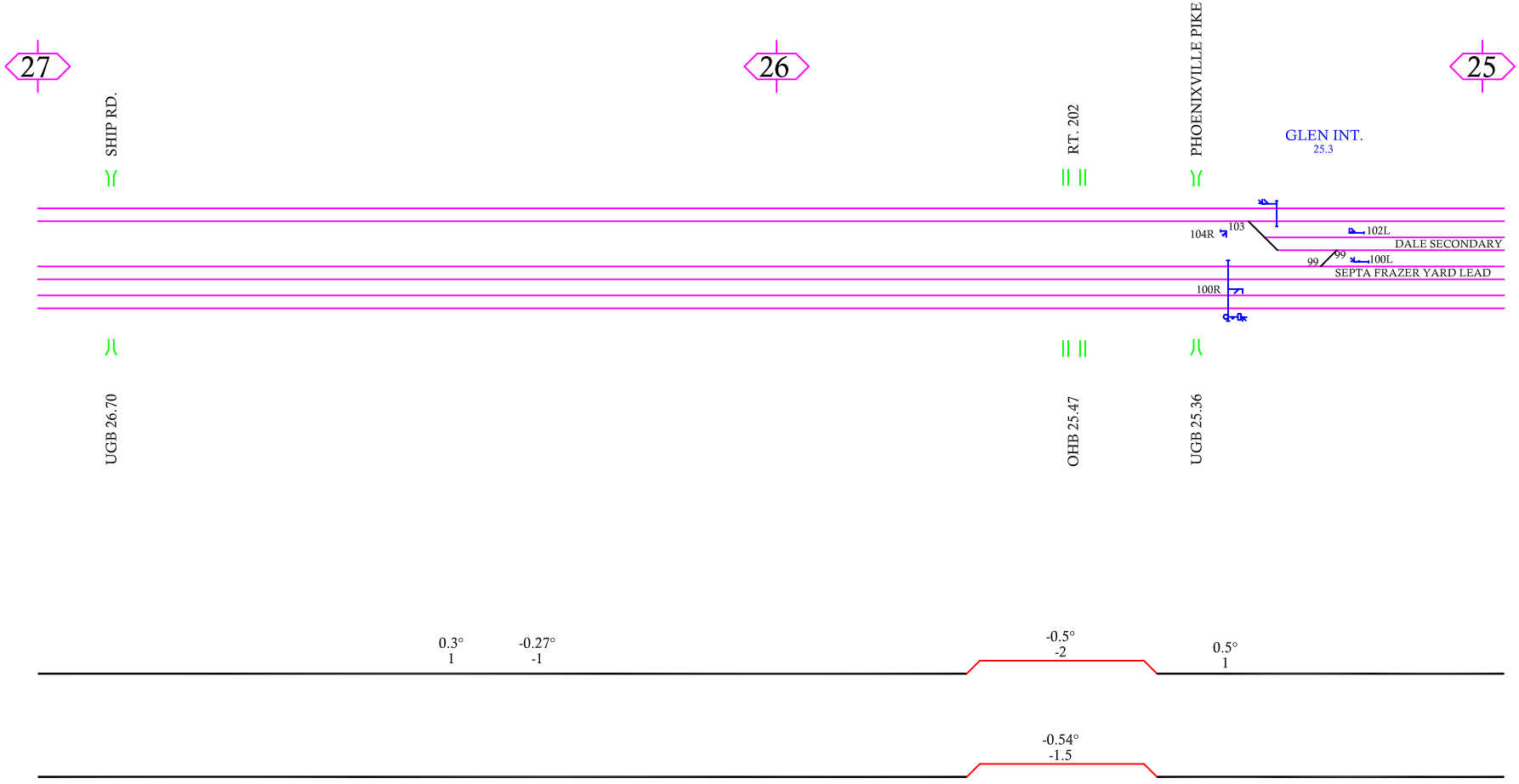
TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK HARRISBURG LINE

(SEPTA PAOLI/MALVERN TO THORNDALE)

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 6/2012



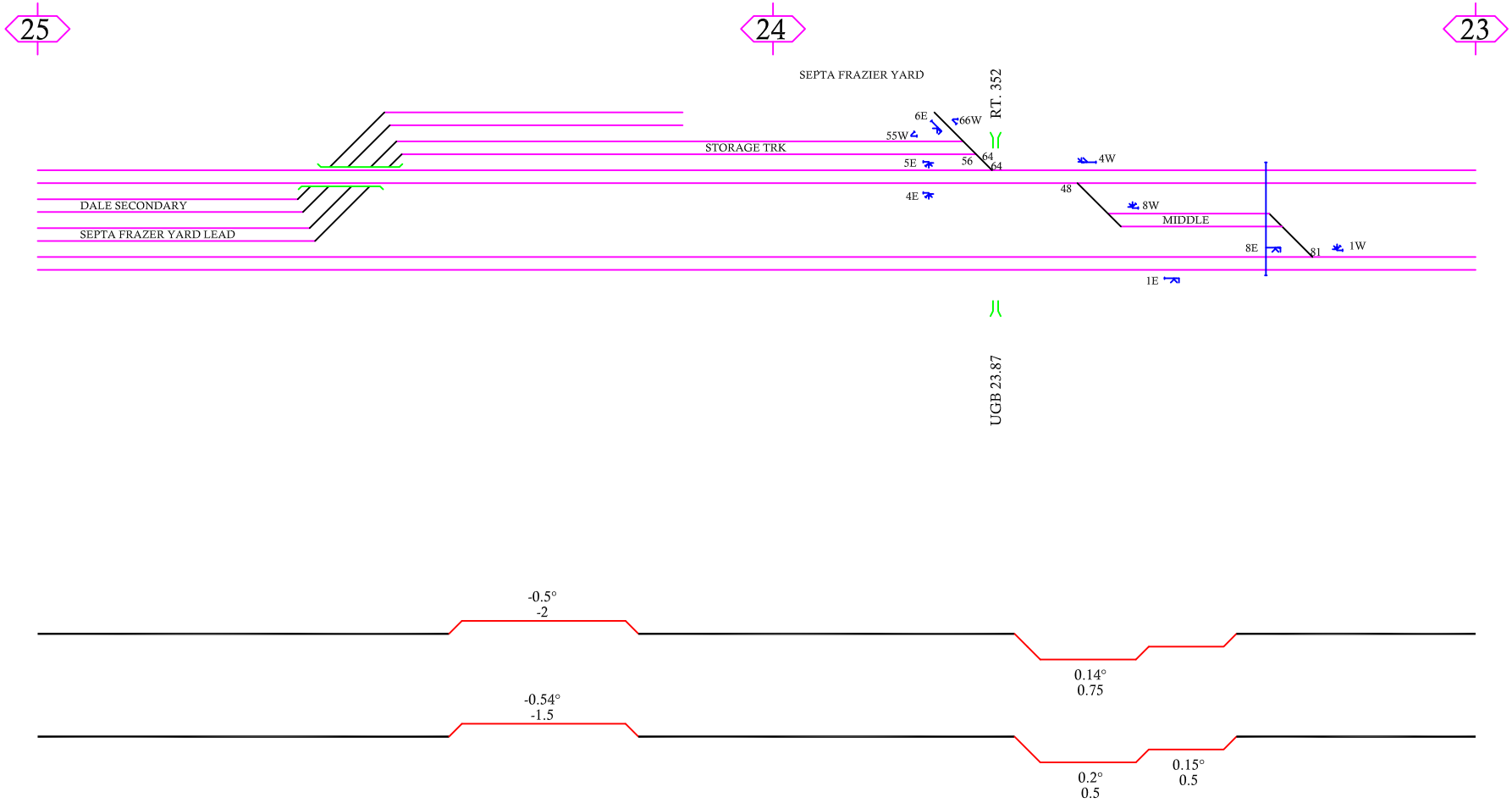
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SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK HARRISBURG LINE

(SEPTA PAOLI/MALVERN TO THORNDALE)

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
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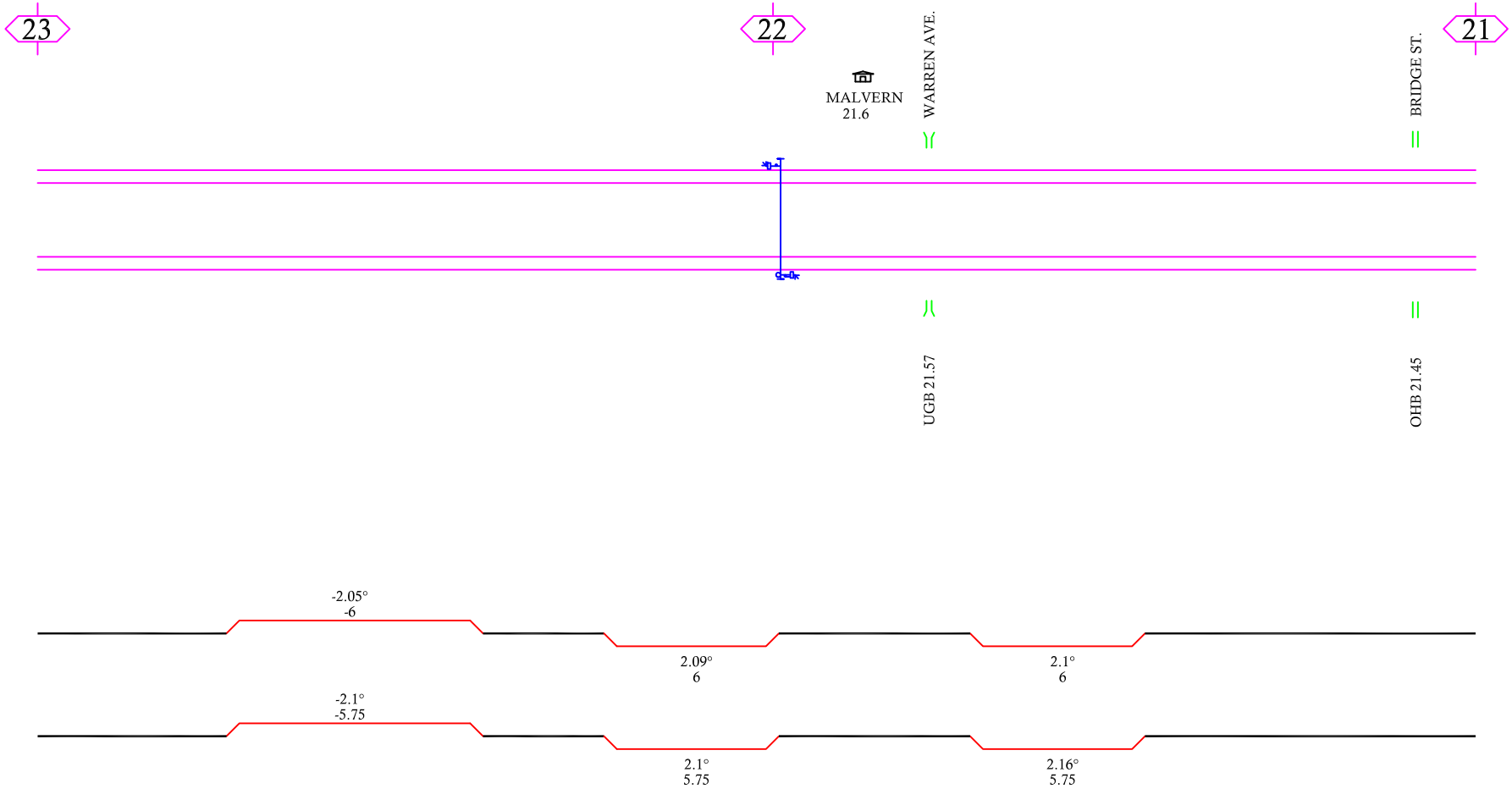
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SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK HARRISBURG LINE

(SEPTA PAOLI/MALVERN TO THORNDALE)

GEOMETRY CAR TRACK CHARTS
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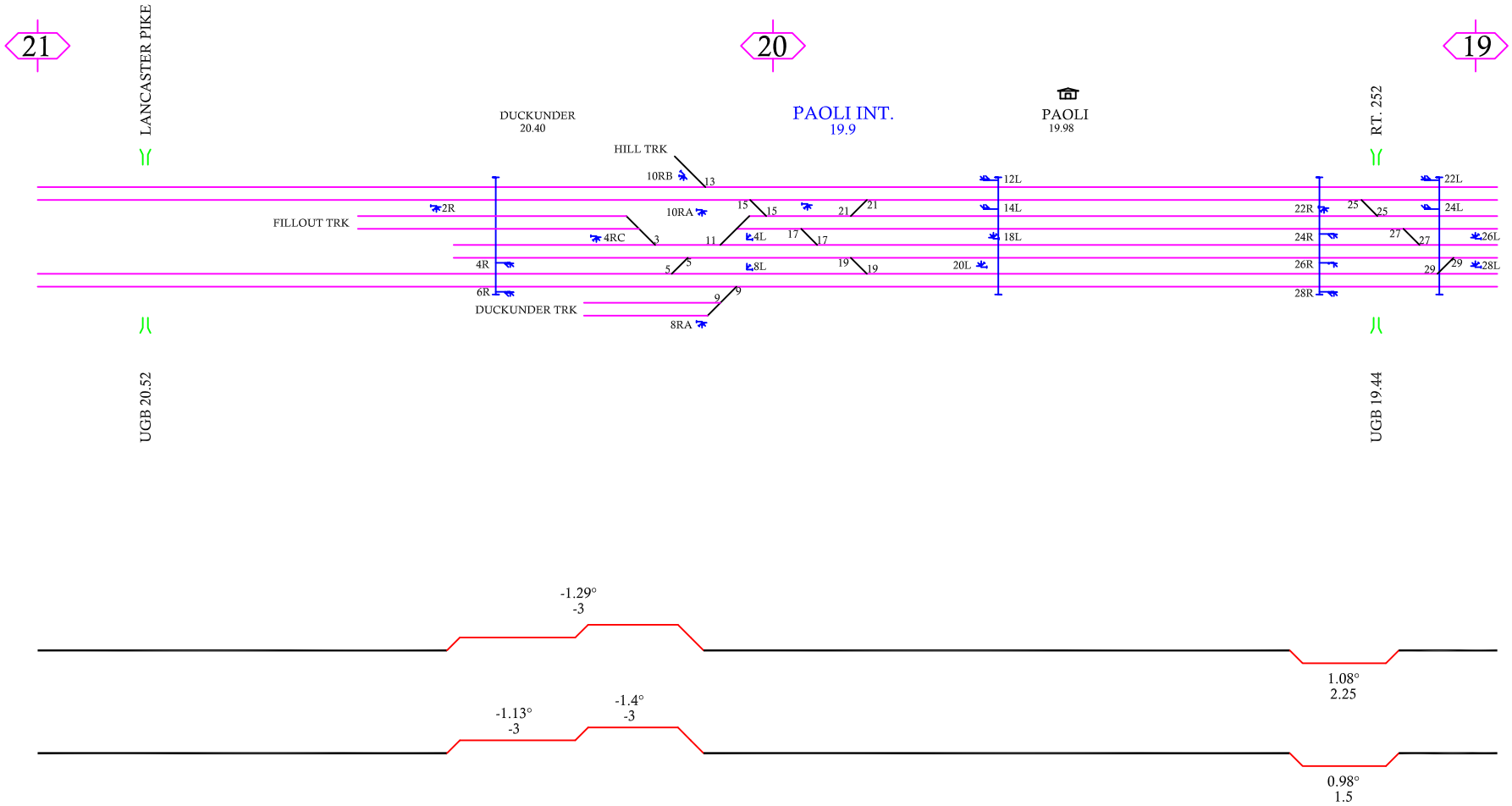
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SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK HARRISBURG LINE

(SEPTA PAOLI/MALVERN TO THORNDALE)

GEOMETRY CAR TRACK CHARTS
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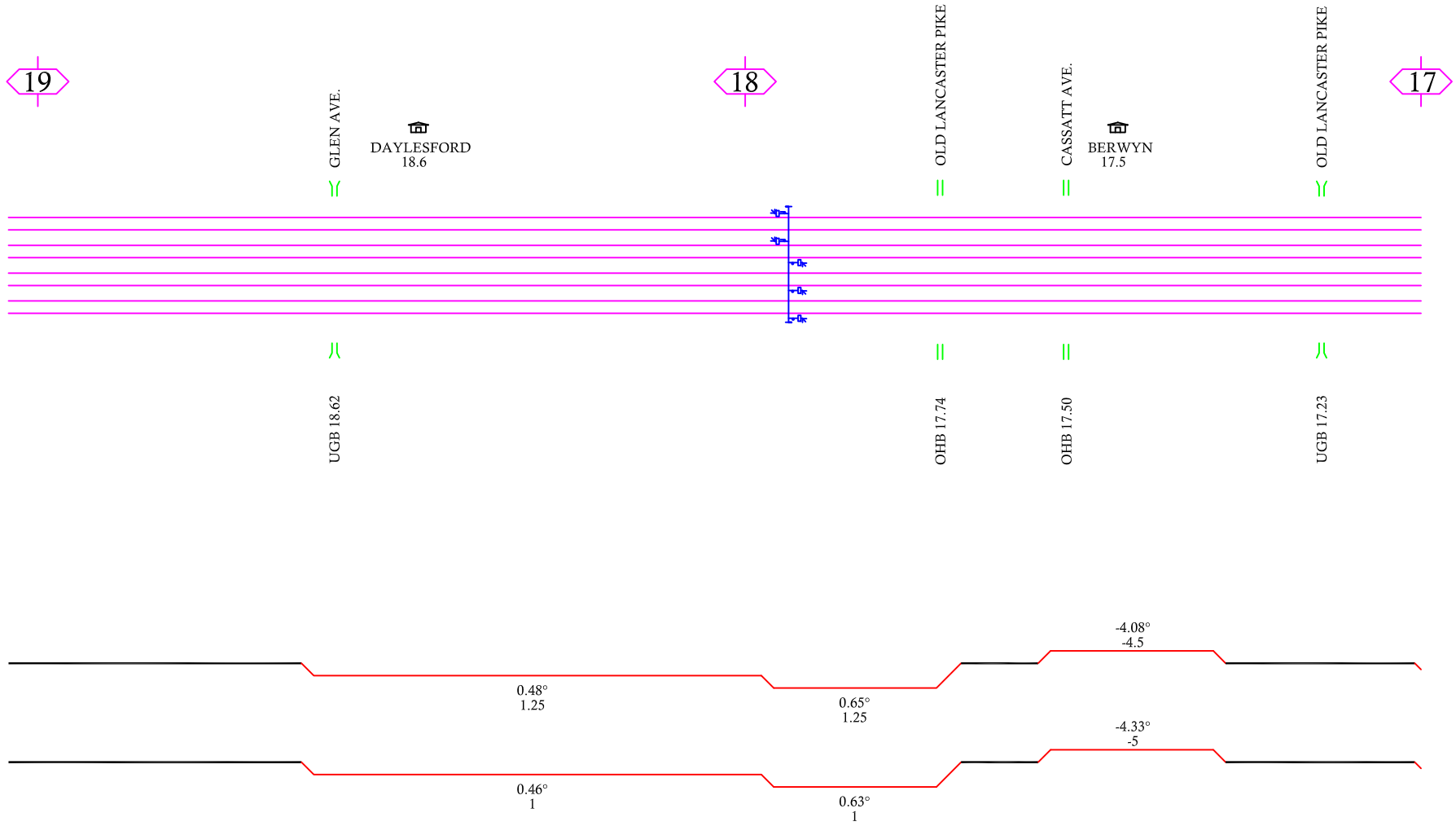
TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK HARRISBURG LINE

(SEPTA PAOLI/MALVERN TO THORNDALE)

GEOMETRY CAR TRACK CHARTS
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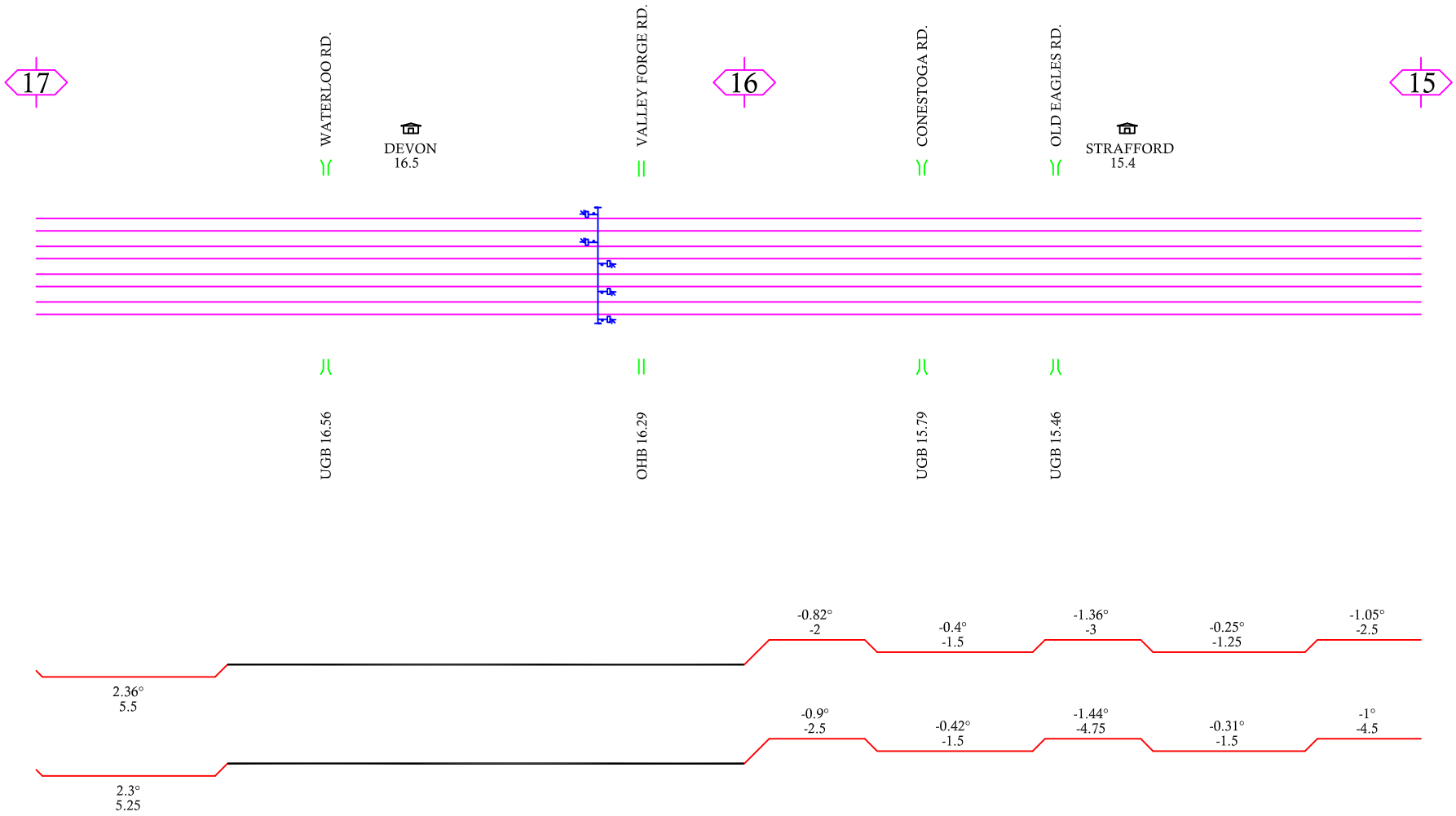
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SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK HARRISBURG LINE

(SEPTA PAOLI/MALVERN TO THORNDALE)

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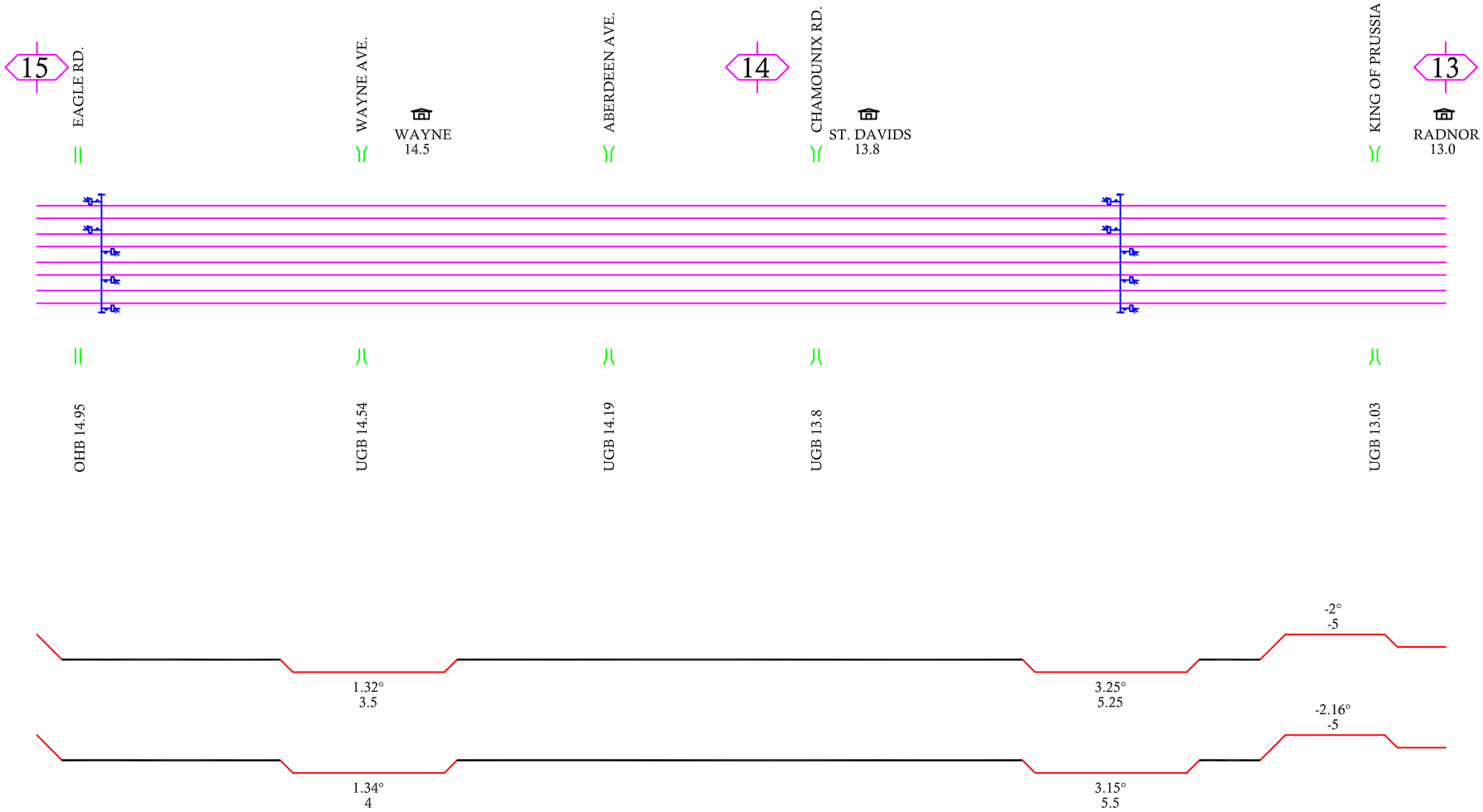
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SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK HARRISBURG LINE

(SEPTA PAOLI/MALVERN TO THORNDALE)

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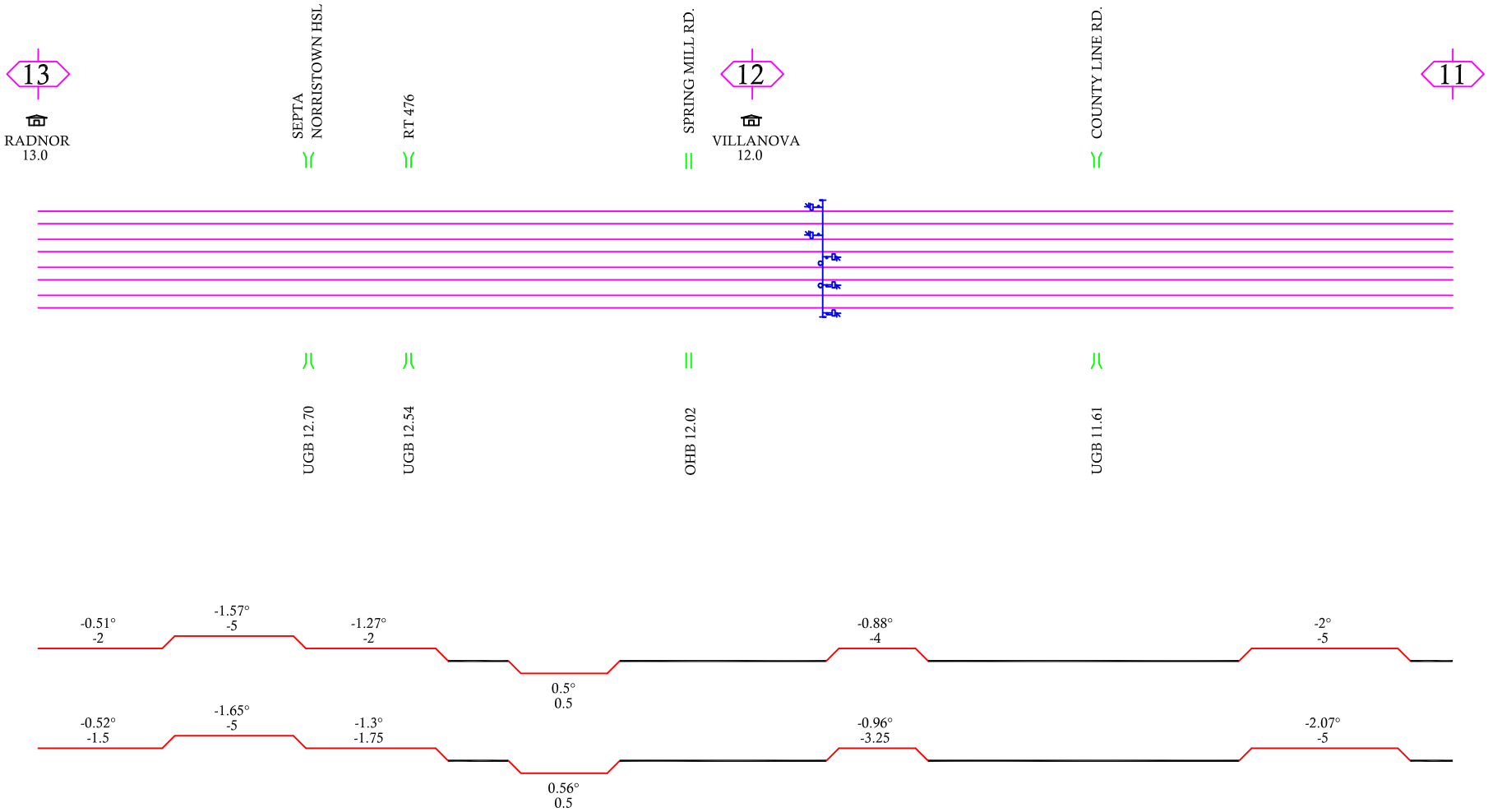
TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK HARRISBURG LINE

(SEPTA PAOLI/MALVERN TO THORNDALE)

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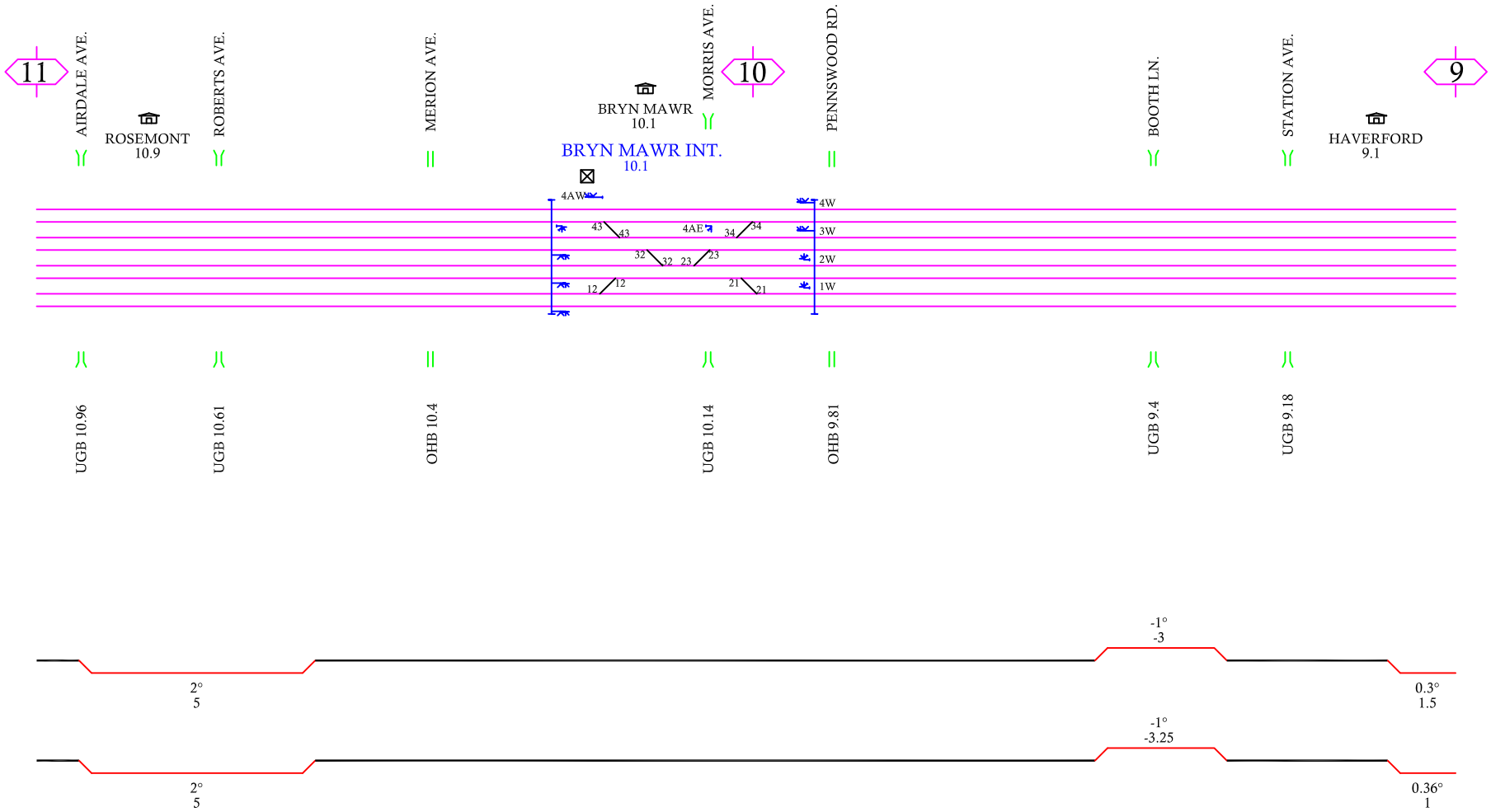
TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK HARRISBURG LINE

(SEPTA PAOLI/MALVERN TO THORNDALE)

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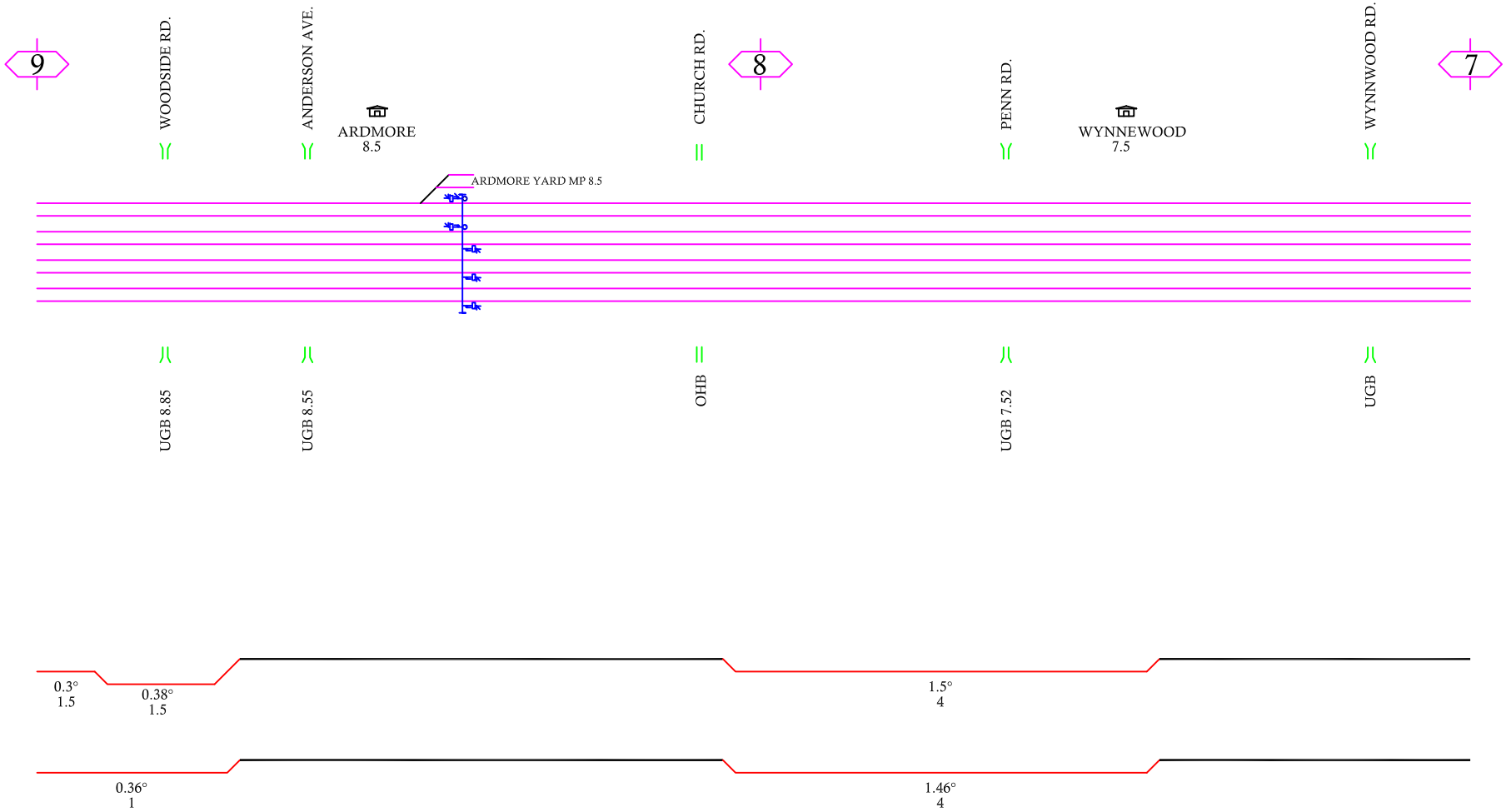
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SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK HARRISBURG LINE

(SEPTA PAOLI/MALVERN TO THORNDALE)

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
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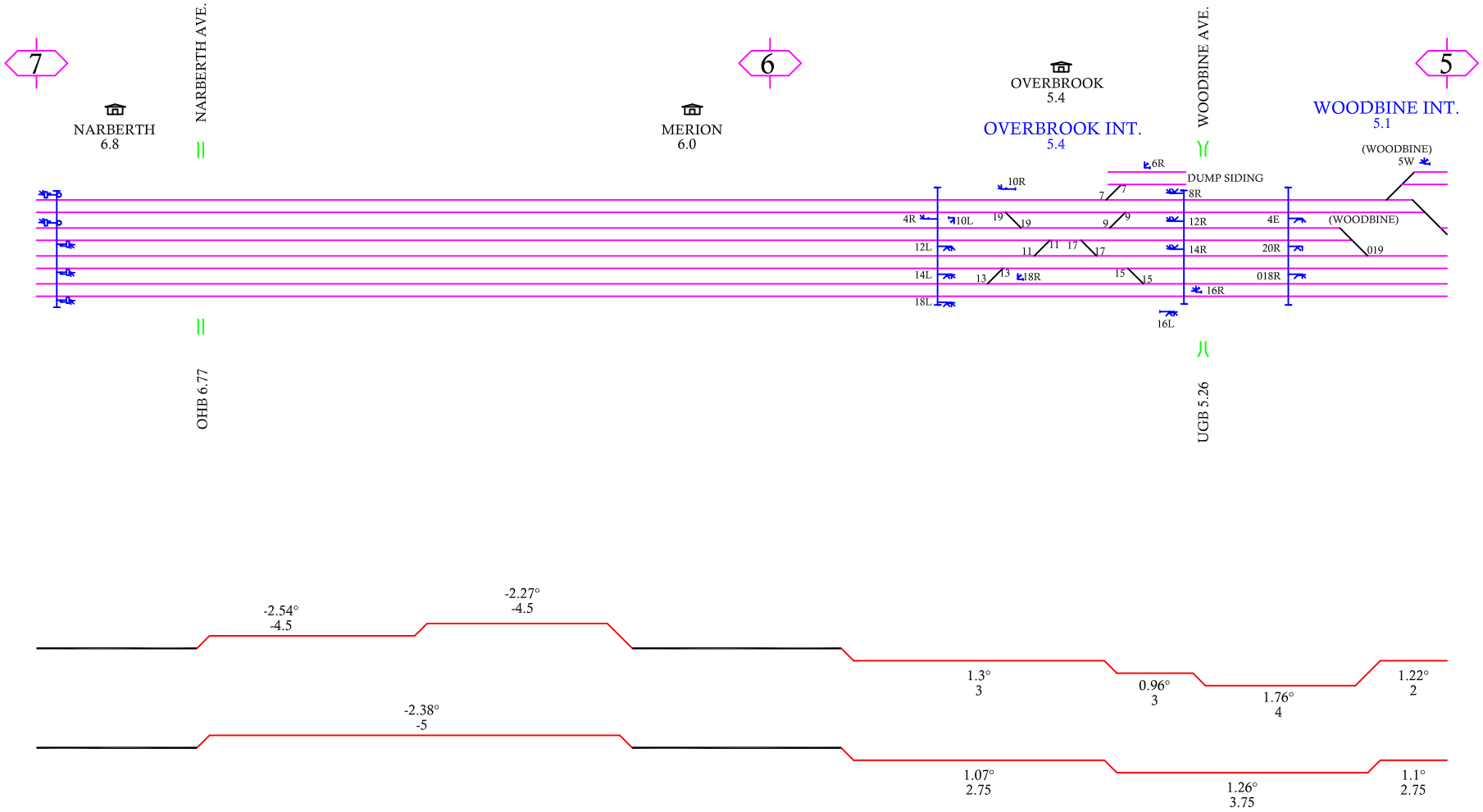
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SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK HARRISBURG LINE

(SEPTA PAOLI/MALVERN TO THORNDALE)

GEOMETRY CAR TRACK CHARTS
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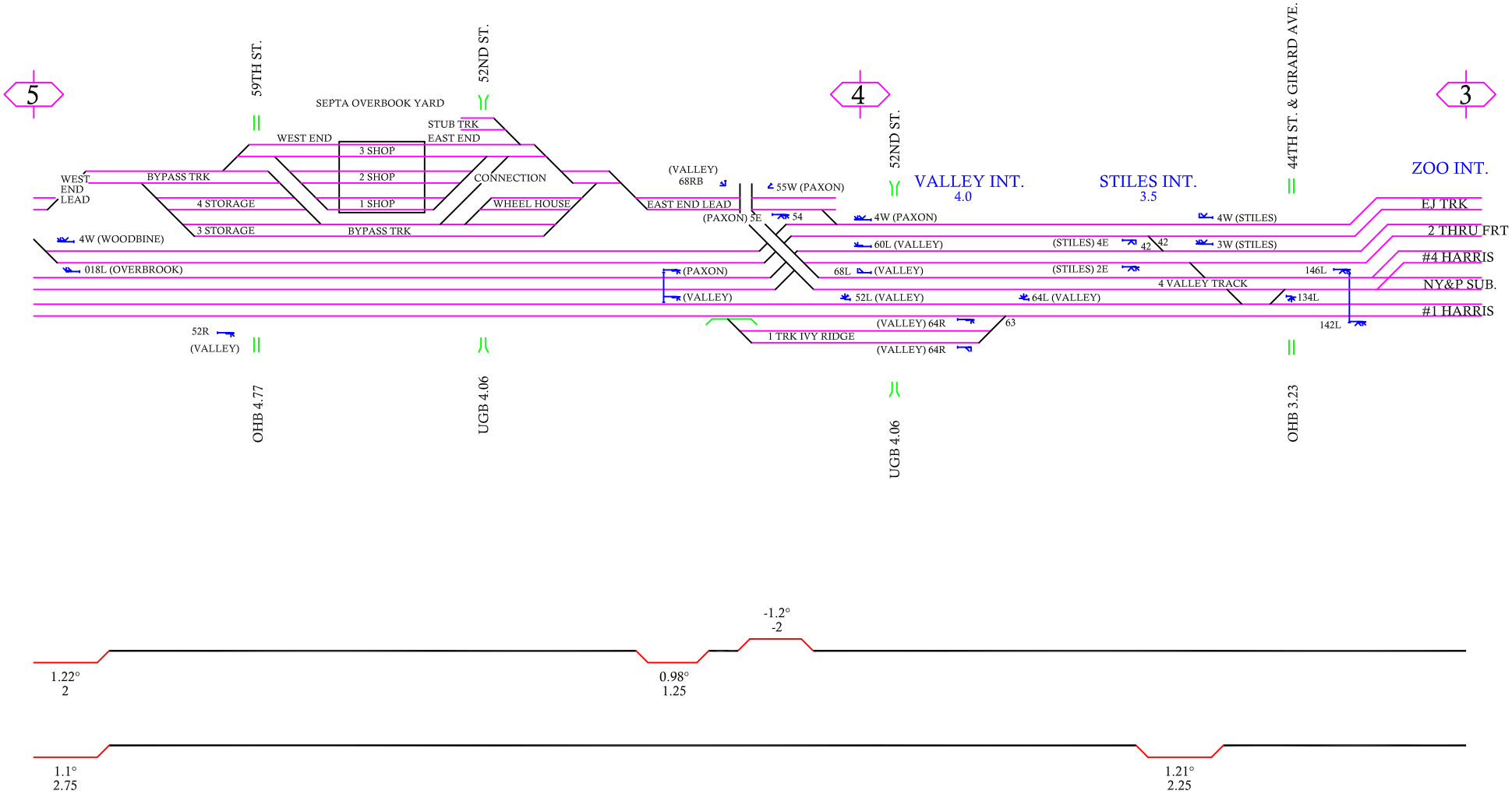
TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
ADJ. RAIL TEMP									
RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK HARRISBURG LINE

(SEPTA PAOLI/MALVERN TO THORNDALE)

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 6/2012



GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 6/2012

#4

TIES	AMTRAK	AMTRAK	AMTRAK	08	08
SURFACING	AMTRAK	AMTRAK	AMTRAK	08	08
ADJ. RAIL TEMP					
RAIL	AMTRAK	AMTRAK	AMTRAK	32 R-07 L-08	
BRUSH CUTTING	AMTRAK	AMTRAK	08	08	

#2/#3

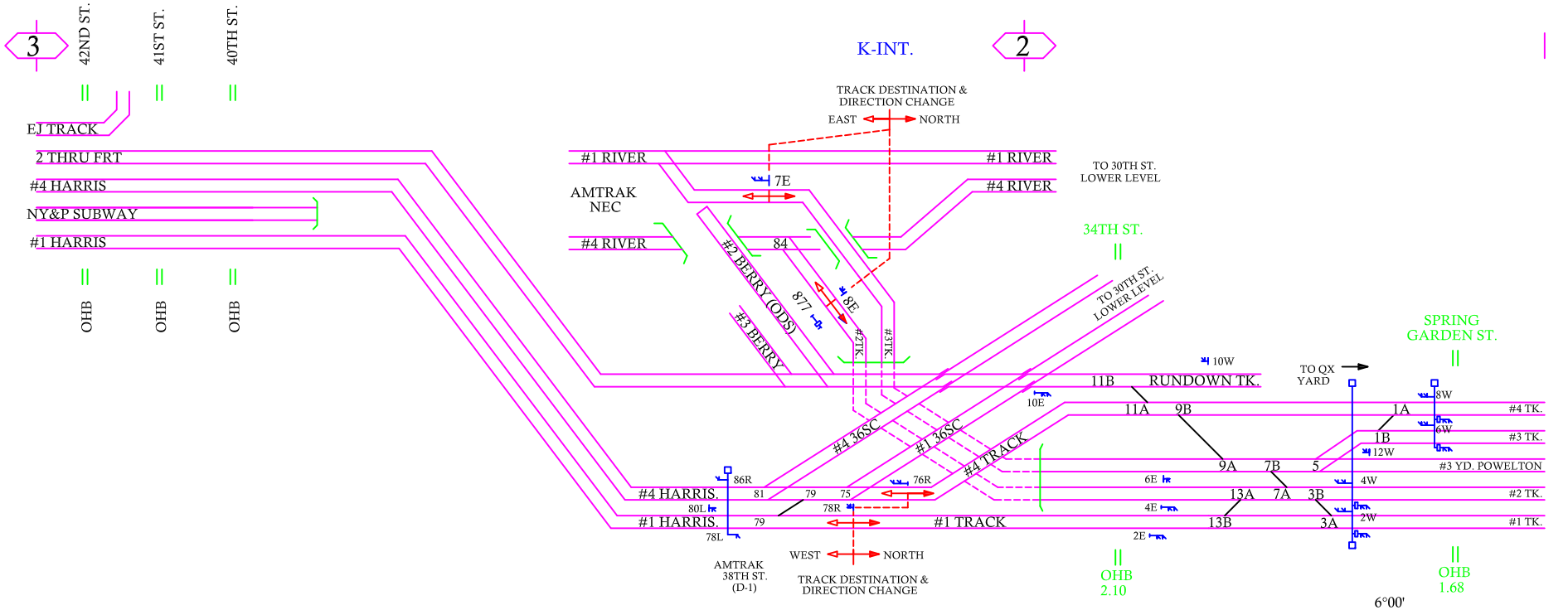
	#2 TRACK		#3 TRACK	
TIES	AMTRAK	08	08	08
SURFACING	AMTRAK	08	08	08
ADJ. RAIL TEMP				
RAIL	AMTRAK	32 R-07 L-08	32 R-07 L-08	
BRUSH CUTTING	AMTRAK	08	08	08

	#3 TRACK		#2 TRACK	
TIES	08	08	08	
SURFACING	08		08	
ADJ. RAIL TEMP				
RAIL	32 R-07 L-08		32 R-07 L-08	
BRUSH CUTTING	08	08	08	

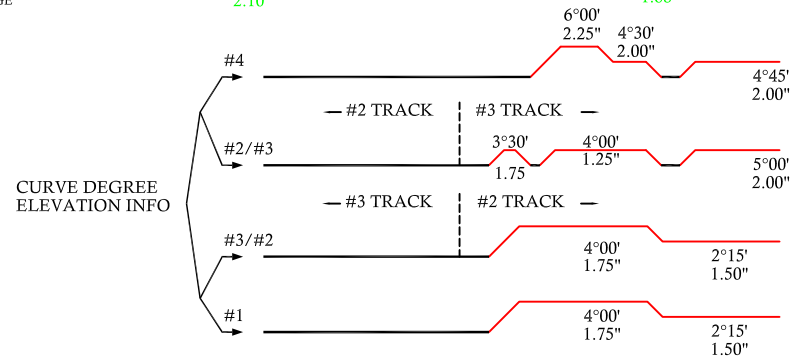
TIES	08	08
SURFACING	08	08
ADJ. RAIL TEMP		
RAIL	32 R-07 L-08	
BRUSH CUTTING	08	08

AMTRAK HARRISBURG LINE

(SEPTA PAOLI/MALVERN TO THORNDALE)



CURVE DEGREE ELEVATION INFO

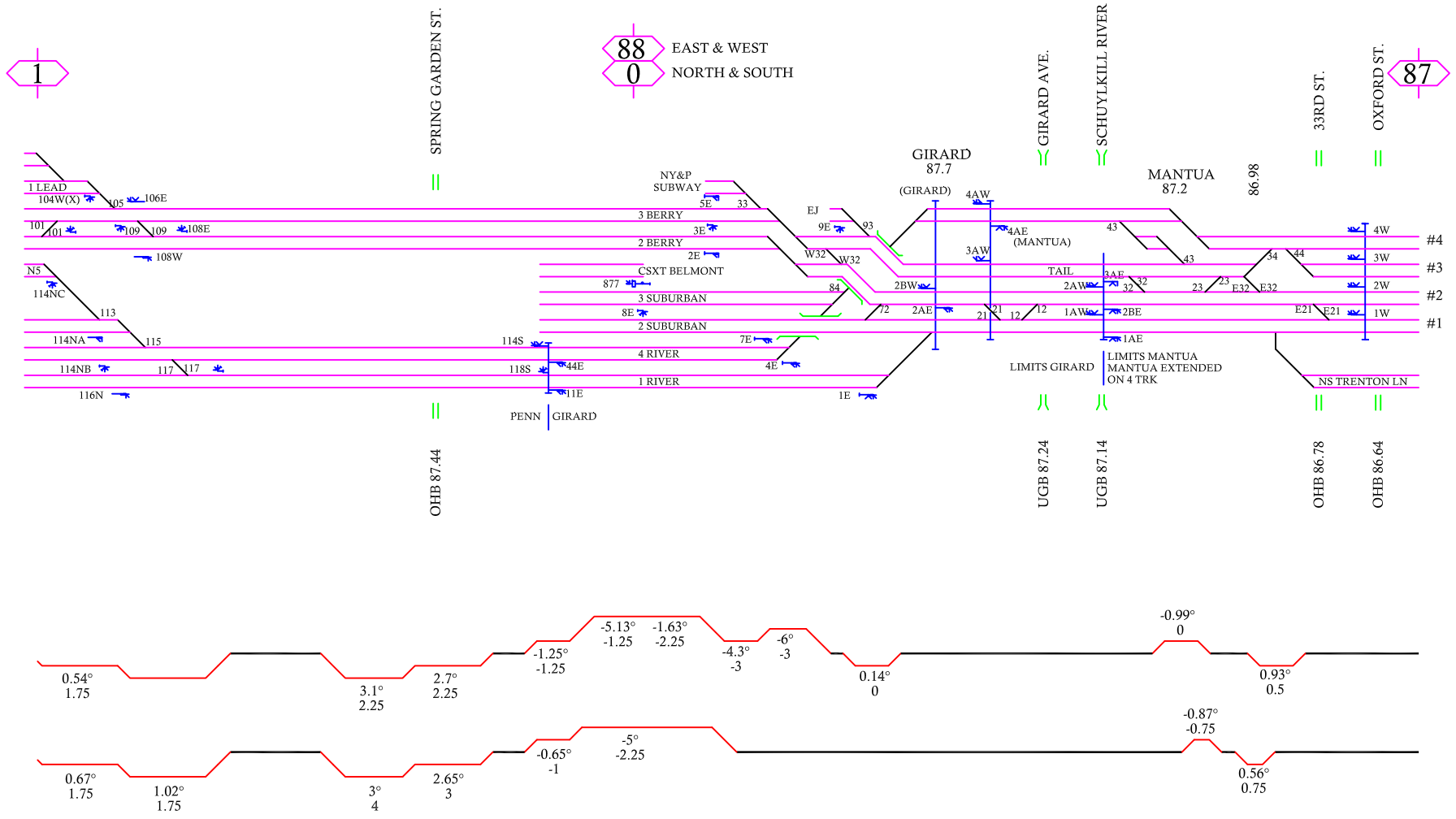


#4	TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
	SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
	ADJ. RAIL TEMP									
	RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
	BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
#2/#3	TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
	SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
	ADJ. RAIL TEMP									
	RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
	BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK NORTHEAST CORRIDOR

(SEPTA TRENTON LINE)

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 6/2012



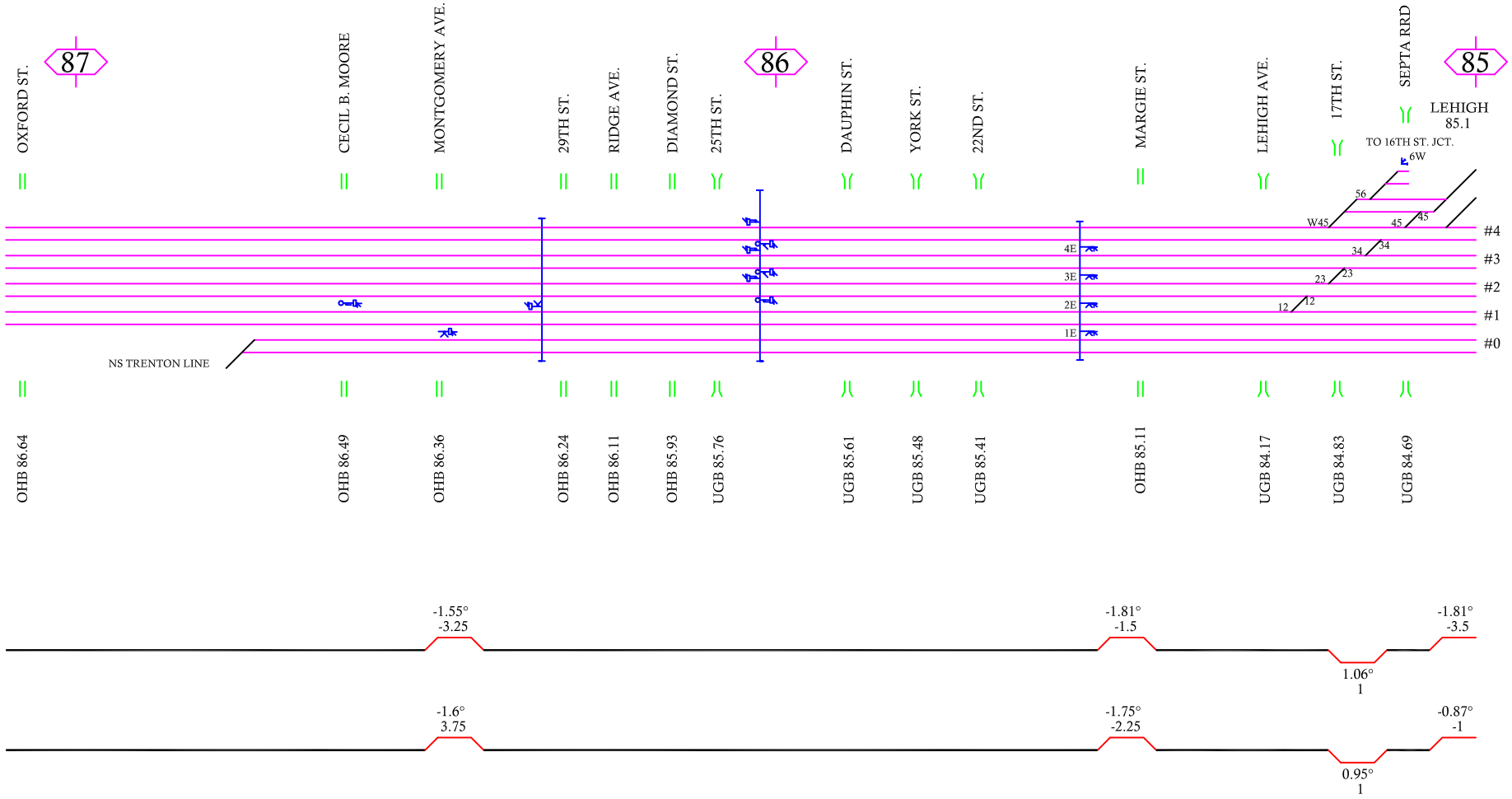
#4	TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
	SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
	ADJ. RAIL TEMP									
	RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
	BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

#2/#3	TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
	SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
	ADJ. RAIL TEMP									
	RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
	BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK NORTHEAST CORRIDOR

(SEPTA TRENTON LINE)

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
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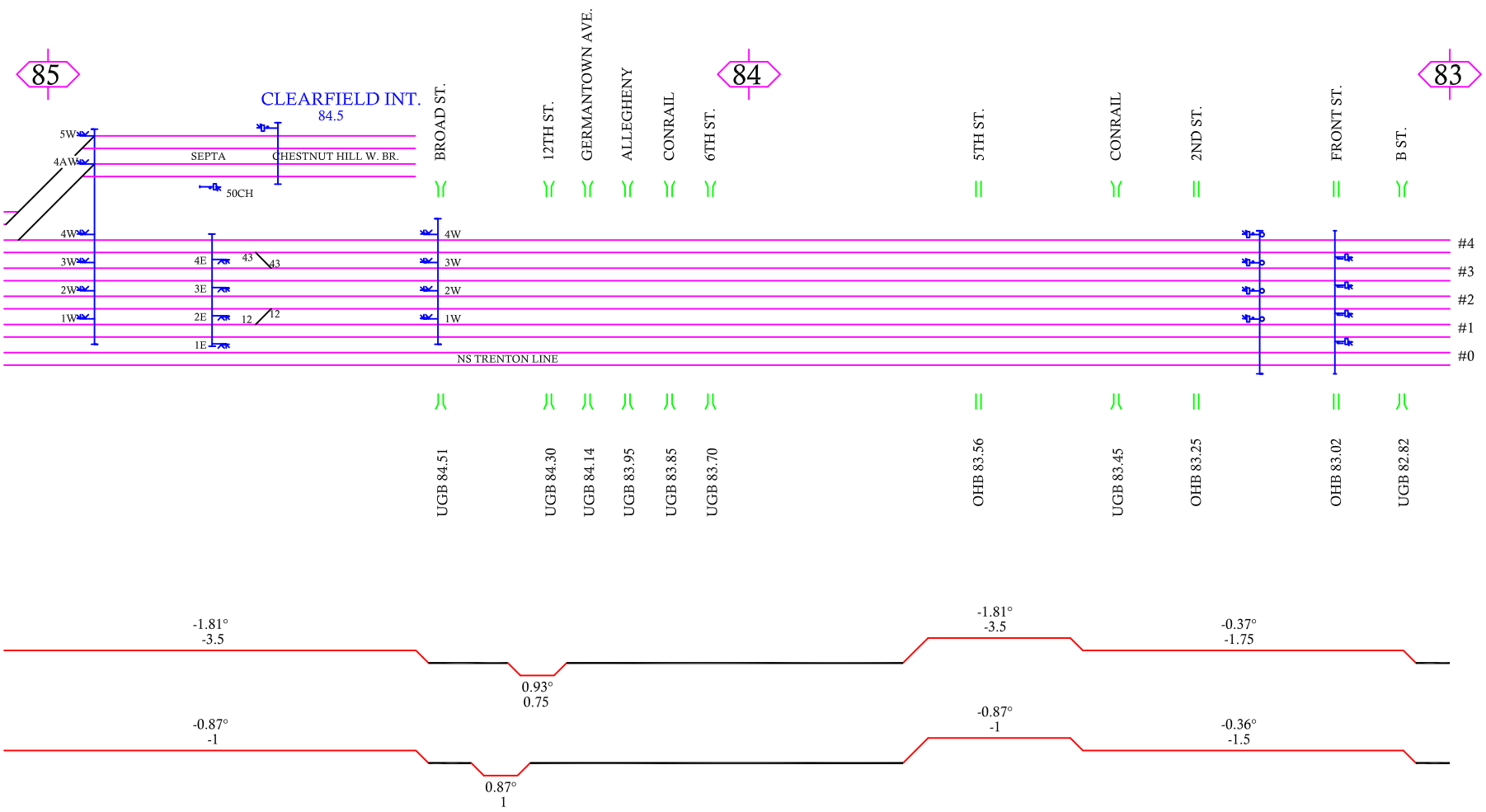
#4	TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
	SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
	ADJ. RAIL TEMP									
	RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
	BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

#2/#3	TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
	SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
	ADJ. RAIL TEMP									
	RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
	BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK NORTHEAST CORRIDOR

(SEPTA TRENTON LINE)

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 6/2012

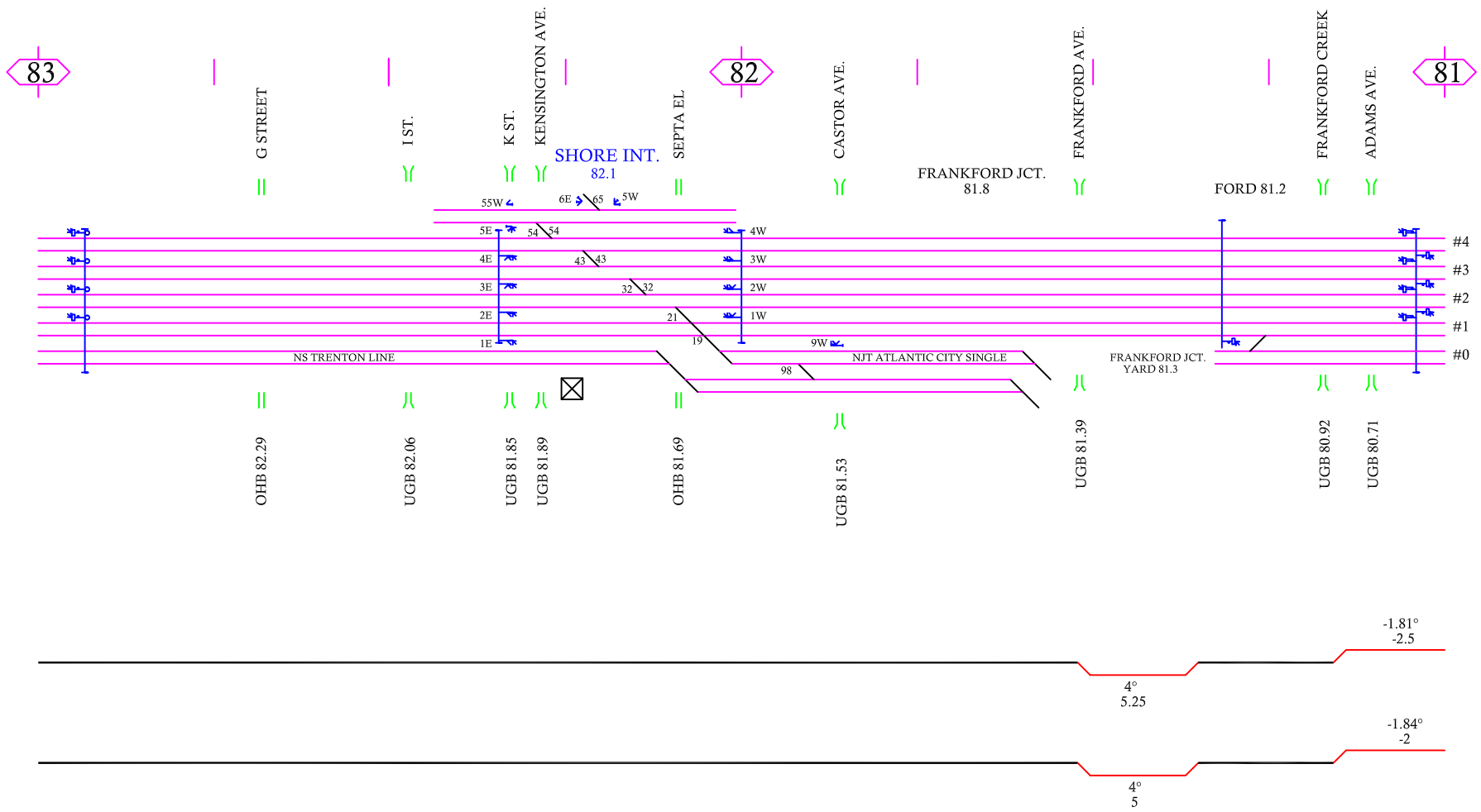


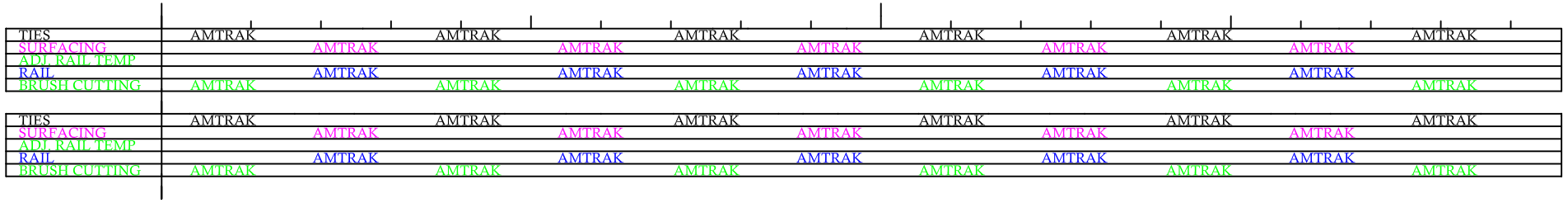
#4	TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
	SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
	ADJ. RAIL TEMP									
	RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
	BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
#2/#3	TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
	SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
	ADJ. RAIL TEMP									
	RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
	BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK NORTHEAST CORRIDOR

(SEPTA TRENTON LINE)

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 6/2012

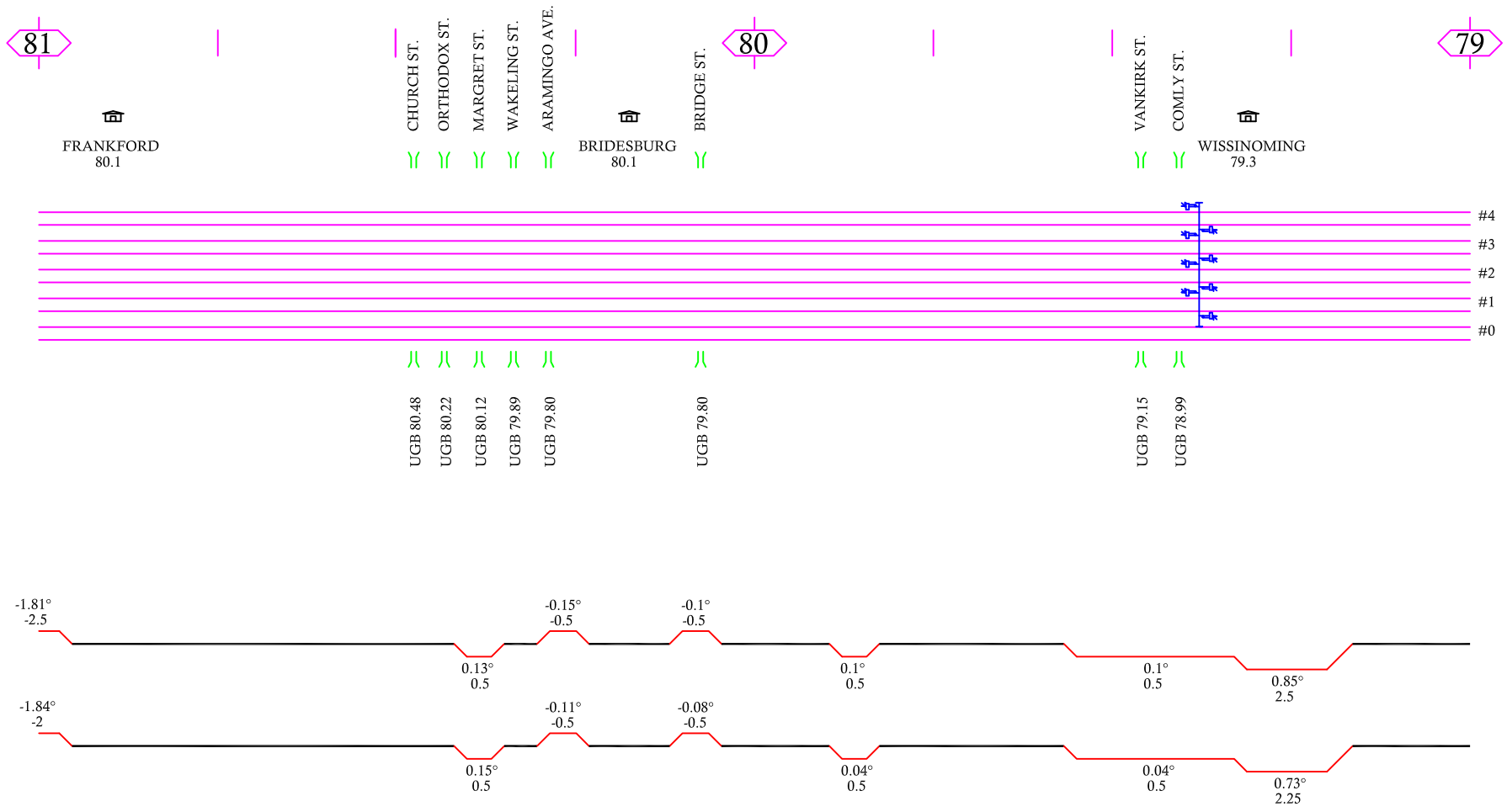


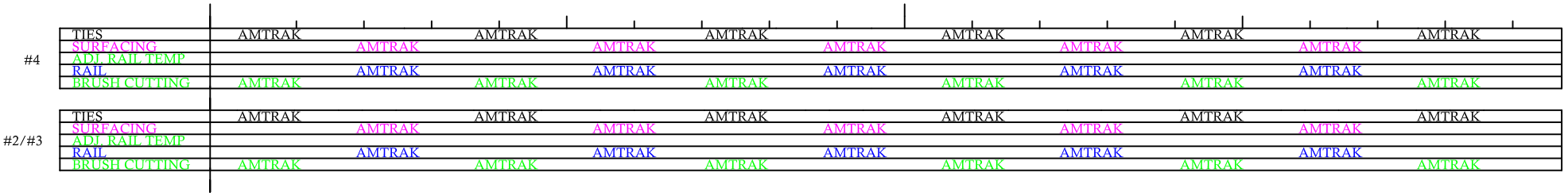


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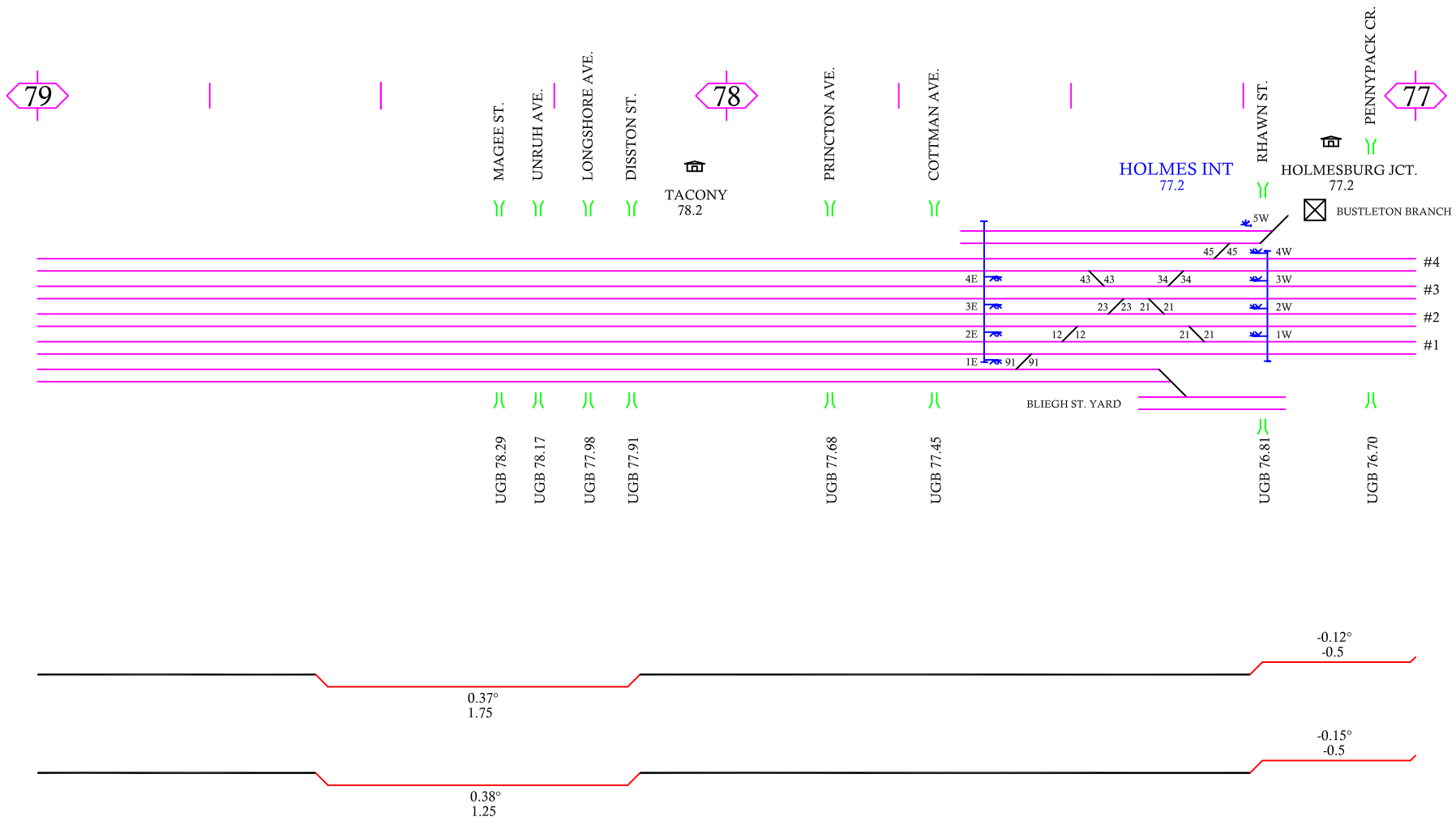


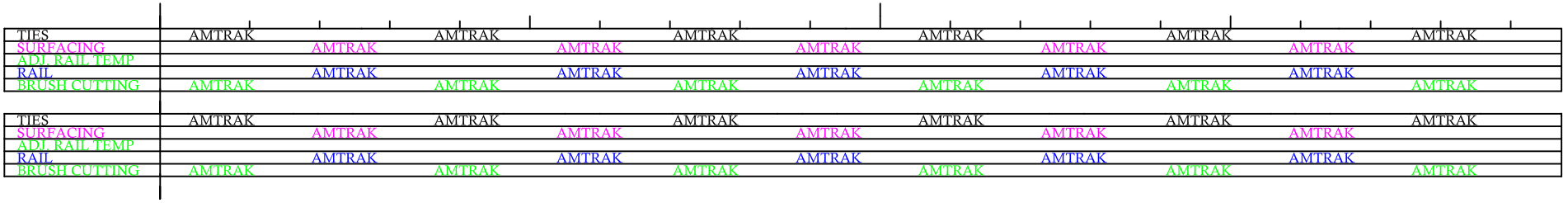


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(SEPTA TRENTON LINE)

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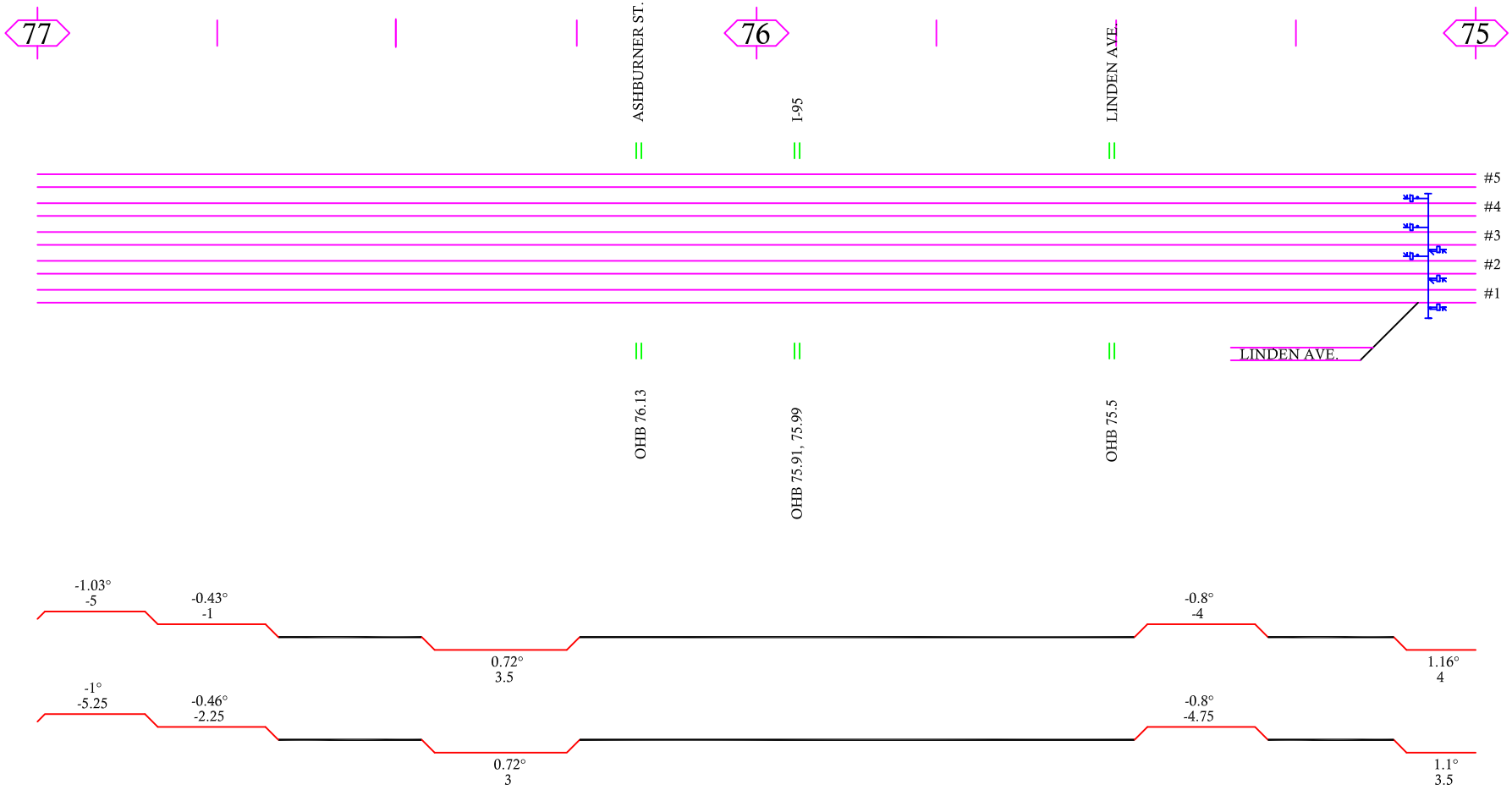




AMTRAK NORTHEAST CORRIDOR

(SEPTA TRENTON LINE)

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DRAWINGS BY T. LEWIS
REV - 6/2012

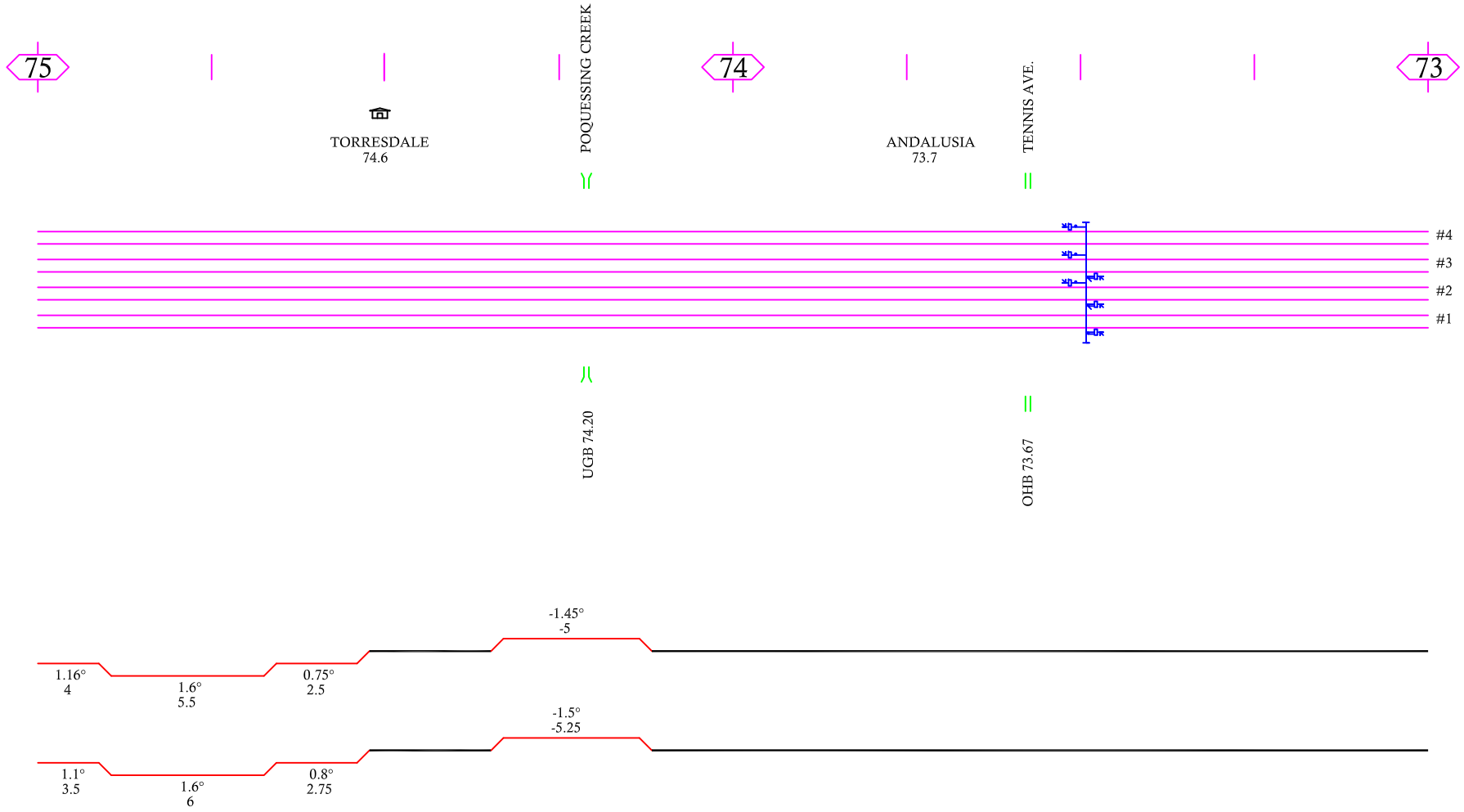


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	BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
#2/#3	TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
	SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
	ADJ. RAIL TEMP									
	RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
	BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK NORTHEAST CORRIDOR

(SEPTA TRENTON LINE)

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 6/2012

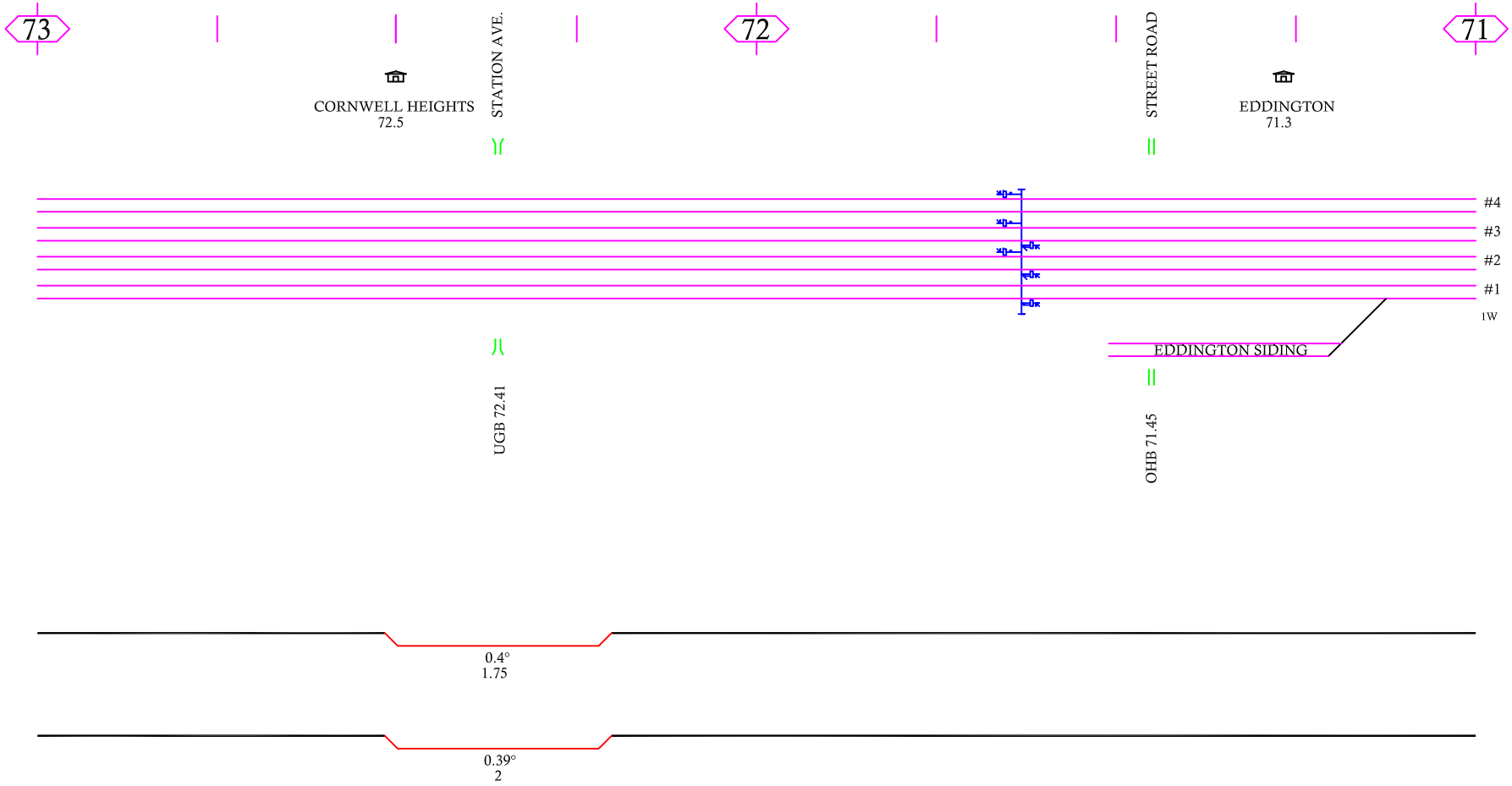


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	ADJ. RAIL TEMP									
	RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
	BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
#2/#3	TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
	SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
	ADJ. RAIL TEMP									
	RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
	BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK NORTHEAST CORRIDOR

(SEPTA TRENTON LINE)

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DRAWINGS BY T. LEWIS
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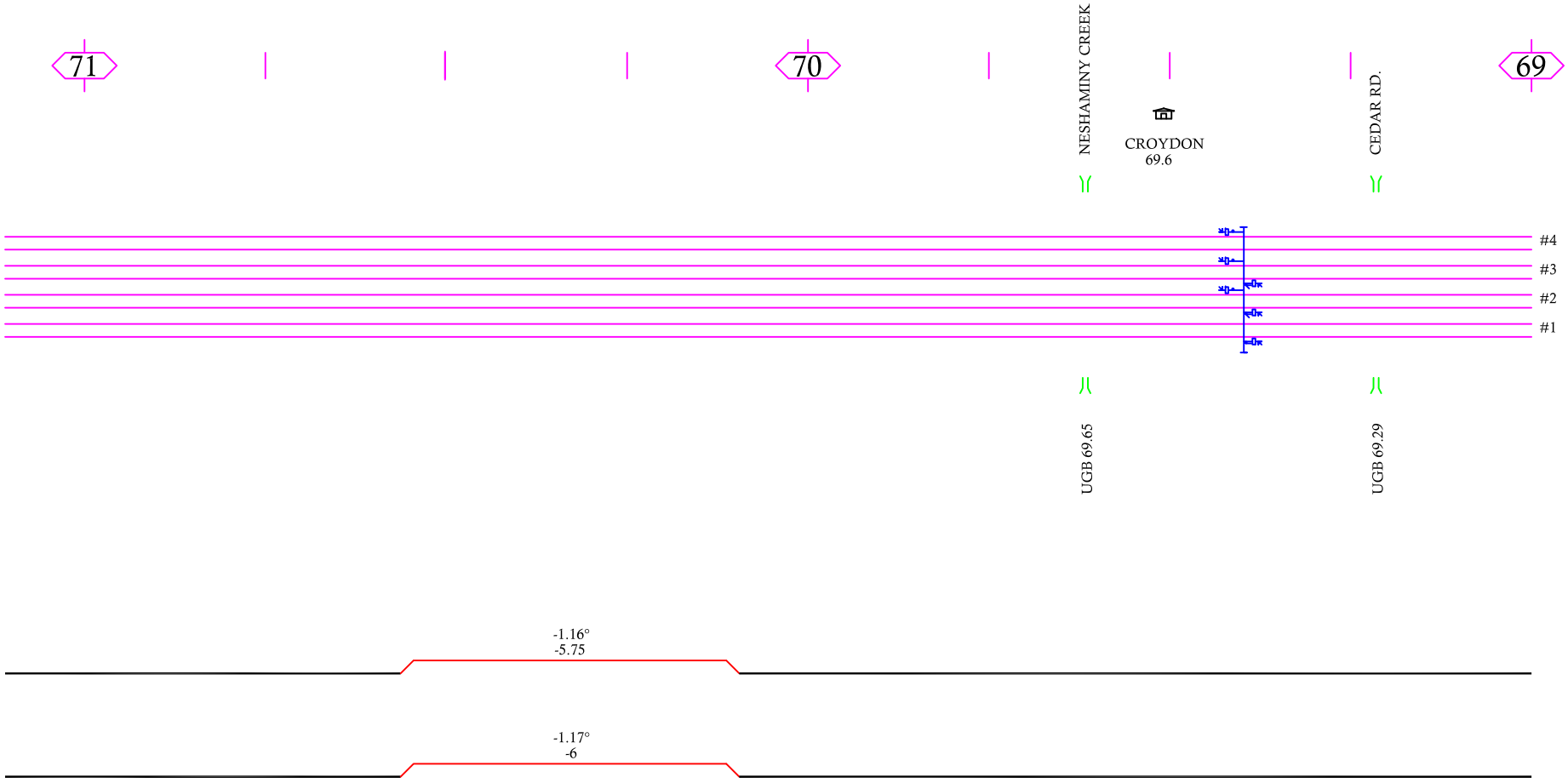
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	BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

#2/#3	TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
	SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
	ADJ. RAIL TEMP									
	RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
	BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK NORTHEAST CORRIDOR

(SEPTA TRENTON LINE)

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 6/2012



#4	TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
	SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
	ADJ. RAIL TEMP									
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	BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

#2/#3	TIES	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
	SURFACING		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
	ADJ. RAIL TEMP									
	RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
	BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK NORTHEAST CORRIDOR

(SEPTA TRENTON LINE)

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 6/2012

69 | | | 68 | | | 67

CROY INT.
68.3

RT. 413

#4
#3
#2
#1

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9E
9I
1W

UGB 67.46

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0.5°
2.25

-0.13°
-0.5

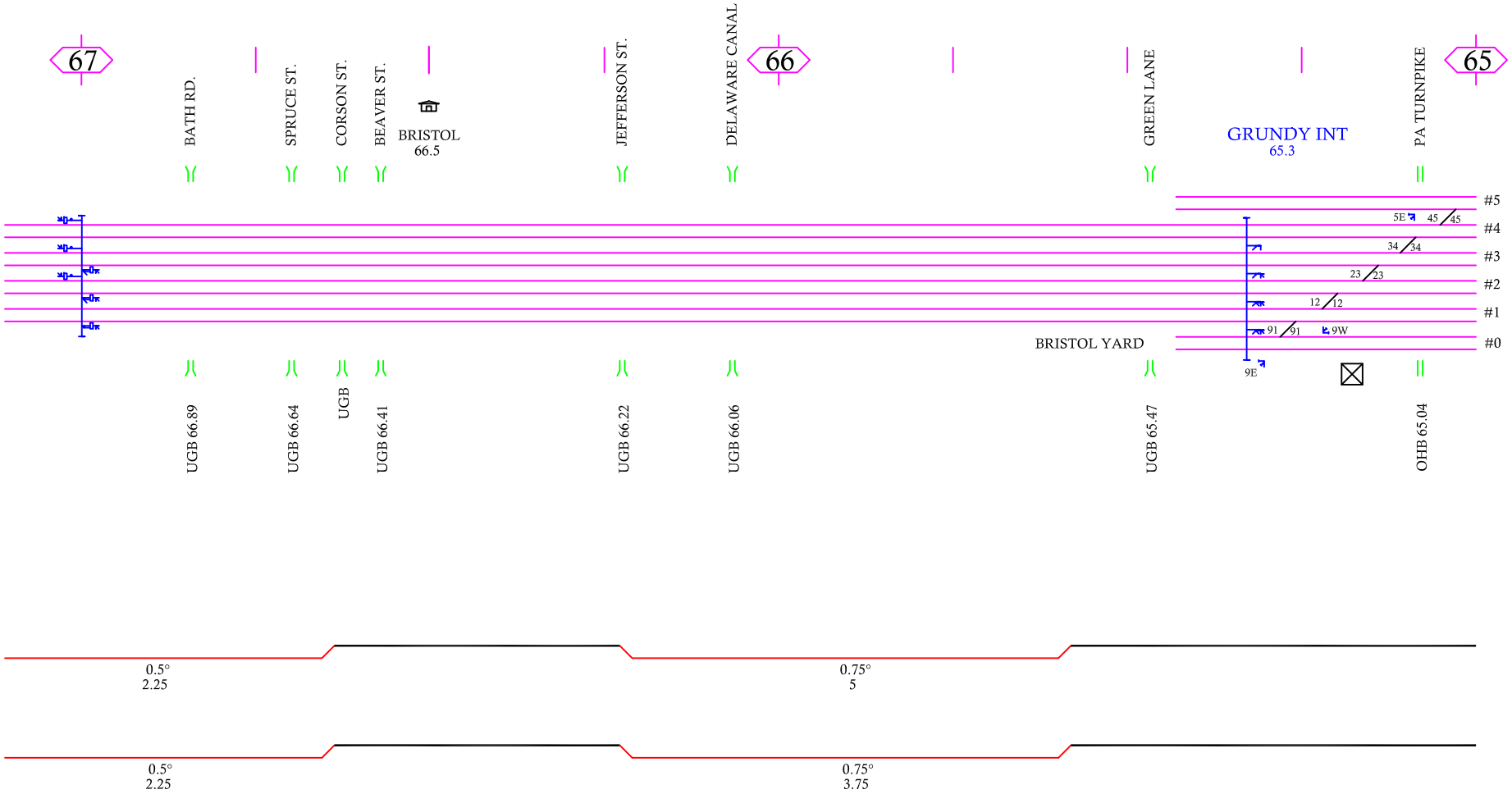
0.5°
2.25

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	BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
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	RAIL		AMTRAK		AMTRAK		AMTRAK		AMTRAK	
	BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

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(SEPTA TRENTON LINE)

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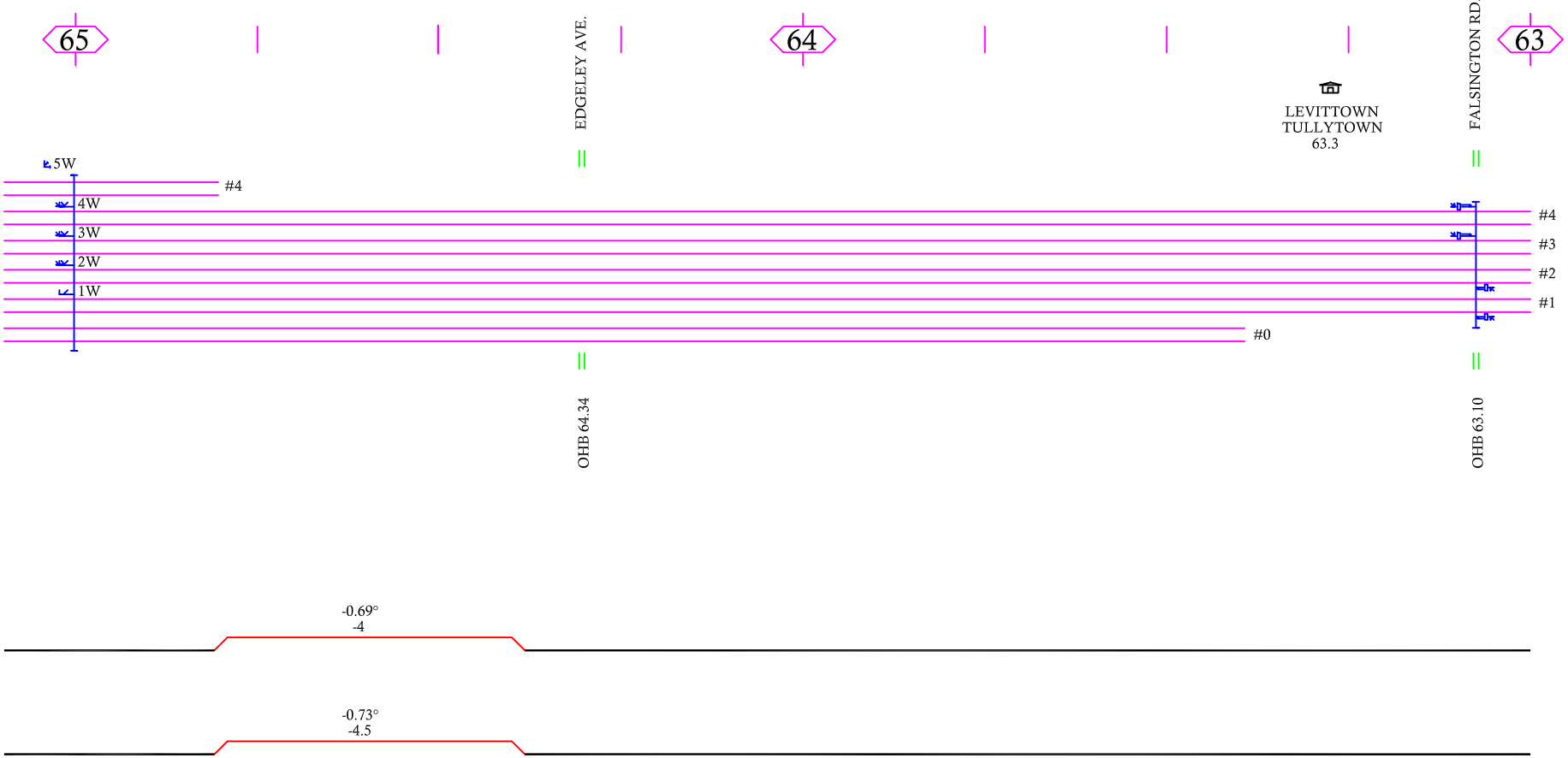


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	BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK NORTHEAST CORRIDOR

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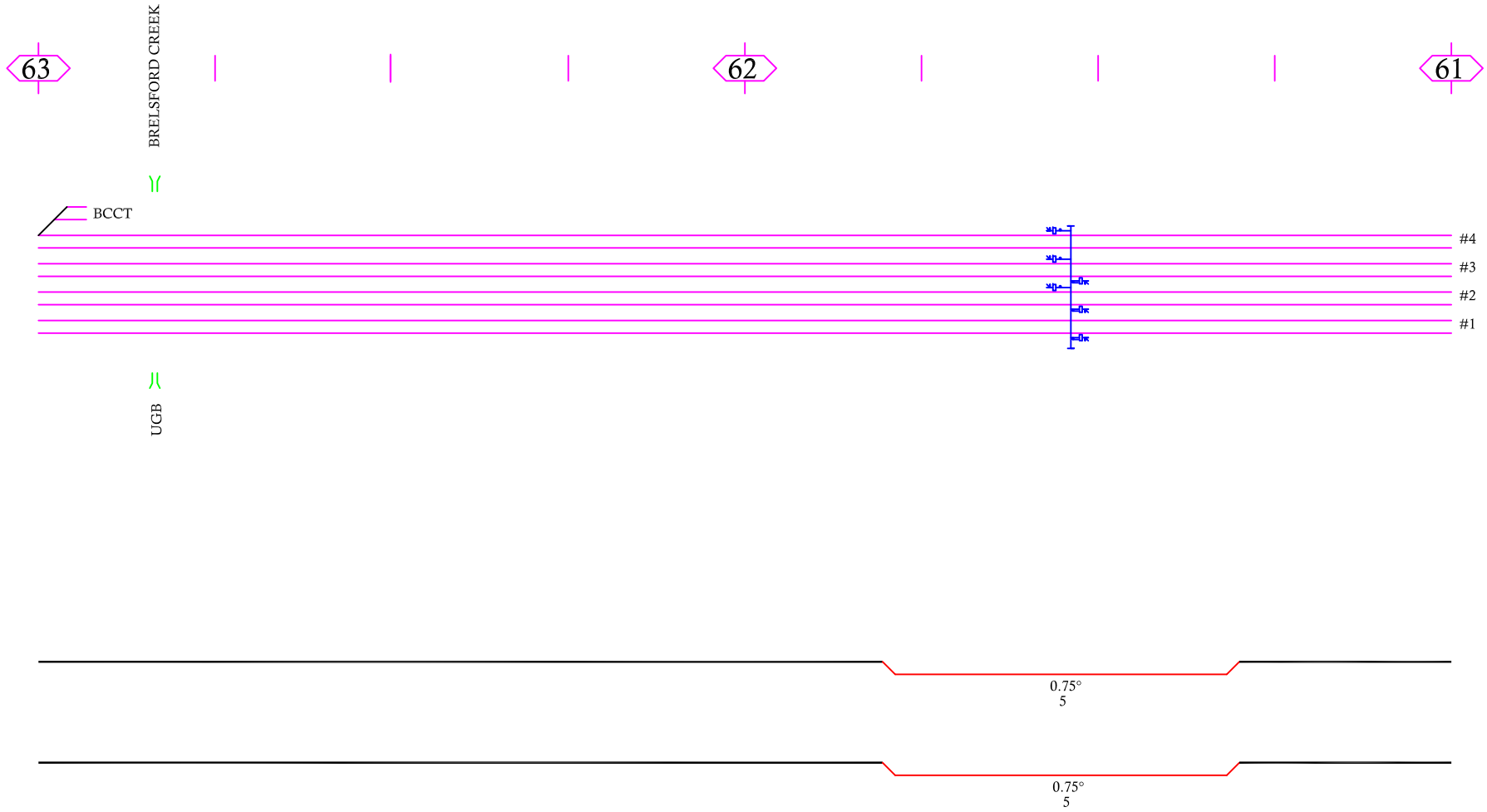


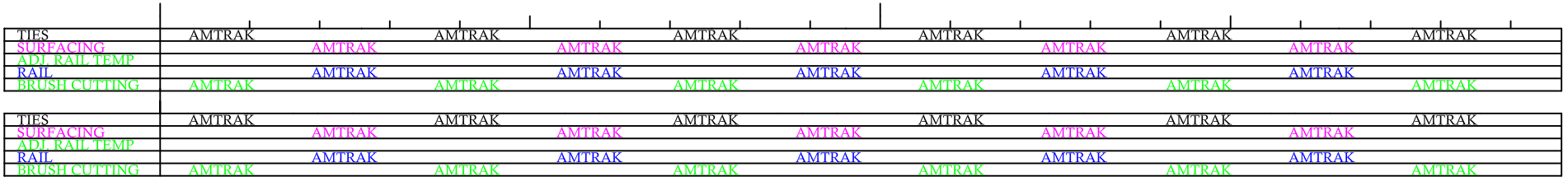
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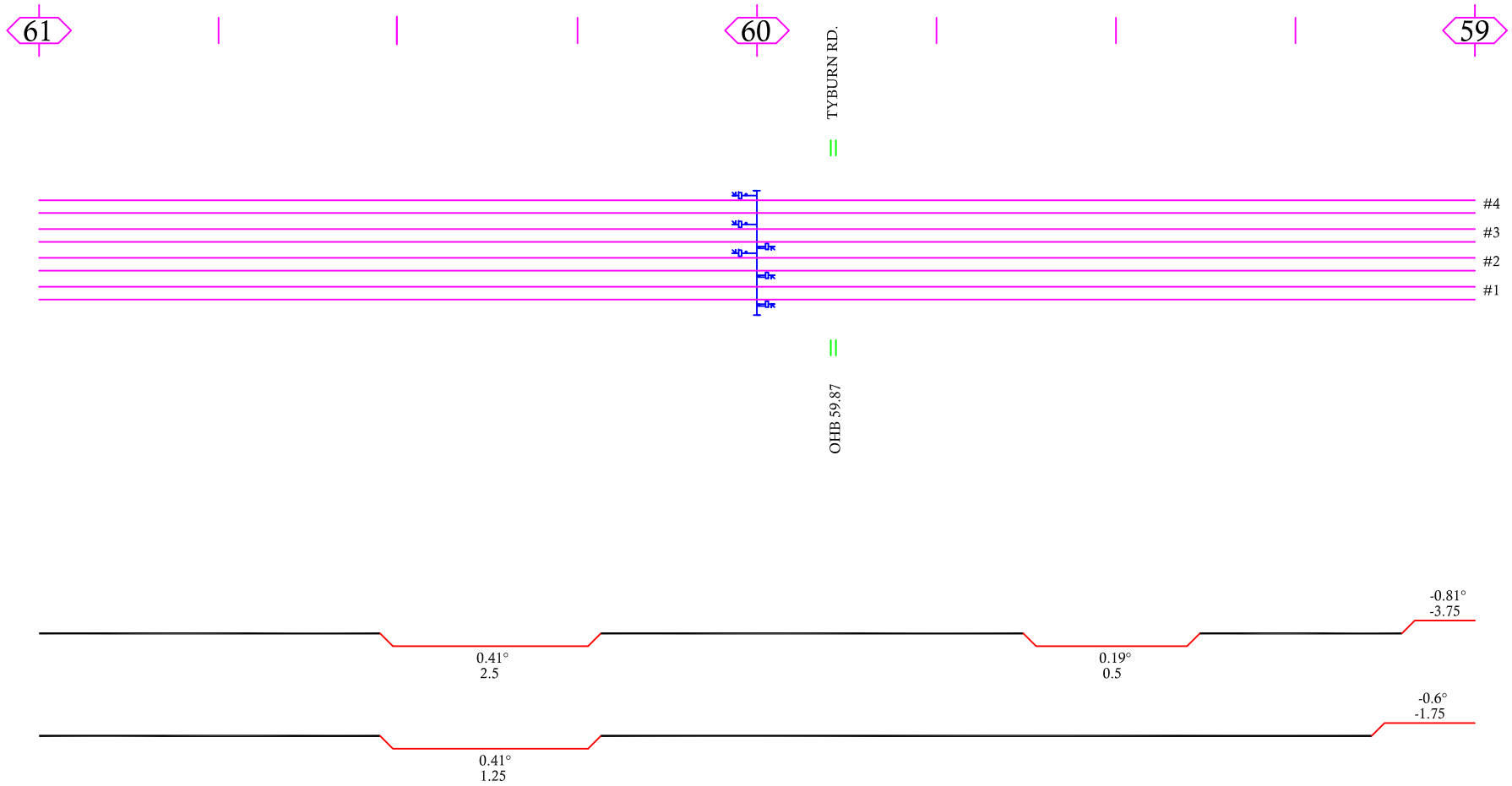




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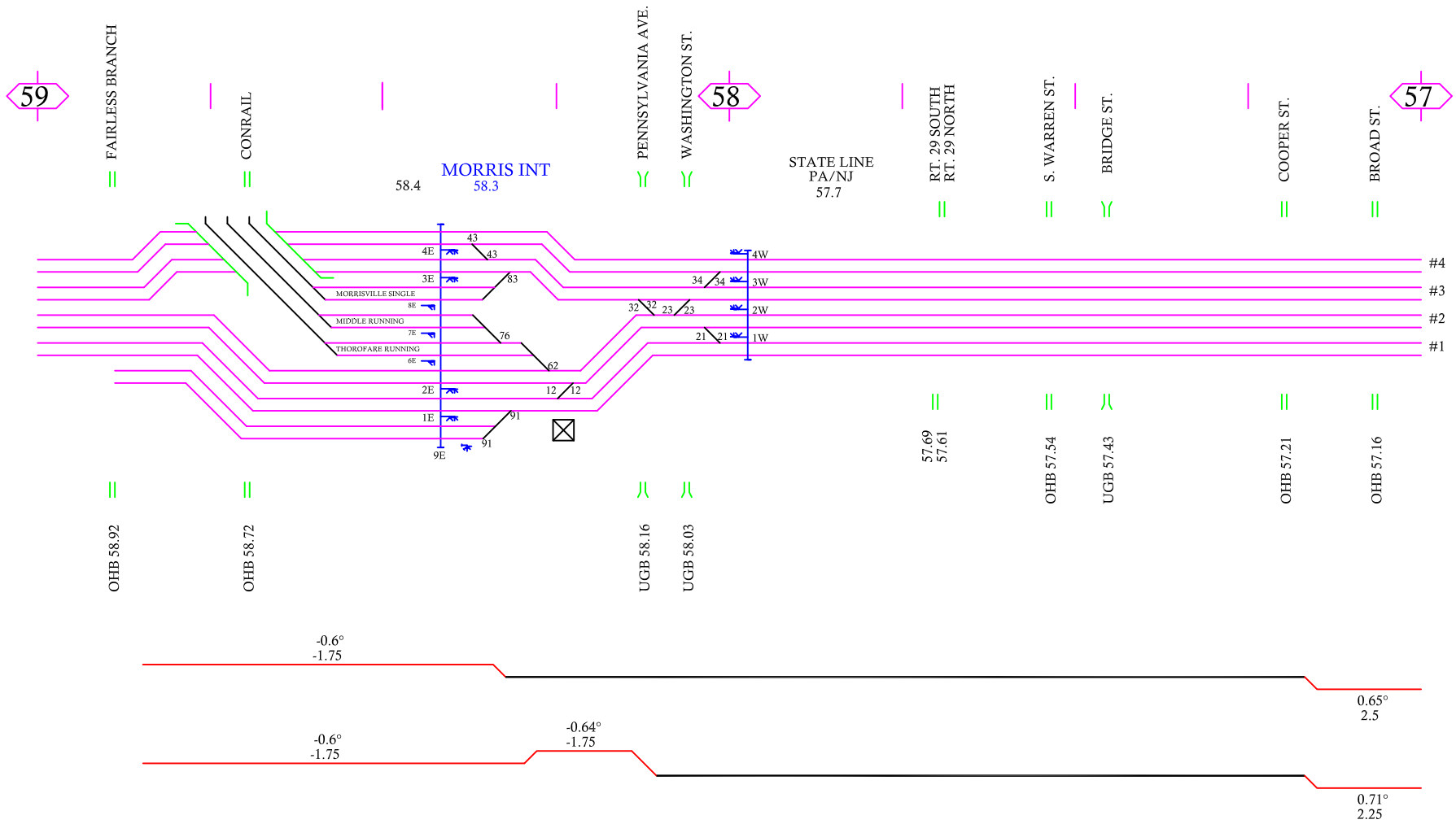
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	BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

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	BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

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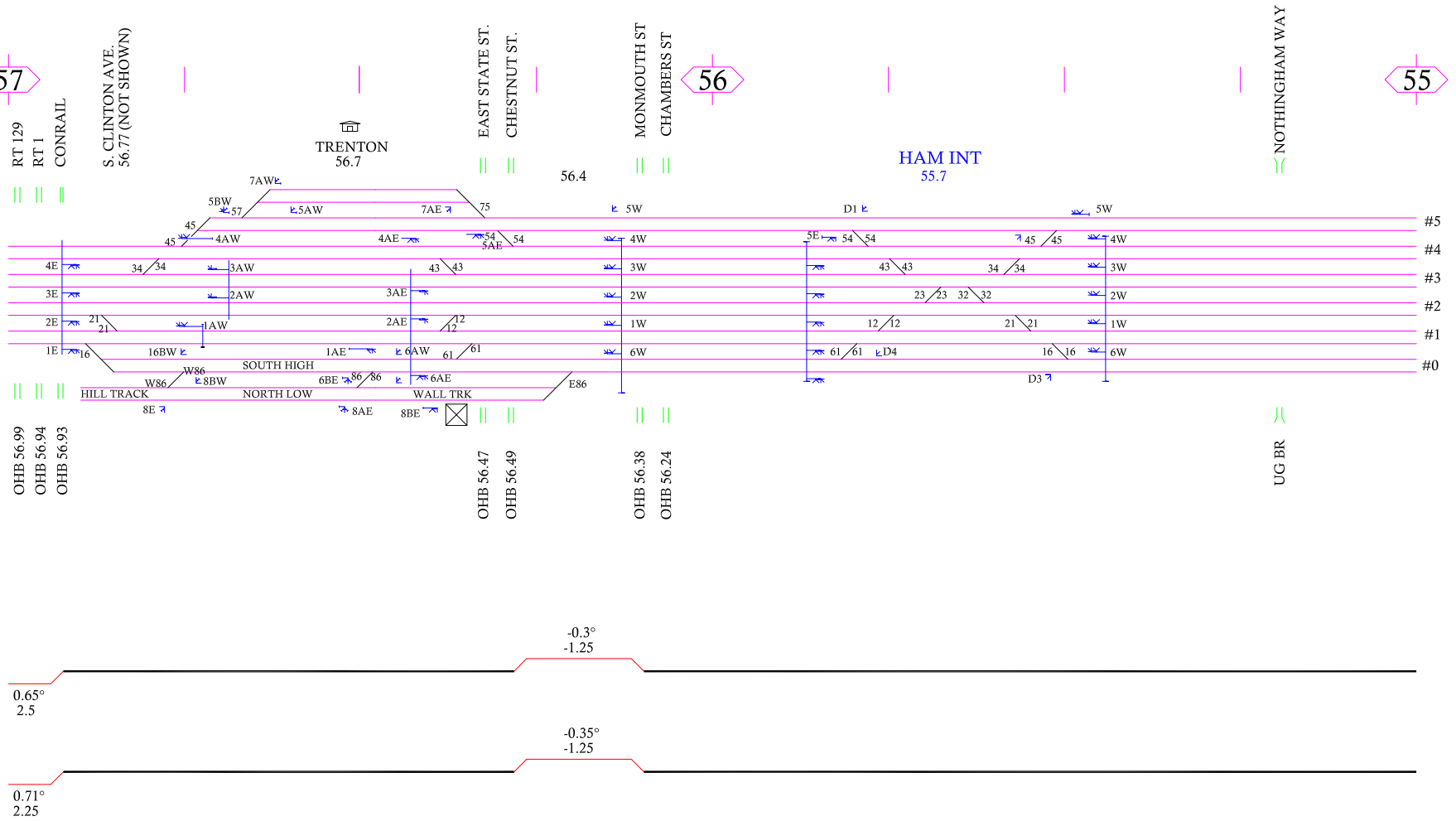
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	BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

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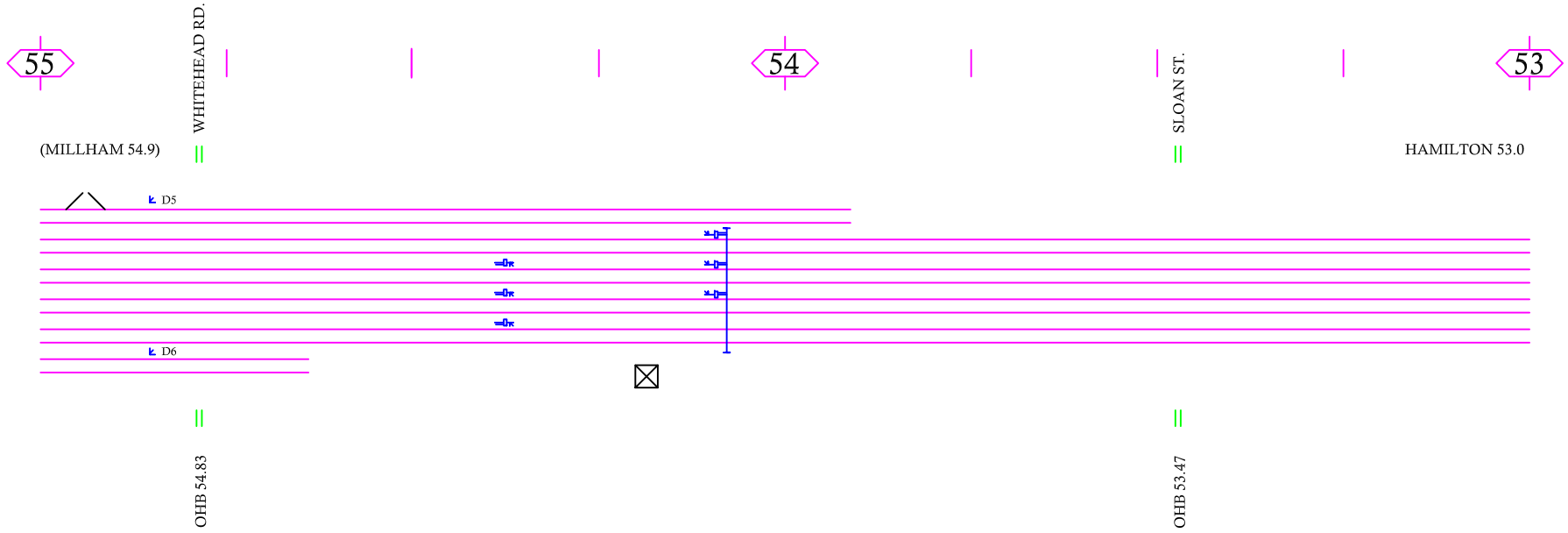


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	BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK
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	ADJ. RAIL TEMP									
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	BRUSH CUTTING	AMTRAK		AMTRAK		AMTRAK		AMTRAK		AMTRAK

AMTRAK NORTHEAST CORRIDOR

(SEPTA TRENTON LINE)

GEOMETRY CAR TRACK CHARTS
DRAWINGS BY T. LEWIS
REV - 6/2012



SEPTA SILVERLINER-VI RAILCAR

TECHNICAL SPECIFICATIONS

Appendix IV

Hoist Drawings

LET.	CHANGE	DATE	BY
A	GENERAL REVISIONS	9/28/93	JRO

ITEM	QTY	PART NO	DESCRIPTION	WT

OVERBROOK DRAWING LIST

ELECTRICAL DRAWING LIST

1)	PD-165-57-1-15	TRANSIT CAR HOIST SYSTEM REMOTE CONTROL STATION
2)	PD-165-57-1-16	TRANSIT CAR HOIST AND SUPPORT SYSTEM CONTROL WIRING DIAGRAM
3)	PD-165-57-1-17	TRANSIT CAR HOIST SYSTEM OPERATING SEQUENCE AND CONTROL FEATURES
4)	PD-165-57-1-18	MOTOR SYSTEM CONTROL CONNECTION DIAGRAM
5)	PD-165-57-1-19	ROTARY LIMIT SWITCH ADJUSTMENT AND BRAKE - MOTOR WIRING
6)	PD-165-57-1-20	PROGRAMMABLE CONTROLLER INSTALLATION
7)	PD-165-57-1-21	MOTOR CONTROL CENTER LAYOUT - CAR HOIST SYSTEM
8)	PD-165-57-1-22	MOTOR CONTROL CENTER PANEL
9)	PD-165-57-1-23	REMOTE CONTROL PANEL
10)	PD-165-57-1-24	TRANSIT CAR HOIST SYSTEM MASTER CONTROL PANEL

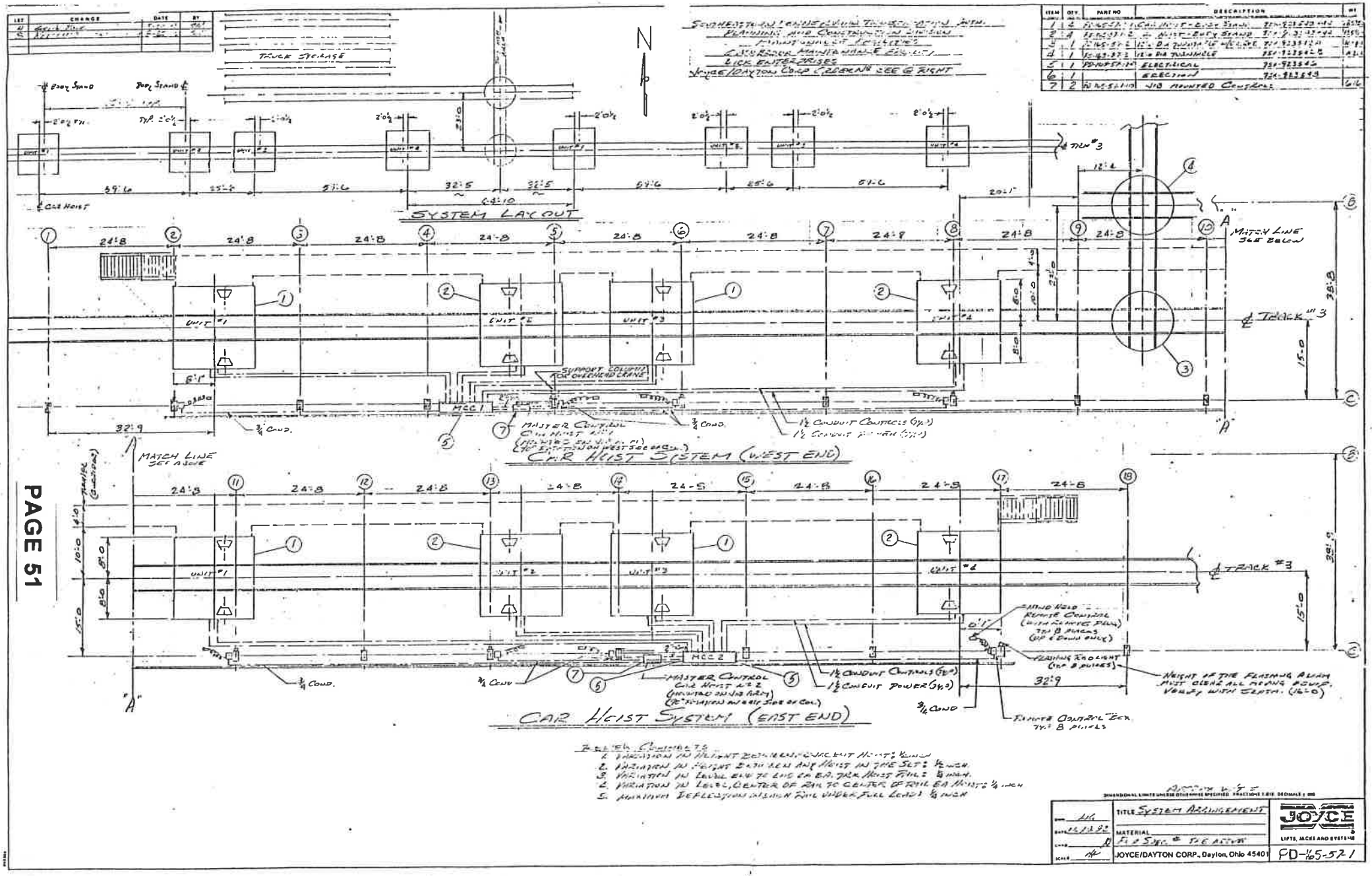
MECHANICAL DRAWING LIST

1)	PD-165-57-1	SYSTEM ARRANGEMENT
2)	PD-165-57-1-1	CAR HOIST AND BODY STAND INSTALLATION DRAWING
3)	PD-165-57-1-2	CAR HOIST AND BODY STAND INSTALLATION DRAWING
4)	PD-165-57-1-3	PIT PLAN (FOUNDATION)
5)	PD-165-57-1-4	BODY SUPPORT SYSTEM
6)	PD-165-57-1-5	BODY SUPPORT SYSTEM
7)	PD-165-57-1-6	BOLSTER - LOAD PAD 180° ROTATION
8)	PD-165-57-1-7	CAR HOIST - HOIST SYSTEM
9)	PD-165-57-1-8	HOIST GUIDE ASSEMBLY
10)	PD-165-57-1-9	PIT COVERS AND SUPPORTS (FIELD ERECTION)
11)	PD-165-57-1-10	CONTROL CONSOLE, WALL MOUNTED AND PIVOTING
12)	PD-165-57-1-11	
13)	PD-165-57-1-12	
14)	PD-165-57-2	12'-0" DIAMETER TURNTABLE INSTALLATION DRAWING
15)	PD-165-57-2-1	TURNTABLE FOUNDATION
16)	PD-165-57-2-2	D.C. NEGATIVE POWER COLLECTING AND BONDING
17)	PD-165-57-2-3	
18)	PD-165-57-2-4	
19)	PD-165-57-3	12'-0" DIAMETER TURNTABLE INSTALLATION DRAWING
20)	PD-165-57-3-1	TURNTABLE FOUNDATION
21)	PD-165-57-3-2	D.C. NEGATIVE POWER COLLECTING AND BONDING
22)	PD-165-57-3-3	

SEPTA OVERBROOK MAINTENANCE FACILITY
SEPTA PROJECT #389
DICK ENTERPRISES
JOYCE/DAYTON CORP. ORDER #TSX-923546

DIMENSIONAL UNITS UNLESS OTHERWISE SPECIFIED. FRACTIONS ± 1/64. DECIMALS ± .005

DWN JRO	TITLE DRAWING LISTING	JOYCE LIFTS AND JACKS
DATE 1/6/93		
CHKD		
SCALE ~	JOYCE/DAYTON CORP., Dayton, Ohio 45401	PD-165-57-0

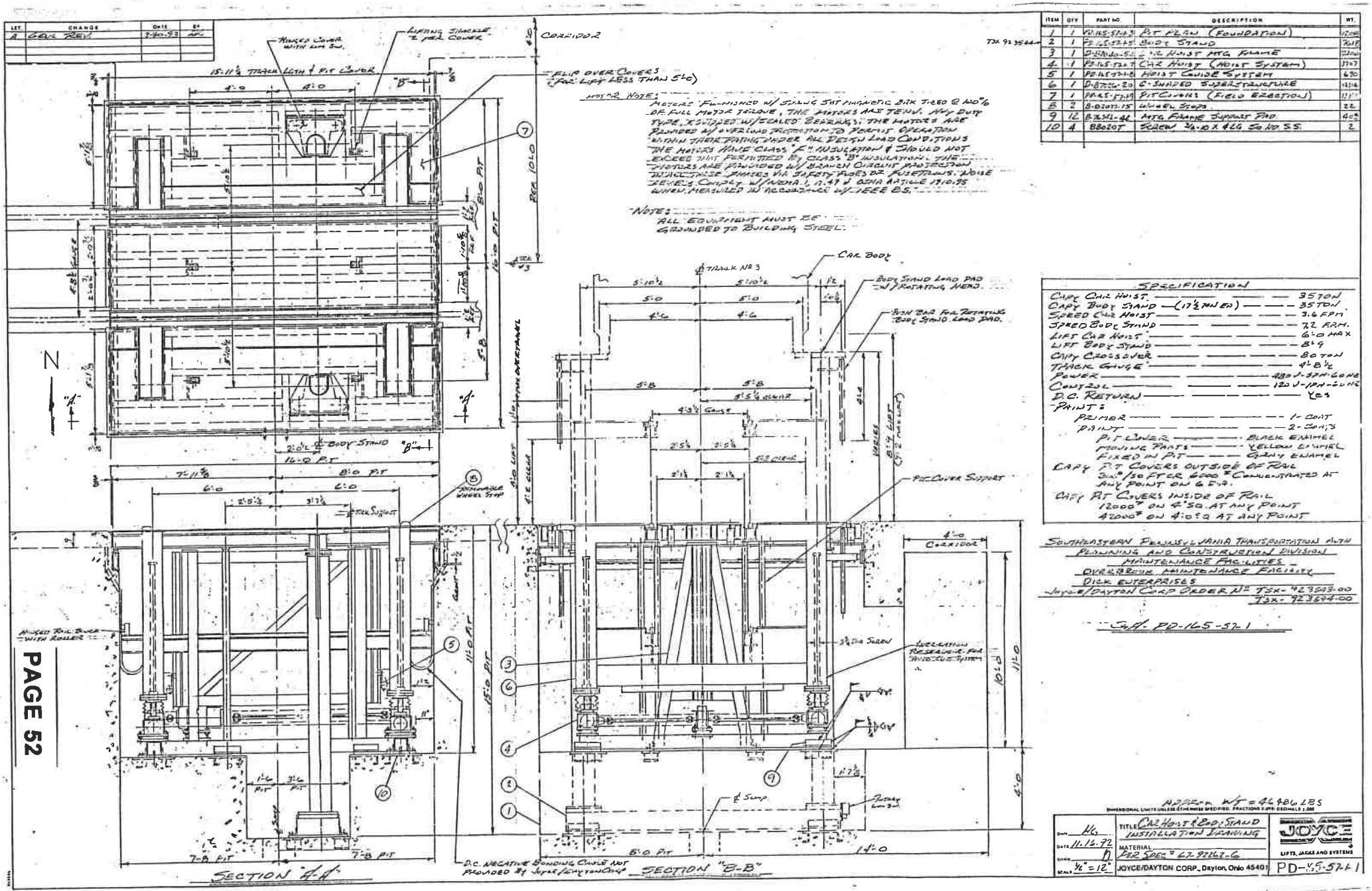


PAGE 51

ITEM	QTY.	PART NO	DESCRIPTION
1	2		CAR HOIST - EAST END
2	4		CAR HOIST - EAST END
3	1		15'-0" DIA TURNTABLE
4	1		15'-0" DIA TURNTABLE
5	1		ELECTRICAL
6	1		ERECTION
7	2		JIB MOUNTED CONTROLS

NO	CHANGE	DATE	BY
A			
B			

TITLE	SYSTEM ARRANGEMENT
MATERIAL	
	JOYCE/DAYTON CORP., Dayton, Ohio 45401
	FD-165-521



ITEM	QTY	PART NO.	DESCRIPTION	WT.
1	1	PD-165-571-3	PIT PLAN (FOUNDATION)	1200
2	1	PD-165-572-5	BODY STAND	7615
3	1	D-BND0-5-1	CAR HOIST MTG. FRAME	7200
4	1	PD-165-524-7	CAR HOIST (HOIST SYSTEM)	3707
5	1	PD-165-574-2	HOIST GUIDE SYSTEM	670
6	1	D-B7CW-20	C-SHAPED 3-JAW STANDARD	1314
7	1	PD-165-577-10	PIT COVERS (FIELD ERECTION)	1111
8	2	B-B2017-15	WHEEL STOPS	22
9	12	B-7X41-42	MTG. FRAME SUPPORT PAD	402
10	4	BB020T	SCREW 3/4-10 X 4LG SQ HD S.S.	2

SPECIFICATION

CAR CHZ HOIST	35 TON
CAR BODY STAND (17½ TON EA)	35 TON
SPEED CHZ HOIST	3.6 FPM
SPEED BODY STAND	72 R.P.M.
LIFT CAR HOIST	6'-0 MAX
LIFT BODY STAND	8'-9
CAR CROSSOVER	80 TON
TRACK GAUGE	4'-8½"
POWER	480 V-3PH-60HZ
CONTROL	120 V-1PH-60HZ
D.C. RETURN	YES
PAINT:	
PRIMER	1- COAT
PAINT	2- COATS
PIT COVER	BLACK ENAMEL
MOVING PARTS	YELLOW ENAMEL
FIXED IN PIT	GRAY ENAMEL

CAR PIT COVERS OUTSIDE OF RAIL 300# PER FT FOR 6000# CONCENTRATED AT ANY POINT ON 6'-0".

CAR PIT COVERS INSIDE OF RAIL
12000# ON 4'-0" SQ. AT ANY POINT
42000# ON 4'-0" SQ AT ANY POINT

SOUTHEASTERN PENNSYLVANIA TRANSPORTATION AUTH.
PLANNING AND CONSTRUCTION DIVISION
MAINTENANCE FACILITIES -
OVERBROOK MAINTENANCE FACILITY
DICK ENTERPRISES
JOYCE/DAYTON CORP ORDER NO. TSX-92-3543.00
TSX-92-3644.00

SAP. PD-165-571

NOMINAL WT = 42,486 LBS

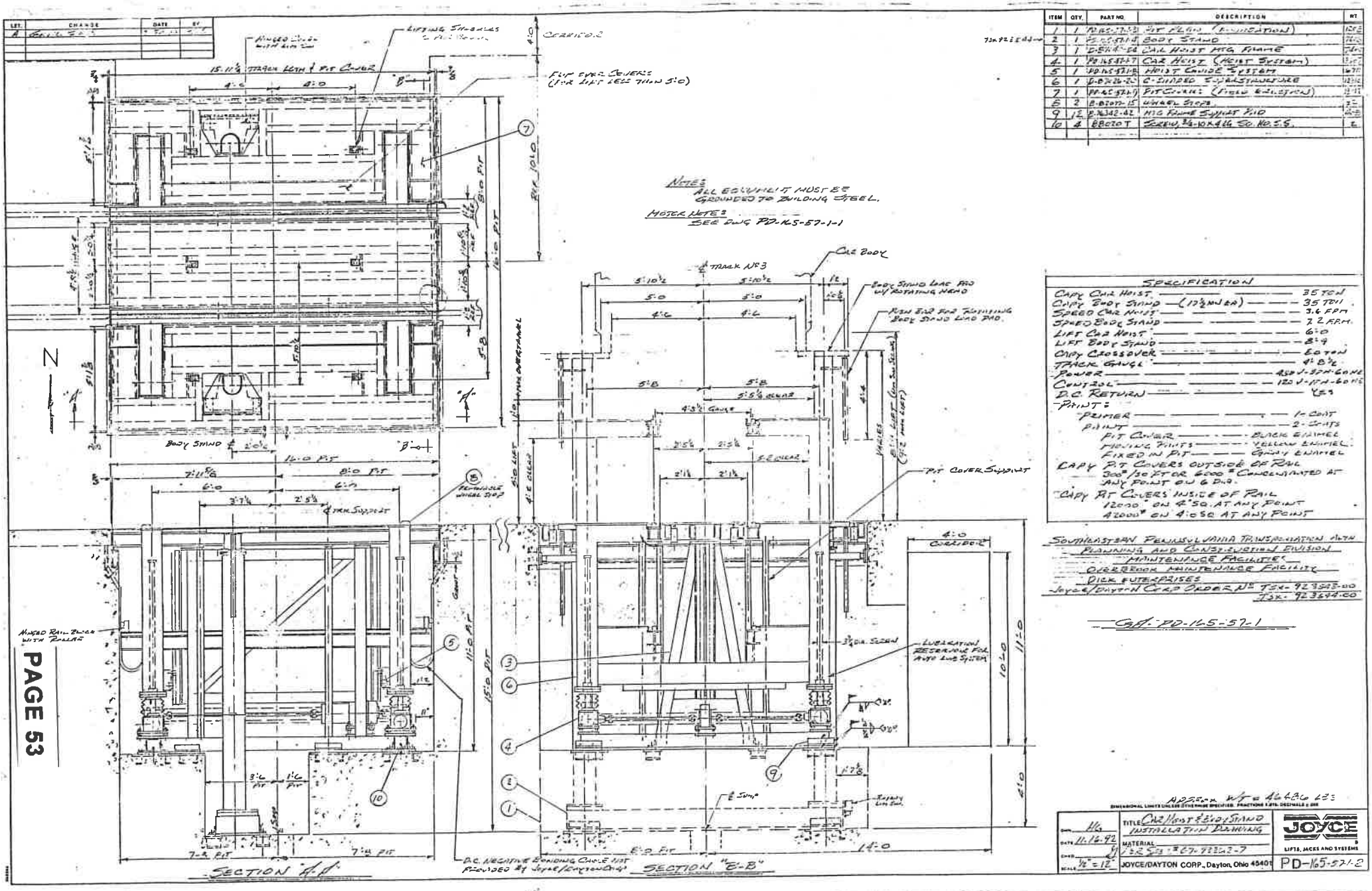
DIMENSIONAL UNITS UNLESS OTHERWISE SPECIFIED. FRACTIONS ± 1/64 DECIMALS ± .005

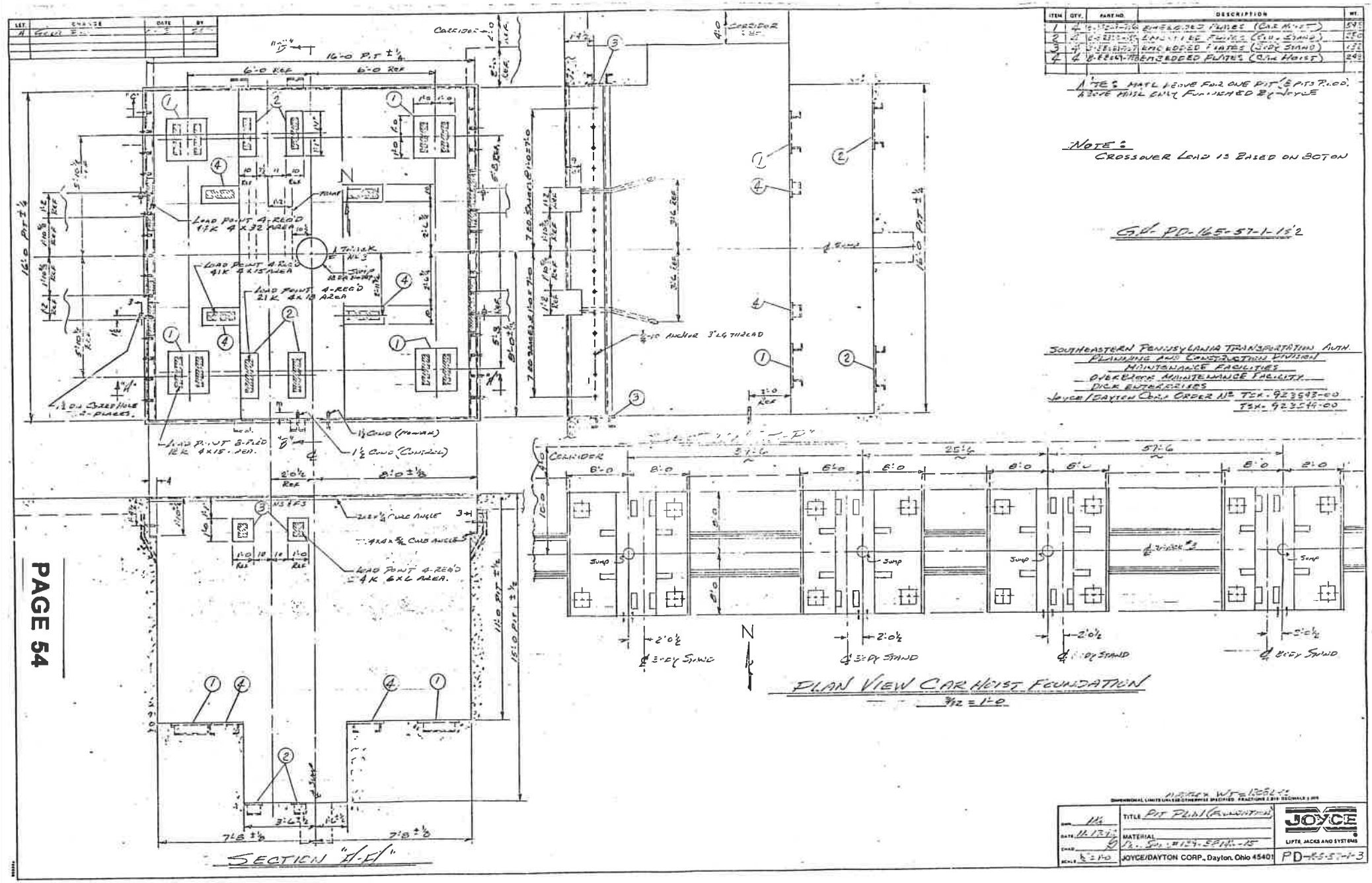
DWN. HG	TITLE CAR HOIST & BODY STAND INSTALLATION DRAWING
DATE 11-16-72	MATERIAL PER SPEC. # 67-92162-6
CHKD. A	JOYCE/DAYTON CORP. Dayton, Ohio 45401
SCALE 1/4" = 1'-0"	JOYCE LIFTS, JACKS AND SYSTEMS

PD-165-571

LET.	CHANGE	DATE	BY
A	GEN. REV.	7-20-73	MC

PAGE 52


SECTION "A-A"
SECTION "E-B"
NOTES
ALL EQUIPMENT MUST BE GROUNDED TO BUILDING STEEL.
MOTOR NOTES
SEE DWG PD-165-57-1-1
SPECIFICATION
Capy Car Hoist — 35 TON
Capy Body Stand — (17½ NUMBER) — 35 TON
Speed Car Hoist — 3.6 FPM
Speed Body Stand — 7.2 FPM
Lift Car Hoist — 6'-0"
Lift Body Stand — 8'-9"
Capy Crossover — 60 TON
Track Gauge — 4'-8½"
Power — 460 V-3PH-60HZ
Control — 120 V-1PH-60 HZ
D.C. Return — YES
Paint:
Primer — 1-Coat
Paint — 2-Coats
Pit Cover — Black Enamel
Moving Parts — Yellow Enamel
Fixed in Pit — Gray Enamel
Capy Pit Covers outside of Rail
300# / 30 FT or 6000# Concentrated at any point on 6 Sq.
Capy Pit Covers inside of Rail
12000# on 4'-50 at any point
42000# on 4'-0 50 at any point
Southeastern Pennsylvania Transportation Auth
Planning and Construction Division
Maintenance Facilities
Overbrook Maintenance Facility
Dick Enterprises
Joyce/Dayton Capy Order No. TSK-92 3643-00
TSK: 92 3644-00
Ref. PD-165-57-1
Addison W/T = 464,860 Lbs
Car Hoist & Body Stand Installation Drawing
JOYCE
Joyce/Dayton Corp., Dayton, Ohio 45401
PD-165-57-2
PAGE 53



ITEM	QTY.	PART NO.	DESCRIPTION	WT.
1	4	[illegible]	EMBEDDED PLATES (CAR HOIST)	54
2	4	[illegible]	EMBEDDED PLATES (CYL. STAND)	250
3	4	[illegible]	EMBEDDED PLATES (JACK STAND)	125
4	4	[illegible]	EMBEDDED PLATES (CAR HOIST)	240

NOTE: MAY REMOVE FOR ONE PIT (2 PITS REQD.) ABOVE HOIST ONLY FURNISHED BY JOYCE

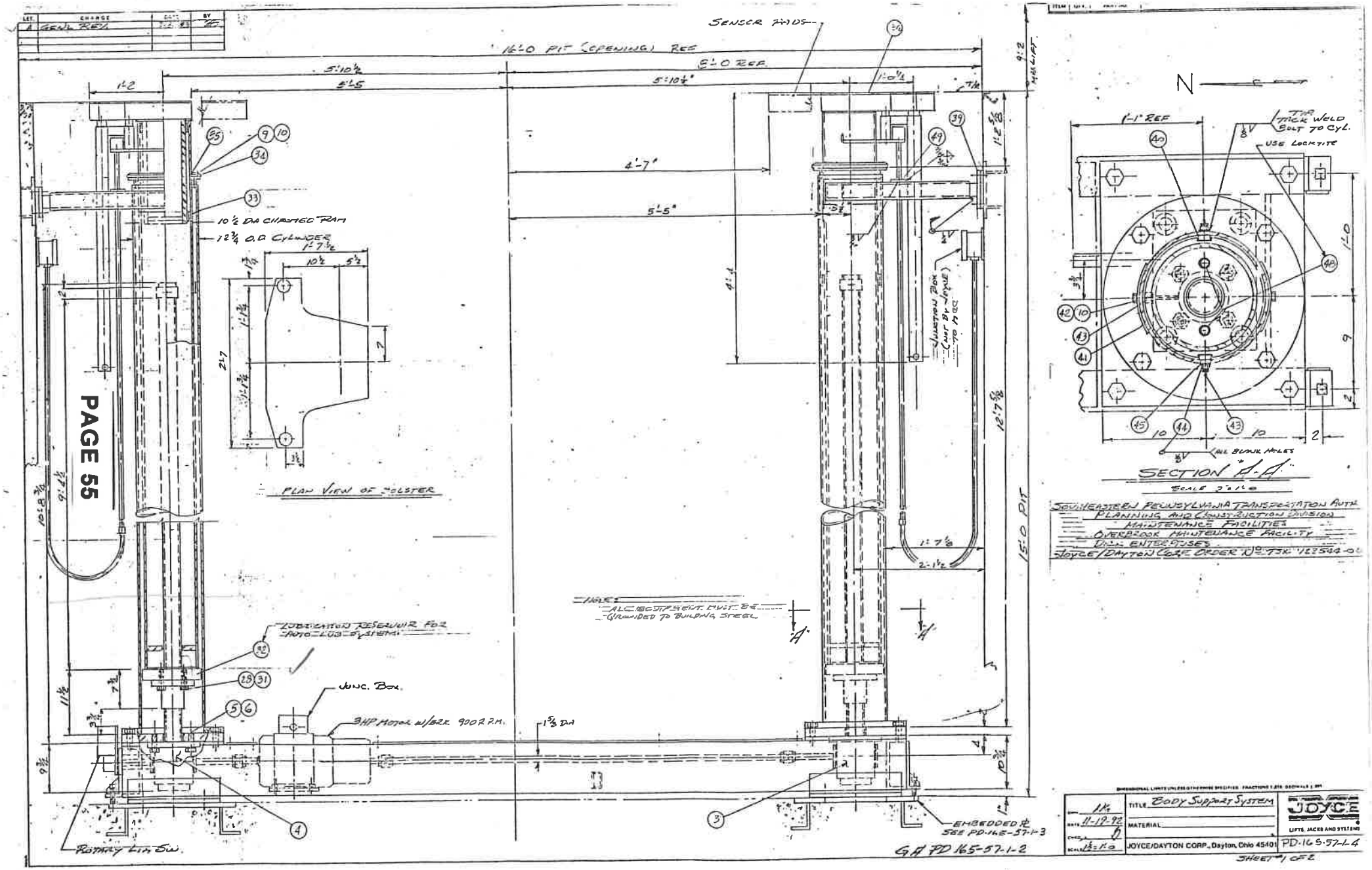
NOTE:
CROSSOVER LOAD IS BASED ON 30 TON

G.O. PD-165-57-1-15'2

SOUTHEASTERN PENNSYLVANIA TRANSPORTATION AUTH.
PLANNING AND CONSTRUCTION DIVISION
MAINTENANCE FACILITIES
OVERHAUL MAINTENANCE FACILITY
DICK ENTERPRISES
JOYCE/DAYTON CORP. ORDER NO. TCK-923543-00
TSK-923544-00

TITLE	PIT PLAN (FOUNDATION)
MATERIAL	PL. SHT. #1/4 - SPAR - 15
JOYCE/DAYTON CORP., Dayton, Ohio 45401	
	PD-165-57-1-3

JOYCE LIFTS, JACKS AND SYSTEMS



PAGE 55

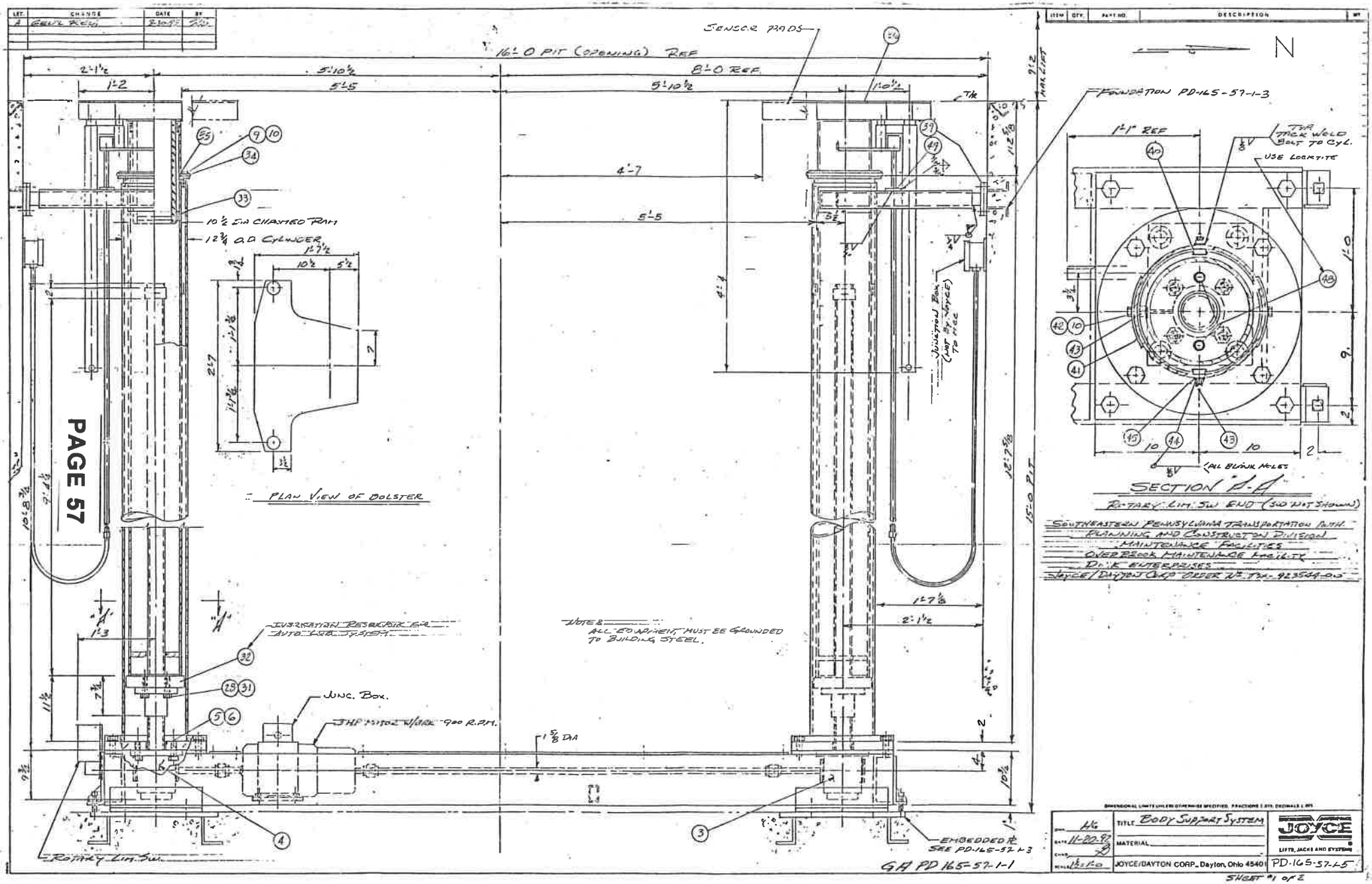
LET.	CHANGE	DATE	BY
A	GEN'L REV.		

SOUTHEASTERN PENNSYLVANIA TRANSPORTATION AUTH.
PLANNING AND CONSTRUCTION DIVISION
MAINTENANCE FACILITIES
OVERBROOK MAINTENANCE FACILITY
UNIT ENTER DOORS
JOYCE/DAYTON CORP. ORDER NO. 73X-162544-01

DRN.	1K	TITLE BODY SUPPORT SYSTEM
DATE	11-19-92	MATERIAL
CHK'D	D	JOYCE/DAYTON CORP., Dayton, Ohio 45401
SCALE	1½=1'-0	PD-165-57-1-4

JOYCE LIFTS, JACKS AND SYSTEMS

SHEET #1 OF 2


16'-0 PIT (OPENING) REF
8'-0 REF
SENSOR PADS
10½ DIA CHANTED RAM
12¾ OD CYLINDER
PLAN VIEW OF BOLSTER
JUNC. BOX.
3HP MOTOR W/BRK 900 R.P.M.
1⅝ DIA
ROTARY LIM. SW.
EMBEDDED PL SEE PD-165-52 & 3
NOTE: ALL EQUIPMENT MUST BE GROUNDED TO BUILDING STEEL.
GA PD 165-57-1-1
FOUNDATION PD-165-57-1-3
1'-1" REF
¾ THK WELD BOLT TO CYL.
USE LOCKTITE
SECTION A-A
ROTARY LIM. SW END (SW NOT SHOWN)
SOUTHEASTERN PENNSYLVANIA TRANSPORTATION AUTH.
PLANNING AND CONSTRUCTION DIVISION
MAINTENANCE FACILITIES
OVERBROOK MAINTENANCE FACILITY
D.I.K. ENTERPRISES
JOYCE/DAYTON CORP ORDER NO. P.O. #923544-01
TITLE BODY SUPPORT SYSTEM
MATERIAL
JOYCE/DAYTON CORP. Dayton, Ohio 45401
PD-165-57-1-5
SHEET #1 OF 2

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LET.	CHANGE	DATE	BY
1	COVER PLT	2-12-82	[illegible]

ITEM	QTY.	PART NO.	DESCRIPTION	WT.
1	1	[illegible]	PIT COVER CURTAIN	54.0
2	1	[illegible]	PIT COVER [illegible]	4.0
3	1	[illegible]	PIT COVER [illegible]	4.0
4	4	[illegible]	TRACK GAUGE ASSY.	22
5	12	[illegible]	PIT COVER GUIDE & SUPPORT	1.2
6	2	[illegible]	CHANNEL SUPPORT	1.6
7	30	[illegible]	WASHER, 3/8 PLAIN	1
8	30	[illegible]	NUT, 3/8-16 HEX	1
9	30	[illegible]	LOCKWASHER, 3/8 SPRING TYPE	1

FLIP GIRL COVERS

4'-8 1/2" GAUGE

2'-4 1/2" REF

1'-10 5/8"

1'-10 5/8"

1:2

1:2

5'-8

5'-8

TRK #3

A

B

A

B

1/4"

A160

16'-0 PIT

4'-10 1/2"

36"

7'-11 5/8"

6'-0

2'-0 1/2"

5'-10 1/2"

5'-10 1/2"

SEE PIT COVER FOLLOW SW ASSY

SEE PIT COVER FOLLOW SW ASSY

2'-5 1/4"

2'-5 1/4"

5'-1 7/8"

5'-1 7/8"

2'-0 3/4"

2'-0 3/4"

3/8

3/8

1/2

1/2

1/2

1/2

3

1

2

11 1/2"

10"

1'-0

1'-0 PIT

TYP

1/4"

1/4"

1/4"

6

7

8

9

5

4

SECTION "A-A"

SEE FD-165-57-1 FOR LOCATION OF 2'-0" SUPPORTS

"C" SHAPED SUPERSTRUCTURE

1/4"

1/2" GROUT ALLOWED BY ELECTOR

REF 3/4-10 STUD

4

SECT "B-B"

GA FD-165-57-1-102

NOTE:

CROSSOVER COPY BASED ON BOTON

SOUTHEASTERN PENNSYLVANIA TRANSPORTATION AUTH.
PLANNING AND CONSTRUCTION DIVISION
HEAVY MAINT. FACILITIES
ELLERSLIE MAINTENANCE FACILITY
DICK ENTERPRISES
JOYCE/DAYTON CORP. CONTRACT NO. 75X-59-6831-00

NOTE:

FLR. PATTERN — DIAMOND TYPE NON SKID "4-WAY" STEEL

PIT COVER COPY OUTSIDE RAILS

UNIFORM LOAD — 300 PSI

CONCENTRATED LOAD — 6000# AT ANY POINT

PIT COVER CONC. EXTENSION PITS:

4'x4' AREA — 12000 #

4'6"x6' AREA — 42000 #

ATTACH. WT = 1350 #

DWN. HK	TITLE PIT COVERS 15 PITS FIELD ELECTION	JOYCE LIFTS, JACKS AND SYSTEMS	
DATE 11-25-82	MATERIAL REF SEC #134-54-298-7		
CHKD D	JOYCE/DAYTON CORP., Dayton, Ohio 45401		FD-165-57-1-J
SCALE 1"=1'-0"			

LET	CHANGE	DATE	BY
A	ADDED	8/23/87	HSY
B	ADDED	10/23/88	HSY
C	ADDED FIXED REMOTE STATION	8/27/91	JMD

SOUTHEASTERN PENNSYLVANIA
TRANSPORTATION AUTHORITY

ROBERTS AVENUE
REPAIR AND CAR WASH FACILITY
SEPTA PROJECT NO. 488
SEPTA SPECIFICATION SECTION NO. 14420

PD-165-32-0	TRANSIT CAR HOIST AND BODY STAND DRAWING LIST
PD-165-32-1	CAR HOIST AND BODY SUPPORTS INSTALLATION DRAWING (A)
PD-165-32-2	PIT PLAN CAR HOIST AND BODY SUPPORTS
PD-165-32-3	BODY SUPPORT SYSTEM (2 SHEETS)
PD-165-32-4	PIT COVERS, LIFTING YOKE GUIDE, & FIELD ERECTION SYSTEM
PD-165-32-5	CAR HOIST - HOIST SYSTEM
PD-165-32-6	CAR HOIST - GUIDE SYSTEM
PD-165-32-7	BODY SUPPORT BOLSTER ASSEMBLY
PD-165-32-8	OPERATIONAL SEQUENCE
PD-165-32-9	RESERVED (B)
PD-165-32-10	PROGRESSION SYSTEM INSTALLATION DRAWING
PD-165-32-11	PIT PLAN PROGRESSION SYSTEM
PD-165-32-12	DRIVE ASSEMBLY AND INSTALLATION
PD-165-32-13	TAKE-UP ASSEMBLY INSTALLATION
PD-165-32-14	ROBOT ASSEMBLY
PD-165-32-15	RESERVED
PD-165-32-16	RESERVED
PD-165-32-17	RESERVED
PD-165-32-18	RESERVED
PD-165-32-19	PROPOSED WHEEL STOP AND LIFTING PAD LOCATIONS
PD-165-32-20	SUPPORT PAD LOCATION SILVERLINER #3
PD-165-32-21	SUPPORT PAD LOCATION SILVERLINER #4
PD-165-32-22	TRANSIT CAR HOIST SYSTEM MASTER CONTROL PANEL (2 SHEETS)
PD-165-32-23	TRANSIT CAR HOIST & PROGRESSION SYSTEM REMOTE CONTROLS
PD-165-32-24	MOTOR CONTROL CENTER CONTROL PANEL
PD-165-32-25	TRANSIT HOIST & SUPPORT SYSTEM WIRING DIAGRAM
PD-165-32-26	TRANSIT HOIST & SUPPORT SYSTEM CONNECTION DIAGRAM
PD-165-32-27	PROGRAMMABLE CONTROLLER INSTALLATION
PD-165-32-28	MOTOR-BRAKE AND LIMIT SWITCH WIRING
PD-165-32-29	FIXED REMOTE STATION PANEL
PD-165-32-30	RESERVED
QD-568	BG375D BEVEL GEAR JACK R.H. (CAR HOIST)
QD-569	BG375D BEVEL GEAR JACK L.H. (CAR HOIST)
QD-570	BG375D BEVEL GEAR JACK L.H. WITH LIMIT SWITCH (CAR HOIST)
QD-571	WJ1125 SCREW JACK R.H. (BODY SUPPORT)
QD-572	WJ1125 SCREW JACK R.H. WITH LIMIT SWITCH (BODY SUPPORT)

JOYCE/DAYTON CORP. MODIFICATION #TSX-942496
SEPTA PROJECT #69250

McCOLUM COMPANY / SEPTA
ROBERTS AVENUE REPAIR AND CAR WASH FACILITY
JOYCE/DAYTON CORP. ORDER #870724-00
SEPTA PROJECT #488
SEPTA SPECIFICATION SECTION #14420

THIS DRAWING RECEIVED A REVIEW OF
A ( ) CONFORMS DATED
B ( ) CONFORMS AS NOTED DATED
C ( ) REVISED AS NOTED AND RESUBMIT DATED
D ( ) REJECTED AND RESUBMIT DATED
E ( ) REVIEW NOT REQUIRED DATED 6/22/87
F ( ) NEW SUBMITTAL - REVIEW PENDING DATED
ALL CORRECTIONS REQUESTED PER THE ABOVE REVIEW DATE HAVE BEEN ADDED TO THIS DRAWING

DIMENSIONAL LIMITS UNLESS OTHERWISE SPECIFIED FRACTIONS = ± .DEC DECIMALS = ± .000

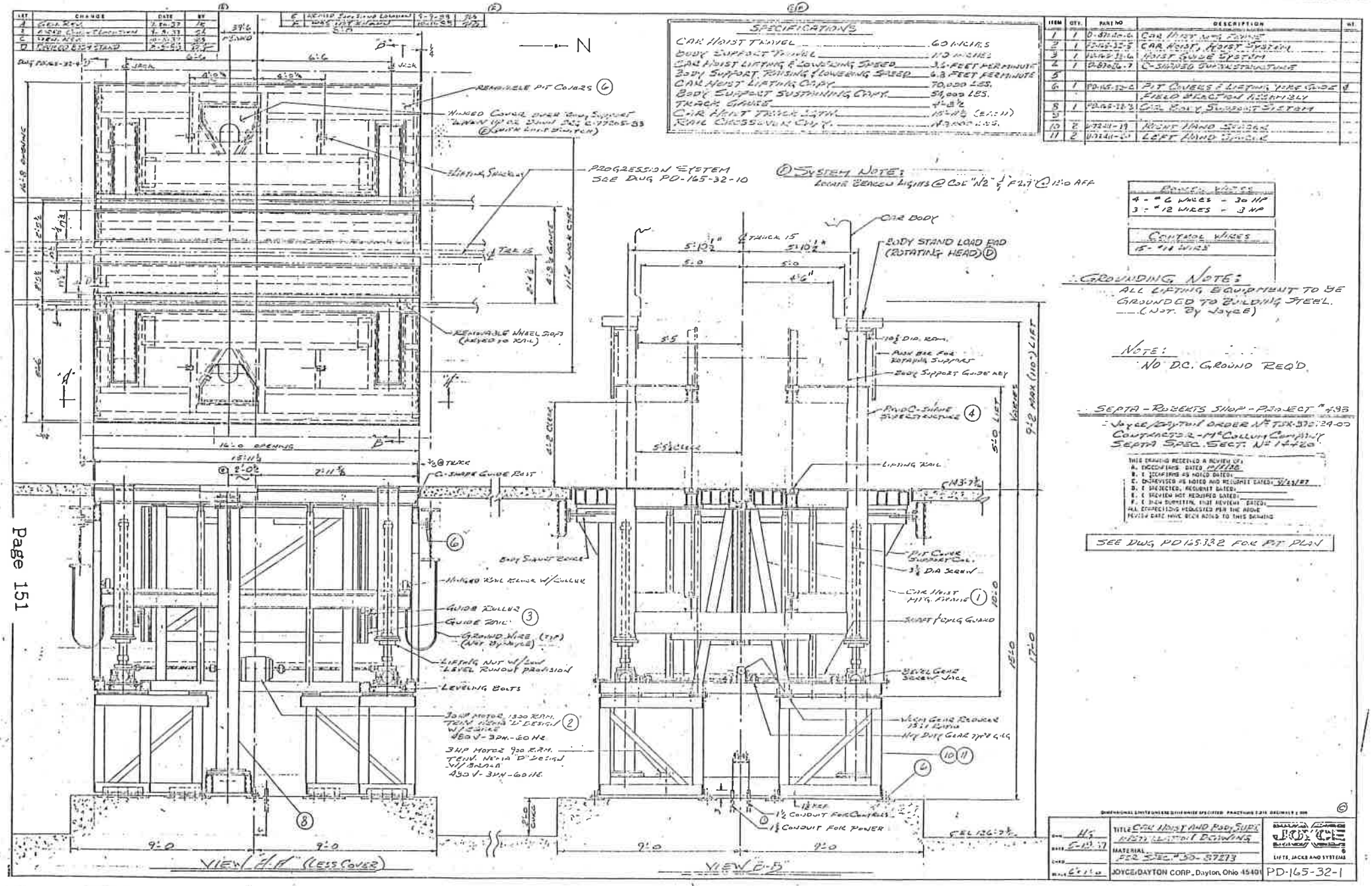
DWN M. LAKES
DATE 6/6/87
CHKD
SCALE NONE

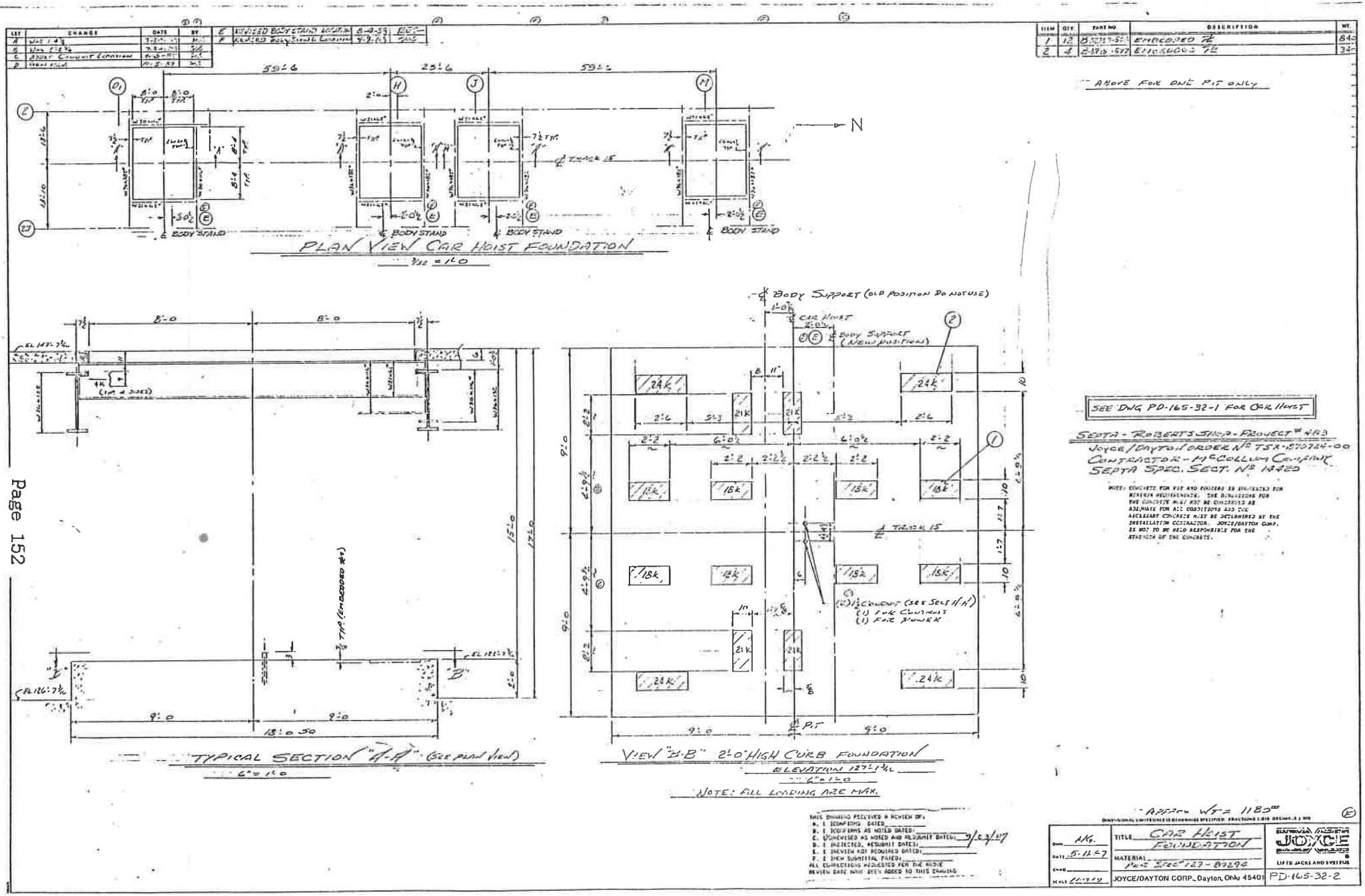
TITLE TRANSIT CAR HOIST AND BODY STAND DRAWING LIST

JOYCE/DAYTON CORP., Dayton, Ohio 45401

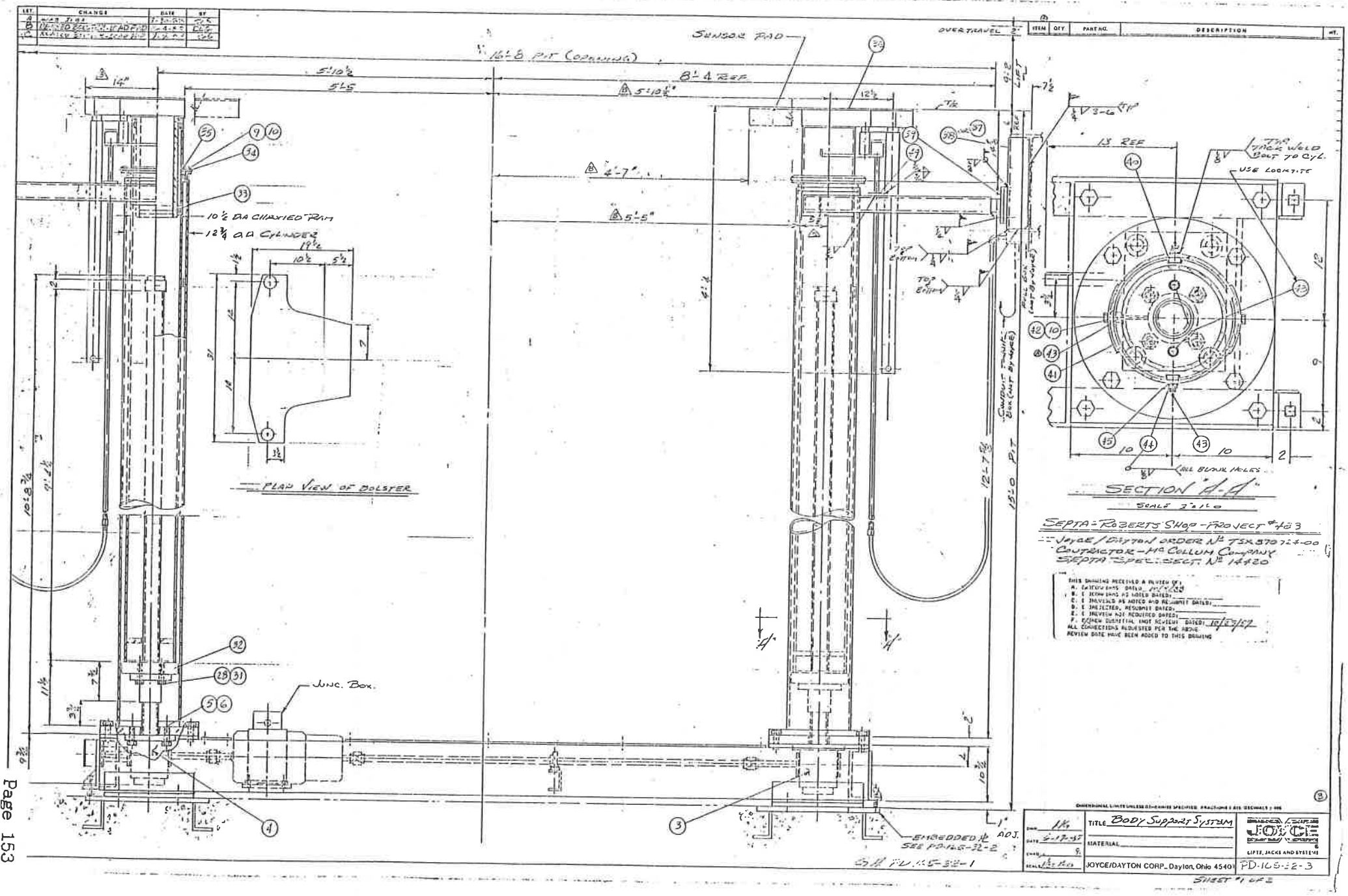
JOYCE LIFTS, JACKS, AND SYSTEMS

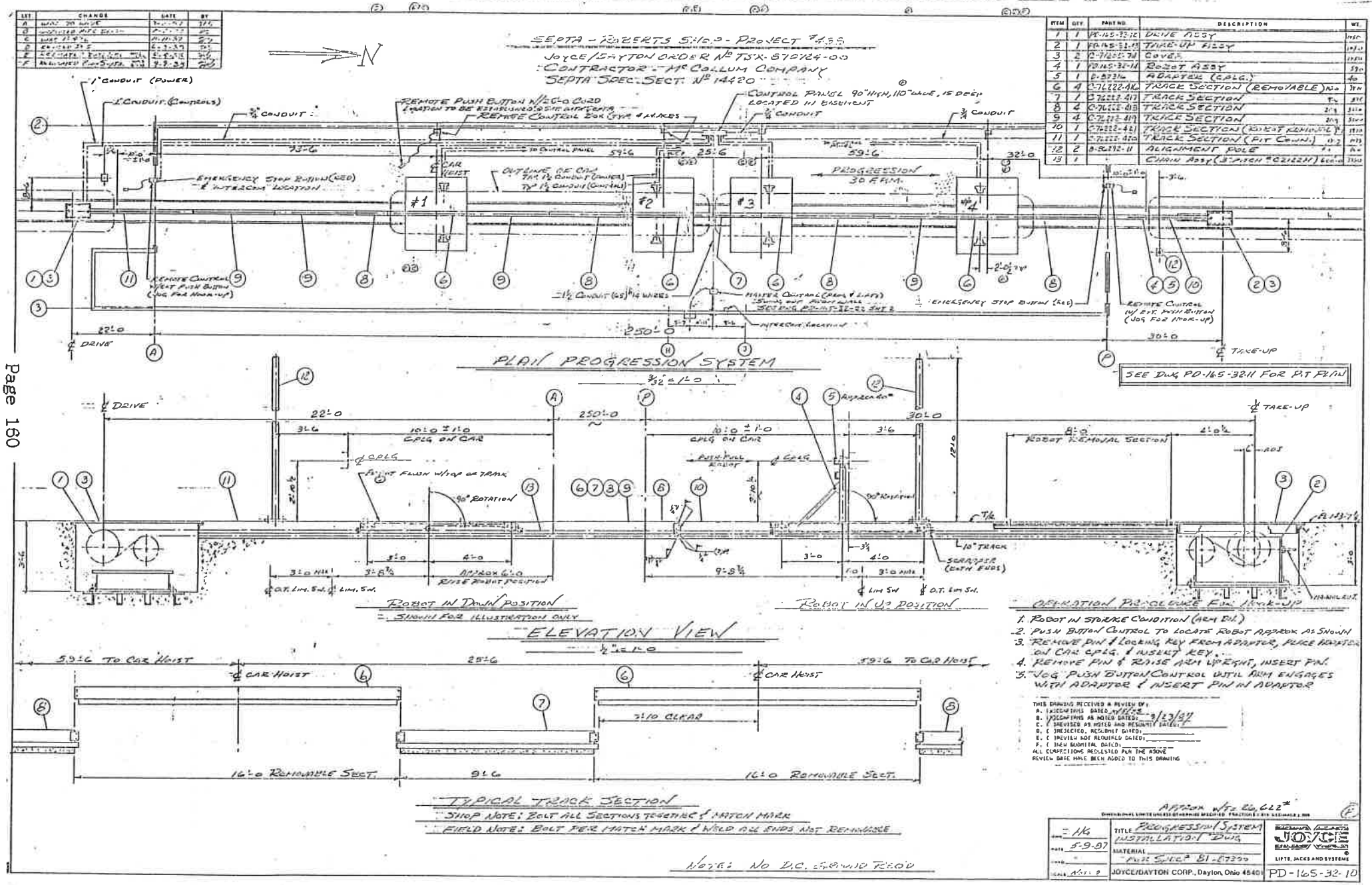
PD-165-32-0


SPECIFICATIONS
CAR HOIST TRAVEL — 60 INCHES
BODY SUPPORT TRAVEL — 11.0 INCHES
CAR HOIST LIFTING & LOWERING SPEED — 3.6 FEET PER MINUTE
BODY SUPPORT RAISING & LOWERING SPEED — 4.3 FEET PER MINUTE
CAR HOIST LIFTING CAPY. — 70,000 LBS.
BODY SUPPORT SUSTAINING CAPY. — 5½,000 LBS.
TRACK GAUGE — 4'-8½"
CAR HOIST TRUCK WITH — 10'-0½" (SEE NOTE 11)
RAIL CROSS-LEVEL CAPY. — NEGLIGIBLE
ITEM QTY. PART NO DESCRIPTION wt.
1 1 D-87116-6 CAR HOIST WITH FRAME
2 1 PDHS-32-5 CAR HOIST, HOIST SYSTEM
3 1 WLHD-11-6 HOIST GUIDE SYSTEM
4 1 D-87206-7 C-SHAPED SUPPORT STRUCTURE
5
6 1 PD-165-32-2 PIT COVERS & LIFTING YOKE GUIDE FIELD ERECTION ASSEMBLY
7 1 PDHS-11-3 CAR BODY SUPPORT SYSTEM
8
10 2 V-7241-19 RIGHT HAND SUPPORT
11 2 V-7241-20 LEFT HAND SUPPORT
POWER WIRES
4 - #6 WIRES - 30 HP
3 - #12 WIRES - 3 HP
CONTROL WIRES
15 - #14 WIRE
GROUNDING NOTE:
ALL LIFTING EQUIPMENT TO BE GROUNDED TO BUILDING STEEL. (NOT BY JOYCE)
NOTE:
NO D.C. GROUND REQ'D.
SEPTA - ROBERTS SHOP - PROJECT #495
JOYCE/DAYTON ORDER NO. TSX-532-29-07
CONTRACTOR - McCOLLUM COMPANY
SEPTA SPEC. SECT. NO. 14420
SEE DWG. PD165332 FOR PIT PLAN
SYSTEM NOTE:
LOWER BEACON LIGHTS @ COL "N2" & F2.7 @ 12'-0 AFF
PROGRESSION SYSTEM SEE DWG PD-165-32-10
REMOVABLE PIT COVERS
HINGED COVER OVER BODY SUPPORT
REMOVABLE WHEEL STOPS (KEYED TO RAIL)
LIFTING SHACKLE
TRK 15
CAR BODY
BODY STAND LOAD PAD (ROTATING HEAD)
PIVOT-DRIVE SIDE CONSTRUCTION
LIFTING RAIL
C-SHAPE GUIDE RAIL
BODY STAND COVER
HINGED RAIL KEEPER W/ROLLER
GUIDE ROLLER
GUIDE RAIL
GROUND WIRE (TYP) (NOT BY JOYCE)
LIFTING NUT W/ LOW LEVEL RUNOUT PROVISION
LEVELING BOLTS
10 HP MOTOR 1800 R.P.M. TENV. NEMA 'D' DESIGN W/ BRAKE 460 V - 3PH - 60 HZ
3 HP MOTOR 900 R.P.M. TENV. NEMA 'D' DESIGN W/ BRAKE 460 V - 3PH - 60 HZ
CAR HOIST MTG. ANGLE
SHAFT MTG GUARD
BEVEL GEAR SCREW JACK
VERTI GEAR REDUCER 15:1 RATIO
HOLLOW SHAFT GEAR MTR & MTG
1½ CONDUIT FOR CONTROLS
1½ CONDUIT FOR POWER
VIEW A-A (LESS COVER)
VIEW B-B
JOYCE/DAYTON CORP., Dayton, Ohio 45401
PD-165-32-1


PLAN VIEW CAR HOIST FOUNDATION
3/32 = 1'-0
TYPICAL SECTION "A-A" (SEE PLAN VIEW)
6" = 1'-0
VIEW "B-B" 2'-0" HIGH CURB FOUNDATION
ELEVATION 127-1 3/4
6" = 1'-0
NOTE: ALL LOADING ARE MAX.
SEE DWG PD-165-32-1 FOR CAR HOIST
SEPTA - ROBERTS SHOP - PROJECT # 483
JOYCE/DAYTON ORDER NO TSX-870724-00
CONTRACTOR - McCOLLUM CONSTRUCTION
SEPTA SPEC. SECT. NO 14420
ABOVE FOR ONE PIT ONLY
APPROX WT = 1180#
CAR HOIST FOUNDATION
JOYCE/DAYTON CORP. Dayton, Ohio 45401
PD-165-32-2

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SENSOR PAD
16'-8 PIT (CORRIDOR)
8'-4 REF.
5'-10½
5'-5
5'-12⅝"
4'-7"
5'-5"
OVERTRAVEL
LIFT
PIT
14"
10½ DIA CHAMFERED TRIM
12¾ OD CYLINDER
PLAN VIEW OF BOLSTER
JUNC. BOX.
EMBEDDED PL ADJ.
SEE PD-165-32-2
SHT PL'S-32-1
SECTION "A-A"
SCALE 3"=1'-0
13 REF
TACK WELD BOLT TO CYL.
USE LOCKTITE
ALL BLIND HOLES
SEPTA - ROBERTS SHOP - PROJECT #483
JOYCE/DAYTON ORDER № TSX 370724-00
CONTRACTOR - H.G. COLLUM COMPANY
SEPTA SPEC. SECT. № 14420
THIS DRAWING RECEIVED A REVIEW OF:
A. EXCEPTIONS TAKEN
B. EXCEPTIONS AS NOTED DATED:
C. EXCEPTIONS AS NOTED AND RESUBMIT DATED:
D. REJECTED, RESUBMIT DATED:
E. REVIEW NOT REQUIRED DATED:
F. FOREN SUBMITTAL ONLY REVIEW DATED: 10/23/97
ALL CORRECTIONS REQUESTED PER THE ABOVE REVIEW DATE HAVE BEEN ADDED TO THIS DRAWING
TITLE BODY SUPPORT SYSTEM
MATERIAL
JOYCE/DAYTON CORP. Dayton, Ohio 45401
PD-165-32-3
SHEET 1 OF 2



LET	CHANGE	DATE	BY
A	WAS: 20 WIDE	9-[illegible]-87	[illegible]
B	[illegible]	[illegible]	[illegible]
C	WAS 17'-9" L	11-11-87	[illegible]
D	[illegible]	[illegible]	[illegible]
E	[illegible]	[illegible]	[illegible]
F	REVISED PER S-[illegible]	4-3-89	[illegible]

ITEM	QTY.	PART NO.	DESCRIPTION	WT.
1	1	VE-165-32-12	DRIVE ASSY	[illegible]
2	1	PD-165-32-13	TAKE-UP ASSY	[illegible]
3	2	D-71251-78	COVER	[illegible]
4	1	PD-165-32-14	ROBOT ASSY	[illegible]
5	1	D-8731L	ADAPTER (CPLG.)	[illegible]
6	4	C-71222-A42	TRACK SECTION (REMOVABLE)	[illegible]
7	1	C-71222-A43	TRACK SECTION	[illegible]
8	4	C-71222-A15	TRACK SECTION	[illegible]
9	4	C-71222-A17	TRACK SECTION	[illegible]
10	1	C-71222-A41	TRACK SECTION (ROBOT REMOVABLE)	[illegible]
11	1	C-71222-A20	TRACK SECTION (PIT CONN.)	[illegible]
12	2	D-8732-11	ALIGNMENT POLE	[illegible]
13	1		CHAIN ASSY (3" PITCH #C2122H)	[illegible]

THIS DRAWING RECEIVED & REVIEW BY:
A. [illegible] DATED 4/12/88
B. [illegible] AS NOTED DATED: 8/23/89
C. [illegible] AS NOTED AND RESUBMIT DATED:
D. [illegible] REQUIRED DATED:
E. [illegible] NOT REQUIRED DATED:
F. [illegible] SUBMITTAL DATED:
ALL CORRECTIONS RECEIVED PER THE ABOVE REVIEW DATE HAVE BEEN ADDED TO THIS DRAWING

APPROX WT. 26,622#

1/4" = 1'-0
DATE 5-9-87
SCALE NOT TO
MATERIAL A.R. SPEC. B1-87339
TITLE PROGRESSION SYSTEM INSTALLATION DWG
JOYCE/DAYTON CORP., Dayton, Ohio 45401
PD-165-32-10

LET	CHANGE	DATE	BY
A	REVISED LAYOUT	9-6-77	WS
B	REV. PIT LINES	6-13-84	JC
C	REVISED ANCHOR BOLTS	1-2-85	JC
D	REVISED PIT AND LOCATION	5-6-85	JC
E	REVISED P.I. AND LOCATION	9-9-85	JC

ITEM	QTY.	PART NO.	DESCRIPTION	WT.
1	2	C-8636-FEM	EM. SLIDE RAIL	648

¾ ANCHOR W/ 2½ PROJECT.

ANCHOR SHOWN FOR ALIGNMENT ONLY

22'-0 | 250'-0 | 30'-0

10'-0 | 73'-6 | 59'-6 | 25'-6 | 59'-6 | 32'-0 | 10'-0

2'-0½ TYP. | 12'-9 REF

N

℄ TRACK 15

293'-6 TRACK

PLAN PROGRESSION SYSTEM FOUNDATION

SCALE 3/32 = 1'-0

SEE DWG "PD-165-32-10 FOR PROGRESSION SYS.

℄ DRIVE SPROCKET

℄ TAKE-UP SPROCKET

22'-0 | 250'-0 | 30'-0

1" CONDUIT (POWER)

1" CONDUIT (CONTROL)

OPENING FOR TRACK (END POUR)

℄ TRACK 15

PLAN

302'-0

204'-6 TRACK

CASE OF TAKE-UP

BASE OF DRIVE

NOTE:
CONDUIT & WIRING TO P.T. NOT BY JOYCE

SECTION

SCALE ½" = 1'-0

CURB ANGLE DET. SCALE 3"=1'-0
NOT BY JOYCE/DAYTON

NOTE: CONCRETE FOR PIT AND FOOTING IS SUGGESTED 3-4 MINIMUM REINFORCING. THE DIMENSIONS FOR THE CONCRETE WERE NOT BE CONSIDERED AS ADEQUATE FOR ALL CONDITIONS AND THE NECESSARY COMPLETE MUST BE DETERMINED BY THE INSTALLATION CONTRACTOR. JOYCE/DAYTON CORP. IS NOT TO BE HELD RESPONSIBLE FOR THE STRENGTH OF THE CONCRETE.

SEPTA - ROBERTS SHOP - PROJECT #488
JOYCE/DAYTON ORDER NO. TSX 873724-00
CONTRACTOR - McCALLUM COMPANY
SEPTA SPEC. SECT. NO. 14420

THIS DRAWING RECEIVED A REVIEW OF:
A. EXCEPTIONS DATED 10/9/87
B. EXCEPTIONS AS NOTED DATED: 12/11/87
C. ( ) REVISED AS NOTED AND RESUBMIT DATED:
D. ( ) REJECTED, RESUBMIT DATED:
E. ( ) REVIEW NOT REQUIRED DATED:
F. ( ) NEW SUBMITTAL (NOT REVIEWED) DATED:
ALL CORRECTIONS REQUESTED PER THE ABOVE REVIEW DATE HAVE BEEN ADDED TO THIS DRAWING

APPROX WT = 6,948 #

DIMENSIONAL LIMITS UNLESS OTHERWISE SPECIFIED, FRACTIONS ± 1/32 DECIMALS ± .030

DRN. HG	TITLE PROGRESSION SYSTEM FOUNDATION
DATE 5-7-87	MATERIAL Per Spec. No. 14420-57331
CHKD.	JOYCE/DAYTON CORP. Dayton, Ohio 45401
SCALE 1/32" = 1'-0"	JOYCE LIFTS, JACKS AND SYSTEMS
	PD-165-32-11

SEPTA SILVERLINER-VI RAILCAR

TECHNICAL SPECIFICATIONS

Appendix V

Track Profiles

Chestnut Hill East Line Route Profile
Suburban Station (MP 0.0) to Chestnut Hill East (MP 10.80)

Mile Post	Start Grade (%)	Station	Speed (mph)
0.00	2.80	Suburban	20
0.07	-2.241		20
0.15	-0.248		20
0.50	-0.248	Jefferson	20
0.55	-0.248		15
0.70	-0.76		50
0.80	0.38		50
0.88	2.11		50
0.95	2.80		50
1.30	0.50		50
1.38	0.50		45
1.75	0.00		45
2.07	0.70		45
2.10	0.70	Temple Univ.	45
2.25	0.70		40
2.30	0.70		45
2.76	-1.00		45
2.90	-1.00		45
3.08	1.32		45
3.27	1.09		45
3.48	1.06		45
3.60	1.06		50
4.00	1.06		50
4.13	0.00		50
4.86	0.16		15
5.05	-0.44		15
5.10	0.10	Wayne Junction	15
5.13	0.30		15
5.25	0.30		40
5.28	0.80		40
5.49	0.60		40
5.72	0.40		40
5.85	0.70		40
5.90	0.70		35
6.10	0.70	Wister	35
6.13	0.10		35
6.20	0.10		40
6.29	0.50		40
6.49	1.30		40
6.70	1.30		15
6.80	1.30	Germantown	15
6.85	0.10		15
6.99	-1.50		15
7.00	-1.50		40
7.08	1.30		40
	0.10		40
	1.30		40
	0.90		40

Chestnut Hill East Line Route Profile
Suburban Station (MP 0.0) to Chestnut Hill East (MP 10.80)

Mile Post	Start Grade (%)	Station	Speed (mph)
7.80	0.90	Washington Lane	40
7.90	0.60		40
8.08	1.30		40
8.43	0.10		40
8.60	0.10	Stenton	40
8.68	0.80		40
8.90	0.80	Sedgwick	40
9.12	1.10		40
9.29	1.30		40
9.30	1.30	Mount Airy	40
9.87	0.50		40
10.00	0.50	Wyndmoor	40
10.25	0.50		15
10.30	0.50	Gravers	15
10.40	0.50		10
10.42	1.50		10
10.51	0.30		10
10.59	0.80		10
10.68	-0.60		10
10.80	-0.60	Chestnut Hill East	10

Grades: A 2.00 percent grade has a rise of 2 feet in a horizontal distance of 100 feet.

Chestnut Hill West Line Route Profile
Suburban Station (MP 0.00) To Chestnut Hill West (MP 11.29)

Mile Post	Start Grade (%)	Station	Speed (mph)
0.00	-0.246	Suburban	20
0.22	2.20		20
0.72	0.00		20
0.90	0.00	William H. Gray III 30	25
1.00	0.70		25
1.16	0.70		30
1.29	-0.05		30
1.63	0.08		30
1.90	0.19	*(Enter AMTRAK)*	30
2.12	-0.25		30
2.25	-0.25		70
2.31	0.23		70
2.48	-0.60		70
2.73	-0.13		70
3.47	0.70		70
3.93	0.20		70
4.27	0.60		50
4.64	3.47	*(Exit AMTRAK)*	50
4.71	3.47	North Philadelphia	15
4.79	1.20		15
4.90	0.80		15
4.94	0.80		50
5.28	2.10		50
5.39	0.53		50
5.64	-0.24		50
6.01	0.82		50
6.22	0.76		50
6.37	1.19		50
6.84	1.19	Queen Lane	50
6.94	1.19		40
6.96	1.43		40
7.20	1.43		30
7.24	-2.00		30
7.40	-2.00		50
7.42	-0.30		50
7.44	-0.30	Chelten Avenue	50
7.47	2.00		50
7.62	-1.20		50
7.85	0.70		50
7.94	0.70	Tulpehocken	50
8.07	0.92		50
8.16	1.04		50
8.25	1.00		50
8.39	1.03		50
8.44	1.03	Upsal	50
8.85	1.27		50
9.04	1.27	Carpenter	50
9.17	1.35		50

Chestnut Hill West Line Route Profile
Suburban Station (MP 0.00) To Chestnut Hill West (MP 11.29)

Mile Post	Start Grade (%)	Station	Speed (mph)
9.44	1.35	Richard Allen Lane	50
9.61	0.71		50
9.79	0.59		50
9.94	-0.87		50
10.04	0.10		50
10.13	1.80		50
10.24	1.80	St. Martins	50
10.36	1.93		50
10.60	1.93		40
10.65	1.87		40
10.74	1.87	Highland	40
10.77	0.00		40
10.86	2.50		40
10.95	0.74		40
11.00	0.74		10
11.29	0.74	Chestnut Hill West	10

Speeds: All speeds listed for Amtrak territory are for Train Type "B".
Grades: A 2.00 percent grade has a rise of 2 feet in a horizontal distance of 100 feet.

Paoli Line Route Profile
Suburban Station (MP 0.0) to Paoli (MP 20.00)

Mile Post	Start Grade (%)	Station	Speed (mph)
0.00	-0.246	Suburban	20
0.22	2.20		20
0.72	0.00		20
0.90	0.00	William H. Gray III 30	25
1.00	-0.70		25
1.16	-0.70		30
1.29	0.05		30
1.63	-0.08		30
1.90	1.19		30
2.10	1.19		50
2.20	0.71		50
2.50	0.54	*(Amtrak Zoo Tower)*	50
3.00	0.54		30
3.30	1.50		30
3.45	1.50		50
3.90	0.94		50
4.10	0.94		60
5.25	1.00		60
5.43	0.94		60
5.50	0.94	Overbrook	60
5.90	0.94		70
6.00	0.94	Merion	60
6.35	1.00		60
6.70	0.64		60
6.90	0.64	Narberth	70
7.30	0.85		70
7.50	0.85	Wynnewood	70
8.50	0.85	Ardmore	70
9.15	0.85	Haverford	70
9.95	-0.10		70
10.05	-0.52		70
10.20	-0.52	Bryn Mawr	70
10.80	0.10		70
10.90	0.10	Rosemont	70
10.95	0.70		70
11.85	0.19		70
11.98	0.36		70
12.00	0.36	Villanova	70
12.15	-0.57		70
13.00	-0.57	Radnor	70
13.32	-0.20		70
13.45	0.00		60
13.65	-0.03		60
13.70	-0.03		70
13.75	-0.07		70
13.80	-0.07	St. Davids	70
14.00	0.21		70

Paoli Line Route Profile
Suburban Station (MP 0.0) to Paoli (MP 20.00)

Mile Post	Start Grade (%)	Station	Speed (mph)
14.40	0.56		70
14.55	0.56	Wayne	70
15.50	0.56	Strafford	70
16.50	0.56	Devon	65
16.80	0.56		70
17.20	0.56		50
17.60	0.56	Berwyn	70
18.35	0.10		70
18.60	0.10	Daylesford	70
18.65	0.02		70
18.75	0.01		70
18.95	-0.02		70
19.05	0.01		60
19.22	0.46		60
19.60	0.54		60
19.80	0.54	Paoli	60
20.25	0.00		60

Speeds: All speeds listed for Amtrak territory are for Train Type "B".
Grades: A 2.00 percent grade has a rise of 2 feet in a horizontal distance of 100 feet.

Trenton Line Route Profile
Suburban Station (MP 0.00) To Trenton, NJ (MP 33.01)

Mile Post	Start Grade (%)	Station	Speed (mph)
0.00	-0.25	Suburban	20
0.22	2.20		20
0.72	0.00		20
0.90	0.00	William H. Gray III 30th	25
1.00	0.70		25
1.16	0.70		30
1.29	-0.05		30
1.63	0.08		30
1.90	0.19	*(Enter AMTRAK)*	30
2.12	-0.25		30
2.25	-0.25		70
2.31	0.23		70
2.48	-0.60		70
2.73	-0.13		70
3.47	0.70		70
4.21	0.20		70
4.51	0.60		40
4.71	-0.60	North Philadelphia	50
4.91	-0.26		40
5.21	0.00		40
5.56	-0.34		40
5.71			65
6.11	-0.56		70
6.91	-0.61		70
7.41	-0.58		70
7.61			90
7.96			50
8.21	-0.39		50
8.51	-0.13		60
8.61	0.37		60
8.81			90
9.41	-0.10		90
9.61		Bridesburg	90
10.41	0.00		90
10.96	0.10		90
11.31	-0.03		90
11.51		Tacony	90
12.51	-0.40	Holmesburg Jct.	100
12.91	0.00		100
13.41	-0.06		100
13.71	0.08		100
14.21	-0.01		80
15.11		Torresdale	100
15.21	-0.07		100
15.71	0.00		100
16.21	-0.16		100
17.21	-0.01	Cornwells Heights	100

Trenton Line Route Profile
Suburban Station (MP 0.00) To Trenton, NJ (MP 33.01)

Mile Post	Start Grade (%)	Station	Speed (mph)
18.11	-0.25		100
18.41	-0.23	Eddington	100
19.51	-0.06		100
20.11		Croydon	100
20.51	0.28		100
21.51	0.00		100
22.31	0.21		100
23.21	-0.40	Bristol	100
24.51	0.13		100
25.21	-0.30		100
26.11	0.09		100
26.41		Levittown	100
27.41	-0.06		100
28.51	0.20		100
29.21	-0.10		100
29.81	0.06		100
30.41	0.34		100
31.41	-0.15		100
32.11	-0.56		100
32.51			65
32.61			80
32.81	0.30		80
33.01		Trenton Transit Center	80

Speeds: All speeds listed for Amtrak territory are for Train Type "B".
Grades: A 2.00 percent grade has a rise of 2 feet in a horizontal distance of 100 feet.

Wilmington/Newark Line Route Profile
Suburban Station (MP 0.00) To Newark, DE (MP 38.9)

Mile Post	Start Grade (%)	Station	Speed (mph)
0.00	-0.25	Suburban	20
0.22	2.20		20
0.72	0.00		20
0.80			25
0.90		William H. Gray III 30th	25
1.40	0.75		40
1.70		Penn Medicine	40
2.20	0.66	*(Enter AMTRAK)*	40
2.50	-0.57		40
2.70			45
2.90	0.48		45
3.00			60
3.25	0.16		60
3.60	-0.13		90
4.10	0.23		90
5.00	-0.17		70
5.60	-0.40		70
6.10		Darby	70
6.20	0.47		70
6.80	0.28	Curtis Park	70
7.20		Sharon Hill	90
7.70		Folcroft	90
8.30	0.25	Glenolden	90
9.00		Norwood	90
9.50	-0.55	Prospect Park-Moore	90
10.40		Ridley Park	90
11.20		Crum Lynne	90
11.70			90
12.30	0.15	Eddystone	90
13.00	0.26		90
13.40		Chester TC	90
13.96	-0.41		90
14.40	0.28		90
14.94	-0.24		90
15.50		Highland Ave.	90
16.80			100
17.10	0.05	Marcus Hook	100
18.00	-0.16		100
18.51			90
18.55			100
19.00	-0.19		100
19.60		Claymont	100
20.00	-0.04		100
20.30			45
20.35			100
21.00	0.25		100
22.40	-0.12		100

Wilmington/Newark Line Route Profile
Suburban Station (MP 0.00) To Newark, DE (MP 38.9)

Mile Post	Start Grade (%)	Station	Speed (mph)
22.60			90
22.70			100
23.00	0.14		100
23.50	-0.30		100
24.50	-0.24		100
25.00	0.26		100
25.40			80
26.00	-0.18		80
26.60	0.13		40
26.80		Wilmington	30
26.90	0.32		30
27.00	-0.28		40
27.10			80
27.70	-0.94		80
28.30	0.04		100
29.00	0.03		10
29.70			45
29.75			100
30.00	0.15		100
31.00	-0.15		100
32.00	0.07		100
33.00	0.29		100
34.00	0.50		100
34.30		Churchman's Crossing	100
35.50	-0.24		100
36.50	0.30		45
36.55			80
37.00	0.40		80
38.00	0.23		80
38.40			30
38.45			35
38.90		Newark	35

Speeds: All speeds listed for Amtrak territory are for Train Type "B".
Grades: A 2.00 percent grade has a rise of 2 feet in a horizontal distance of 100 feet.

SEPTA SILVERLINER-VI RAILCAR

TECHNICAL SPECIFICATIONS

Appendix VI

Timetables

Airport Line

To/From Center City Philadelphia

Effective September 2, 2025

SEPTA REGIONAL RAIL

- Airport Terminals E & F
- Airport Terminals C & D
- Airport Terminal B
- Airport Terminal A
- Eastwick
- Penn Medicine Station
- William H. Gray III 30th St Station
- Suburban Station
- Jefferson Station
- Temple University
- Wayne Junction
- Fern Rock Transit Center
- Melrose Park
- Elkins Park
- Jenkintown-Wyncote
- Glenside

Customer Service: **215-580-7800**
TDD/TTY: **215-580-7853**
www.septa.org

Penn Medicine
800.789.PENN PennMedicine.org

Station Locations & Connecting Services

Airport Terminals E & F	37, 108, 115
Airport Terminals C & D	37, 108, 115
Airport Terminal B	37, 108, 115
Airport Terminal A	37, 108, 115
Eastwick 8511 Bartram Av	37, 68, 108, 115
Penn Medicine Station 3149 Convention Blvd • 215-580-6565	40, LUCY
William H. Gray III 30th St Station 30th St & Market St	L T 9, 30, 31, 44, 49, 62, 78, 124, 125, LUCY Amtrak, NJ Transit Atlantic City Line
Suburban Station 16th St & JFK Blvd	L B T 2, 4, 16, 17, 27, 31, 32, 33, 38, 44, 48, 62, 78, 124, 125
Jefferson Station Market St between 10th St & 12th St	L B3 17, 23, 33, 38, 44, 45, 47, 47M, 48, 61, 62, 78, NJ Transit Buses
Temple University 927 W. Berks St • 215-580-5440	
Wayne Junction 2129 Windrim Av • 215-580-6892	2, 23, 53, 75
Fern Rock Transit Center 900 Nedro Av	B 4, 28, 57, 70
Melrose Park 900 Valley Rd	
Elkins Park 7876 Spring Av	28
Jenkintown-Wyncote 2 Greenwood Av • 215-580-6887	77
Glenside 49 W. Glenside Av	22, 77

P – **Parking available**

$ – **Sales Office** (hours vary, visit **www.septa.org/stations** for details)

© **SEPTA** 09/25

Mondays through Fridays (Except Major Holidays)

TO CENTER CITY & GLENSIDE

Fare Zone	Train Number	402	404	4806	408	4210	412	9414	416	9418	420	9422	424	9426	428	9430	432	9434	436	9438	440	9442	444	9446	448	9450	452	9454	456	9458	460	9462	464	9466	468	9470	472	4574	9476	4578
	Stations	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	AM
4	**Airport Terminals E & F** ♿	5:07	5:37	6:07	6:37	7:07	7:37	8:07	8:37	9:07	9:37	10:07	10:37	11:07	11:37	12:07	12:37	1:07	1:37	2:07	2:37	3:07	3:37	4:07	4:37	5:07	5:37	6:07	6:37	7:07	7:37	8:07	8:37	9:07	9:37	10:07	10:37	11:07	11:37	12:07
4	**Airport Terminals C & D** ♿	5:09	5:39	6:09	6:39	7:09	7:39	8:09	8:39	9:09	9:39	10:09	10:39	11:09	11:39	12:09	12:39	1:09	1:39	2:09	2:39	3:09	3:39	4:09	4:39	5:09	5:39	6:09	6:39	7:09	7:39	8:09	8:39	9:09	9:39	10:09	10:39	11:09	11:39	12:09
4	**Airport Terminal B** ♿	5:10	5:40	6:10	6:40	7:10	7:40	8:10	8:40	9:10	9:40	10:10	10:40	11:10	11:40	12:10	12:40	1:10	1:40	2:10	2:40	3:10	3:40	4:10	4:40	5:10	5:40	6:10	6:40	7:10	7:40	8:10	8:40	9:10	9:40	10:10	10:40	11:10	11:40	12:10
4	**Airport Terminal A** ♿	5:11	5:41	6:11	6:41	7:11	7:41	8:11	8:41	9:11	9:41	10:11	10:41	11:11	11:41	12:11	12:41	1:11	1:41	2:11	2:41	3:11	3:41	4:11	4:41	5:11	5:41	6:11	6:41	7:11	7:41	8:11	8:41	9:11	9:41	10:11	10:41	11:11	11:41	12:11
1	**Eastwick** ♿	5:15	5:45	6:15	6:45	7:15	7:45	8:15	8:45	9:15	9:45	10:15	10:45	11:15	11:45	12:15	12:45	1:15	1:45	2:15	2:45	3:15	3:45	4:15	4:45	5:15	5:45	6:15	6:45	7:15	7:45	8:15	8:45	9:15	9:45	10:15	10:45	11:15	11:45	12:15
C	**Penn Medicine Station** ♿	**D5:27**	5:57	6:27	6:57	7:27	7:57	**D8:27**	8:57	**D9:27**	9:57	**D10:27**	10:57	**D11:27**	11:57	**D12:27**	12:57	**D1:27**	1:57	**D2:27**	2:57	**D3:27**	3:57	**D4:27**	4:57	**D5:27**	5:57	**D6:27**	6:57	**D7:27**	7:57	**D8:27**	8:57	**D9:27**	9:57	**D10:27**	10:57	11:27	**D11:57**	12:27
C	**Gray 30th St Station** ♿	**D5:30**	6:00	**D6:30**	7:00	7:30	8:00	**D8:30**	9:00	**D9:30**	10:00	**D10:30**	11:00	**D11:30**	12:00	**D12:30**	1:00	**D1:30**	2:00	**D2:30**	3:00	**D3:30**	4:00	**D4:30**	5:00	**D5:30**	6:00	**D6:30**	7:00	**D7:30**	8:00	**D8:30**	9:00	**D9:30**	10:00	**D10:30**	11:00	11:30	**D12:00**	12:30
C	**Suburban Station** ♿	**D5:35**	6:05	**D6:35**	7:05	7:35	8:05	**D8:35**	9:05	**D9:35**	10:05	**D10:35**	11:05	**D11:35**	12:05	**D12:35**	1:05	**D1:35**	2:05	**D2:35**	3:05	**D3:35**	4:05	**D4:35**	5:05	**D5:35**	6:05	**D6:35**	7:05	**D7:35**	8:05	**D8:35**	9:05	**D9:35**	10:05	**D10:35**	11:05	11:35	**D12:05**	12:35
C	**Jefferson Station** ♿	**D5:40**	6:10	**D6:40**	7:10	7:40	8:10	**D8:40**	9:10	**D9:40**	10:10	**D10:40**	11:10	**D11:40**	12:10	**D12:40**	1:10	**D1:40**	2:10	**D2:40**	3:10	**D3:40**	4:10	**D4:40**	5:10	**D5:40**	6:10	**D6:40**	7:10	**D7:40**	8:10	**D8:40**	9:10	**D9:40**	10:10	**D10:40**	11:10	11:40	**D12:10**	12:40
C	**Temple University** ♿	5:45	6:15	6:44	7:15	7:45	8:15	8:44	9:15	9:44	10:15	10:44	11:15	11:44	12:15	12:44	1:15	1:44	2:15	2:44	3:15	3:44	4:15	4:44	5:15	5:44	6:15	6:44	7:15	7:44	8:15	8:44	9:15	9:44	10:15	10:44	11:15	11:45	12:15	12:45
1	**Wayne Junction** ♿	–	6:21	–	7:21	–	8:21	–	9:21	–	10:21	–	11:21	–	12:21	–	1:21	–	2:21	–	3:21	–	4:21	–	5:21	–	6:21	–	7:21	–	8:21	–	9:21	–	10:21	–	11:21	11:51	–	12:52
1	**Fern Rock Transit Center** ♿	–	6:25	–	7:25	–	8:25	–	9:25	–	10:25	–	11:25	–	12:25	–	1:25	–	2:25	–	3:25	–	4:25	–	5:25	–	6:25	–	7:25	–	8:25	–	9:25	–	10:25	–	11:25	11:55	–	12:55
2	**Melrose Park** ♿	–	6:27	–	7:27	–	8:27	–	9:27	–	10:27	–	11:27	–	12:27	–	1:27	–	2:27	–	3:27	–	4:27	–	5:27	–	6:27	–	7:27	–	8:27	–	9:27	–	10:27	–	11:27	–	–	–
2	**Elkins Park**	–	6:29	–	7:29	–	8:29	–	9:29	–	10:29	–	11:29	–	12:29	–	1:29	–	2:29	–	3:29	–	4:29	–	5:29	–	6:29	–	7:29	–	8:29	–	9:29	–	10:29	–	11:29	–	–	–
3	**Jenkintown-Wyncote**	–	6:34	–	7:34	–	8:34	–	9:34	–	10:34	–	11:34	–	12:34	–	1:34	–	2:34	–	3:34	–	4:34	–	5:34	–	6:34	–	7:34	–	8:34	–	9:34	–	10:34	–	11:34	12:02	–	1:02
3	**Glenside**	–	**D6:38**	–	**D7:38**	–	**D8:38**	–	**D9:38**	–	**D10:38**	–	11:38	–	**D12:38**	–	**D1:38**	–	**D2:38**	–	**D3:38**	–	**D4:38**	–	**D5:38**	–	**D6:38**	–	**D7:38**	–	**D8:38**	–	**D9:38**	–	**D10:38**	–	**D11:38**	12:05	–	1:05
	(See Destination Codes)	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	AM	AM	AM
	Train continues to	–	**WAR**	–	**WAR**	**MIQ**	**WAR**	–	**WAR**	–	**WAR**	–	**WAR**	–	**WAR**	–	**WAR**	–	**WAR**	–	**WAR**	–	**WAR**	–	**WAR**	–	**WAR**	–	**WAR**	–	**WAR**	–	**WAR**	–	**WAR**	**DOY**	–	**LAN**

TO PHILADELPHIA AIRPORT

Fare Zone	Train Number	401	403	405	407	409	9411	413	9415	417	8419	421	9423	425	9427	429	9431	433	9435	437	9439	441	9443	445	5447	449	9451	453	9455	457	9459	461	9463	465	9467	469	9471	473	9475	477
	Stations	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
3	**Glenside**	–	4:22	4:52	5:22	5:52	–	6:52	–	7:52	–	8:52	–	9:52	–	10:52	–	11:52	–	12:52	–	1:52	–	2:52	3:22	3:52	–	4:52	–	5:52	–	6:52	–	7:52	–	8:52	–	9:52	–	10:52
3	**Jenkintown-Wyncote**	–	4:25	4:55	5:25	5:55	–	6:55	–	7:55	–	8:55	–	9:55	–	10:55	–	11:55	–	12:55	–	1:55	–	2:55	3:25	3:55	–	4:55	–	5:55	–	6:55	–	7:55	–	8:55	–	9:55	–	10:55
2	**Elkins Park**	–	4:27	4:57	5:27	5:57	–	6:57	–	7:57	–	8:57	–	9:57	–	10:57	–	11:57	–	12:57	–	1:57	–	2:57	–	3:57	–	4:57	–	5:57	–	6:57	–	7:57	–	8:57	–	9:57	–	10:57
2	**Melrose Park** ♿	–	4:29	4:59	5:29	5:59	–	6:59	–	7:59	–	8:59	–	9:59	–	10:59	–	11:59	–	12:59	–	1:59	–	2:59	–	3:59	–	4:59	–	5:59	–	6:59	–	7:59	–	8:59	–	9:59	–	10:59
1	**Fern Rock Transit Center** ♿	4:03	4:33	5:03	5:33	6:03	–	7:03	–	8:03	–	9:03	–	10:03	–	11:03	–	12:03	–	1:03	–	2:03	–	3:03	3:32	4:03	–	5:03	–	6:03	–	7:03	–	8:03	–	9:03	–	10:03	–	11:03
1	**Wayne Junction** ♿	4:07	4:37	5:07	5:37	6:07	–	7:07	–	8:07	8:38	9:07	–	10:07	–	11:07	–	12:07	–	1:07	–	2:07	–	3:07	3:35	4:07	–	5:07	–	6:07	–	7:07	–	8:07	–	9:07	–	10:07	–	11:07
C	**Temple University** ♿	4:13	4:43	5:13	5:43	6:13	6:43	7:13	7:43	8:13	8:43	9:13	9:43	10:13	10:43	11:13	11:43	12:13	12:43	1:13	1:43	2:13	2:43	3:13	3:43	4:13	4:43	5:13	5:43	6:13	6:43	7:13	7:43	8:13	8:43	9:13	9:43	10:13	10:43	11:13
C	**Jefferson Station** ♿	4:20	4:50	5:20	5:50	6:20	6:50	7:20	7:50	8:20	8:50	9:20	9:50	10:20	10:50	11:20	11:50	12:20	12:50	1:20	1:50	2:20	2:50	3:20	3:50	4:20	4:50	5:20	5:50	6:20	6:50	7:20	7:50	8:20	8:50	9:20	9:50	10:20	10:50	11:20
C	**Suburban Station** ♿	4:25	4:55	5:25	5:55	6:25	6:55	7:25	7:55	8:25	8:55	9:25	9:55	10:25	10:55	11:25	11:55	12:25	12:55	1:25	1:55	2:25	2:55	3:25	3:55	4:25	4:55	5:25	5:55	6:25	6:55	7:25	7:55	8:25	8:55	9:25	9:55	10:25	10:55	11:25
C	**Gray 30th St Station** ♿	4:29	4:59	5:29	5:59	6:29	6:59	7:29	7:59	8:29	8:59	9:29	9:59	10:29	10:59	11:29	11:59	12:29	12:59	1:29	1:59	2:29	2:59	3:29	3:59	4:29	4:59	5:29	5:59	6:29	6:59	7:29	7:59	8:29	8:59	9:29	9:59	10:29	10:59	11:29
C	**Penn Medicine Station** ♿	4:32	5:02	5:32	6:02	6:32	7:02	7:32	8:02	8:32	9:02	9:32	10:02	10:32	11:02	11:32	12:02	12:32	1:02	1:32	2:02	2:32	3:02	3:32	4:02	4:32	5:02	5:32	6:02	6:32	7:02	7:32	8:02	8:32	9:02	9:32	10:02	10:32	11:02	11:32
1	**Eastwick** ♿	4:41	5:11	5:41	6:11	6:41	7:11	7:41	8:11	8:41	9:11	9:41	10:11	10:41	11:11	11:41	12:11	12:41	1:11	1:41	2:11	2:41	3:11	3:41	4:11	4:41	5:11	5:41	6:11	6:41	7:11	7:41	8:11	8:41	9:11	9:41	10:11	10:41	11:11	11:41
4	**Airport Terminal A** ♿	4:47	5:17	5:47	6:17	6:47	7:17	7:47	8:17	8:47	9:17	9:47	10:17	10:47	11:17	11:47	12:17	12:47	1:17	1:47	2:17	2:47	3:17	3:47	4:17	4:47	5:17	5:47	6:17	6:47	7:17	7:47	8:17	8:47	9:17	9:47	10:17	10:47	11:17	11:47
4	**Airport Terminal B** ♿	4:48	5:18	5:48	6:18	6:48	7:18	7:48	8:18	8:48	9:18	9:48	10:18	10:48	11:18	11:48	12:18	12:48	1:18	1:48	2:18	2:48	3:18	3:48	4:18	4:48	5:18	5:48	6:18	6:48	7:18	7:48	8:18	8:48	9:18	9:48	10:18	10:48	11:18	11:48
4	**Airport Terminals C & D** ♿	4:50	5:20	5:50	6:20	6:50	7:20	7:50	8:20	8:50	9:20	9:50	10:20	10:50	11:20	11:50	12:20	12:50	1:20	1:50	2:20	2:50	3:20	3:50	4:20	4:50	5:20	5:50	6:20	6:50	7:20	7:50	8:20	8:50	9:20	9:50	10:20	10:50	11:20	11:50
4	**Airport Terminals E & F** ♿	4:52	5:22	5:52	6:22	6:52	7:22	7:52	8:22	8:52	9:22	9:52	10:22	10:52	11:22	11:52	12:22	12:52	1:22	1:52	2:22	2:52	3:22	3:52	4:22	4:52	5:22	5:52	6:22	6:52	7:22	7:52	8:22	8:52	9:22	9:52	10:22	10:52	11:22	11:52
		AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM

♿ – **Accessible station**

D – Train stops to discharge or pick up passengers, but may depart ahead of schedule.

Saturdays, Sundays and Major Holidays

TO CENTER CITY & GLENSIDE

Fare Zone	Train Number	4402	4204	4406	4208	4410	4212	4414	4216	4418	4220	4422	4224	4426	4228	4430	4232	4434	4236	4438	4240	4442	4244	4446	4248	4450	4252	4454	4256	4458	4260	4462	4264	4466	4268	4470	4272	4474	4276	4478
	Stations	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	AM
4	**Airport Terminals E & F** ♿	5:07	5:37	6:07	6:37	7:07	7:37	8:07	8:37	9:07	9:37	10:07	10:37	11:07	11:37	12:07	12:37	1:07	1:37	2:07	2:37	3:07	3:37	4:07	4:37	5:07	5:37	6:07	6:37	7:07	7:37	8:07	8:37	9:07	9:37	10:07	10:37	11:07	11:37	12:07
4	**Airport Terminals C & D** ♿	5:09	5:39	6:09	6:39	7:09	7:39	8:09	8:39	9:09	9:39	10:09	10:39	11:09	11:39	12:09	12:39	1:09	1:39	2:09	2:39	3:09	3:39	4:09	4:39	5:09	5:39	6:09	6:39	7:09	7:39	8:09	8:39	9:09	9:39	10:09	10:39	11:09	11:39	12:09
4	**Airport Terminal B** ♿	5:10	5:40	6:10	6:40	7:10	7:40	8:10	8:40	9:10	9:40	10:10	10:40	11:10	11:40	12:10	12:40	1:10	1:40	2:10	2:40	3:10	3:40	4:10	4:40	5:10	5:40	6:10	6:40	7:10	7:40	8:10	8:40	9:10	9:40	10:10	10:40	11:10	11:40	12:10
4	**Airport Terminal A** ♿	5:11	5:41	6:11	6:41	7:11	7:41	8:11	8:41	9:11	9:41	10:11	10:41	11:11	11:41	12:11	12:41	1:11	1:41	2:11	2:41	3:11	3:41	4:11	4:41	5:11	5:41	6:11	6:41	7:11	7:41	8:11	8:41	9:11	9:41	10:11	10:41	11:11	11:41	12:11
1	**Eastwick** ♿	5:15	5:45	6:15	6:45	7:15	7:45	8:15	8:45	9:15	9:45	10:15	10:45	11:15	11:45	12:15	12:45	1:15	1:45	2:15	2:45	3:15	3:45	4:15	4:45	5:15	5:45	6:15	6:45	7:15	7:45	8:15	8:45	9:15	9:45	10:15	10:45	11:15	11:45	12:15
C	**Penn Medicine Station** ♿	5:27	5:57	6:27	6:57	7:27	7:57	8:27	8:57	9:27	9:57	10:27	10:57	11:27	11:57	12:27	12:57	1:27	1:57	2:27	2:57	3:27	3:57	4:27	4:57	5:27	5:57	6:27	6:57	7:27	7:57	8:27	8:57	9:27	9:57	10:27	10:57	11:27	11:57	12:27
C	**Gray 30th St Station** ♿	5:30	6:00	6:30	7:00	7:30	8:00	8:30	9:00	9:30	10:00	10:30	11:00	11:30	12:00	12:30	1:00	1:30	2:00	2:30	3:00	3:30	4:00	4:30	5:00	5:30	6:00	6:30	7:00	7:30	8:00	8:30	9:00	9:30	10:00	10:30	11:00	11:30	12:00	12:30
C	**Suburban Station** ♿	5:35	6:05	6:35	7:05	7:35	8:05	8:35	9:05	9:35	10:05	10:35	11:05	11:35	12:05	12:35	1:05	1:35	2:05	2:35	3:05	3:35	4:05	4:35	5:05	5:35	6:05	6:35	7:05	7:35	8:05	8:35	9:05	9:35	10:05	10:35	11:05	11:35	12:05	12:35
C	**Jefferson Station** ♿	5:40	6:10	6:40	7:10	7:40	8:10	8:40	9:10	9:40	10:10	10:40	11:10	11:40	12:10	12:40	1:10	1:40	2:10	2:40	3:10	3:40	4:10	4:40	5:10	5:40	6:10	6:40	7:10	7:40	8:10	8:40	9:10	9:40	10:10	10:40	11:10	11:40	12:10	12:40
C	**Temple University** ♿	5:45	6:15	6:45	7:15	7:45	8:15	8:45	9:15	9:45	10:15	10:45	11:15	11:45	12:15	12:45	1:15	1:45	2:15	2:45	3:15	3:45	4:15	4:45	5:15	5:45	6:15	6:45	7:15	7:45	8:15	8:45	9:15	9:45	10:15	10:45	11:15	11:45	12:15	12:45
1	**Wayne Junction** ♿	5:51	–	6:51	–	7:51	–	8:51	–	9:51	–	10:51	–	11:51	–	12:51	–	1:51	–	2:51	–	3:51	–	4:51	–	5:51	–	6:51	–	7:51	–	8:51	–	9:51	–	10:51	–	11:51	–	12:51
1	**Fern Rock Transit Center** ♿	5:55	–	6:55	–	7:55	–	8:55	–	9:55	–	10:55	–	11:55	–	12:55	–	1:55	–	2:55	–	3:55	–	4:55	–	5:55	–	6:55	–	7:55	–	8:55	–	9:55	–	10:55	–	11:55	–	12:55
2	**Melrose Park** ♿	5:57	–	6:57	–	7:57	–	8:57	–	9:57	–	10:57	–	11:57	–	12:57	–	1:57	–	2:57	–	3:57	–	4:57	–	5:57	–	6:57	–	7:57	–	8:57	–	9:57	–	10:57	–	11:57	–	12:57
2	**Elkins Park**	5:59	–	6:59	–	7:59	–	8:59	–	9:59	–	10:59	–	11:59	–	12:59	–	1:59	–	2:59	–	3:59	–	4:59	–	5:59	–	6:59	–	7:59	–	8:59	–	9:59	–	10:59	–	11:59	–	12:59
3	**Jenkintown-Wyncote**	6:04	–	7:04	–	8:04	–	9:04	–	10:04	–	11:04	–	12:04	–	1:04	–	2:04	–	3:04	–	4:04	–	5:04	–	6:04	–	7:04	–	8:04	–	9:04	–	10:04	–	11:04	–	12:04	–	1:04
3	**Glenside**	**D6:08**	–	**D7:08**	–	**D8:08**	–	**D9:08**	–	**D10:08**	–	**D11:08**	–	**D12:08**	–	**D1:08**	–	**D2:08**	–	**D3:08**	–	**D4:08**	–	**D5:08**	–	**D6:08**	–	**D7:08**	–	**D8:08**	–	**D9:08**	–	**D10:08**	–	11:08	–	**D12:08**	–	1:08
	(See Destination Codes)	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	AM	AM	AM
	Train continues to	**WAR**	**ELM**	**WAR**	**ELM**	**WAR**	**ELM**	**WAR**	**ELM**	**WAR**	**ELM**	**WAR**	**ELM**	**WAR**	**ELM**	**WAR**	**ELM**	**WAR**	**ELM**	**WAR**	**ELM**	**WAR**	**ELM**	**WAR**	**ELM**	**WAR**	**ELM**	**WAR**	**ELM**	**WAR**	**ELM**	**WAR**	**ELM**	**WAR**	**ELM**	**GLN**	**ELM**	**WAR**	**ELM**	**GLN**

TO PHILADELPHIA AIRPORT

Fare Zone	Train Number	4401	4403	4405	4407	2409	4411	2413	4415	2417	4419	2421	4423	2425	4427	2429	4431	2433	4435	2437	4439	2441	4443	2445	4447	2449	4451	2453	4455	2457	4459	2461	4463	2465	4467	2469	4471	2473	4475	2477
	Stations	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
3	**Glenside**	–	4:22	4:52	5:22	–	6:22	–	7:22	–	8:22	–	9:22	–	10:22	–	11:22	–	12:22	–	1:22	–	2:22	–	3:22	–	4:22	–	5:22	–	6:22	–	7:22	–	8:22	–	9:22	–	10:22	–
3	**Jenkintown-Wyncote**	–	4:25	4:55	5:25	–	6:25	–	7:25	–	8:25	–	9:25	–	10:25	–	11:25	–	12:25	–	1:25	–	2:25	–	3:25	–	4:25	–	5:25	–	6:25	–	7:25	–	8:25	–	9:25	–	10:25	–
2	**Elkins Park**	–	4:27	4:57	5:27	–	6:27	–	7:27	–	8:27	–	9:27	–	10:27	–	11:27	–	12:27	–	1:27	–	2:27	–	3:27	–	4:27	–	5:27	–	6:27	–	7:27	–	8:27	–	9:27	–	10:27	–
2	**Melrose Park** ♿	–	4:29	4:59	5:29	–	6:29	–	7:29	–	8:29	–	9:29	–	10:29	–	11:29	–	12:29	–	1:29	–	2:29	–	3:29	–	4:29	–	5:29	–	6:29	–	7:29	–	8:29	–	9:29	–	10:29	–
1	**Fern Rock Transit Center** ♿	4:03	4:33	5:03	5:33	–	6:33	–	7:33	–	8:33	–	9:33	–	10:33	–	11:33	–	12:33	–	1:33	–	2:33	–	3:33	–	4:33	–	5:33	–	6:33	–	7:33	–	8:33	–	9:33	–	10:33	–
1	**Wayne Junction** ♿	4:07	4:37	5:07	5:37	–	6:37	–	7:37	–	8:37	–	9:37	–	10:37	–	11:37	–	12:37	–	1:37	–	2:37	–	3:37	–	4:37	–	5:37	–	6:37	–	7:37	–	8:37	–	9:37	–	10:37	–
C	**Temple University** ♿	4:14	4:44	5:14	5:44	6:14	6:44	7:14	7:44	8:14	8:44	9:14	9:44	10:14	10:44	11:14	11:44	12:14	12:44	1:14	1:44	2:14	2:44	3:14	3:44	4:14	4:44	5:14	5:44	6:14	6:44	7:14	7:44	8:14	8:44	9:14	9:44	10:14	10:44	11:14
C	**Jefferson Station** ♿	4:20	4:50	5:20	5:50	6:20	6:50	7:20	7:50	8:20	8:50	9:20	9:50	10:20	10:50	11:20	11:50	12:20	12:50	1:20	1:50	2:20	2:50	3:20	3:50	4:20	4:50	5:20	5:50	6:20	6:50	7:20	7:50	8:20	8:50	9:20	9:50	10:20	10:50	11:20
C	**Suburban Station** ♿	4:25	4:55	5:25	5:55	6:25	6:55	7:25	7:55	8:25	8:55	9:25	9:55	10:25	10:55	11:25	11:55	12:25	12:55	1:25	1:55	2:25	2:55	3:25	3:55	4:25	4:55	5:25	5:55	6:25	6:55	7:25	7:55	8:25	8:55	9:25	9:55	10:25	10:55	11:25
C	**Gray 30th St Station** ♿	4:30	5:00	5:30	6:00	6:30	7:00	7:30	8:00	8:30	9:00	9:30	10:00	10:30	11:00	11:30	12:00	12:30	1:00	1:30	2:00	2:30	3:00	3:30	4:00	4:30	5:00	5:30	6:00	6:30	7:00	7:30	8:00	8:30	9:00	9:30	10:00	10:30	11:00	11:30
C	**Penn Medicine Station** ♿	4:33	5:03	5:33	6:03	6:33	7:03	7:33	8:03	8:33	9:03	9:33	10:03	10:33	11:03	11:33	12:03	12:33	1:03	1:33	2:03	2:33	3:03	3:33	4:03	4:33	5:03	5:33	6:03	6:33	7:03	7:33	8:03	8:33	9:03	9:33	10:03	10:33	11:03	11:33
1	**Eastwick** ♿	4:42	5:12	5:42	6:12	6:42	7:12	7:42	8:12	8:42	9:12	9:42	10:12	10:42	11:12	11:42	12:12	12:42	1:12	1:42	2:12	2:42	3:12	3:42	4:12	4:42	5:12	5:42	6:12	6:42	7:12	7:42	8:12	8:42	9:12	9:42	10:12	10:42	11:12	11:42
4	**Airport Terminal A** ♿	4:47	5:17	5:47	6:17	6:47	7:17	7:47	8:17	8:47	9:17	9:47	10:17	10:47	11:17	11:47	12:17	12:47	1:17	1:47	2:17	2:47	3:17	3:47	4:17	4:47	5:17	5:47	6:17	6:47	7:17	7:47	8:17	8:47	9:17	9:47	10:17	10:47	11:17	11:47
4	**Airport Terminal B** ♿	4:48	5:18	5:48	6:18	6:48	7:18	7:48	8:18	8:48	9:18	9:48	10:18	10:48	11:18	11:48	12:18	12:48	1:18	1:48	2:18	2:48	3:18	3:48	4:18	4:48	5:18	5:48	6:18	6:48	7:18	7:48	8:18	8:48	9:18	9:48	10:18	10:48	11:18	11:48
4	**Airport Terminals C & D** ♿	4:50	5:20	5:50	6:20	6:50	7:20	7:50	8:20	8:50	9:20	9:50	10:20	10:50	11:20	11:50	12:20	12:50	1:20	1:50	2:20	2:50	3:20	3:50	4:20	4:50	5:20	5:50	6:20	6:50	7:20	7:50	8:20	8:50	9:20	9:50	10:20	10:50	11:20	11:50
4	**Airport Terminals E & F** ♿	4:52	5:22	5:52	6:22	6:52	7:22	7:52	8:22	8:52	9:22	9:52	10:22	10:52	11:22	11:52	12:22	12:52	1:22	1:52	2:22	2:52	3:22	3:52	4:22	4:52	5:22	5:52	6:22	6:52	7:22	7:52	8:22	8:52	9:22	9:52	10:22	10:52	11:22	11:52
		AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM

♿ – **Accessible station**

D – Train stops to discharge or pick up passengers, but may depart ahead of schedule.

Philadelphia International Airport Information

Terminal A-West	• International Arrivals • Aer Lingus • British Airways • Discover Airlines	
Terminal A-East	• Aeromexico • American Airlines	TSA Pre✓
Terminal B	• Airport Marriott Hotel • American Airlines	TSA Pre✓ Only
Terminal C	• American Airlines	
Terminal D	• Air Canada • Delta Air Lines • Spirit Airlines • United Airlines	TSA Pre✓
Terminal E	• Alaska Airlines • Frontier Airlines • jetBlue • Southwest Airlines • Spirit Airlines • Sun Country Airlines	TSA Pre✓
Terminal F	• American Eagle • Landline (Buses)	
Flight Information	**1-800-PHL-GATE** Trains make four stops at Terminals A, B, C & D, and E & F for ticketing and check-in. Terminal gates may differ beyond TSA security screening. Visit **www.phl.org** for TSA PreCheck availability.	
SEPTA Bus Routes Serving the Airport	**37** **Eastbound** to Chester Transit Center **Westbound** to Broad-Snyder **108** **Northbound** to 69th St Transit Center **Southbound** to UPS **115** **Northbound** to Delaware County Community College **Southbound** to Airport Business Center	

Airport Lines Points of Interest

Eastwick 8511 Bartram Av	• Airport Remote Hotels
Penn Medicine Station 3149 Convention Blvd	• Children's Hospital of Philadelphia • University of Pennsylvania • Hospital of the University of Pennsylvania • Penn Museum • **SEPTA Regional Rail:** Media/Wawa Line, Wilmington/Newark Line
William H. Gray III 30th St Station 30th St & Market St	• Drexel University • Amtrak • NJ Transit Atlantic City Line • All SEPTA Regional Rail Lines
Suburban Station 16th St & JFK Blvd	• Ben Franklin Parkway Museums • The Logan, Sheraton, Windsor Suites, Sonesta • All SEPTA Regional Rail Lines
Jefferson Station Market St between 10th St & 12th St	• Thomas Jefferson University Hospital • Pennsylvania Hospital • Pennsylvania Convention Center • Marriott, Residence Inn, Loews, Hilton Garden Inn • SEPTA Regional Rail Lines

Travel Tips

Schedule Times: Indicate when trains depart the station.

Fare Payment Options: Contactless, SEPTA Key, Quick Trip Ticket, or cash. Visit **www.septa.org/fares** for more information.

QuietRide Car: Available on all weekday trains (Monday–Friday 4:00 AM to 7:00 PM) with 3 or more cars open for passenger service. The first car will be designated as your QuietRide Car.

Regional Rail Major Holidays: New Year's Day, Martin Luther King Jr. Day, Memorial Day, July 4th, Labor Day, Thanksgiving Day, Christmas Day (Special Schedule). *Please note: Holidays may be observed on another day.*

Disclaimer: SEPTA does not assume responsibility for inconvenience, experience or damage resulting from errors in timetables, delayed trains, failure to make connections or for shortage of equipment. Information is subject to change.

Severe Weather Schedule: During extreme weather conditions, trains may operate on a special schedule. Visit **www.septa.org/alerts** for more information.

Destination Codes

CHE	Chestnut Hill East	**LAN**	Lansdale
DOY	Doylestown	**MIQ**	Miquon
ELM	Elm Street	**NTC**	Norristown Transit Center
FOX	Fox Chase	**NSH**	Neshaminy Falls
GLN	Glenside	**WAR**	Warminster
JNK	Jenkintown-Wyncote	**WTR**	West Trenton

Safety Tips

- **Never** pass between cars when a train is moving
- **Never** attempt to board a moving train
- **Always** wait for the train to come to a complete stop **before** exiting
- **Never** ride in the vestibule or on the steps of a moving train
- **Never** lean against the train doors

For more information, visit **www.septa.org/safety**.

Quick Trip Tickets



Fare Kiosks are located on the train platforms at the Philadelphia Airport. For information about Quick Trip Tickets and more ways to pay, visit **www.septa.org/fares**

Chestnut Hill East Line

To/From Center City Philadelphia

Effective September 2, 2025

SEPTA REGIONAL RAIL

- Chestnut Hill East
- Gravers
- Wyndmoor
- Mount Airy
- Sedgwick
- Stenton
- Washington Ln
- Germantown
- Wister
- Wayne Junction
- Temple University
- Jefferson Station
- Suburban Station
- William H. Gray III 30th St Station

Customer Service: **215-580-7800**
TDD/TTY: **215-580-7853**
www.septa.org

Penn Medicine
800.789.PENN PennMedicine.org

Station Locations & Connecting Services

Chestnut Hill East 100 E. Chestnut Hill Av	P 51, 94
Gravers 300 E. Gravers Ln	P 51
Wyndmoor 246 Wyndmoor St	P 77
Mount Airy 149 E. Gowen Av	
Sedgwick 7139 Devon St	P 71
Stenton 6797 Blakemore St	P 18
Washington Ln 823 E. Washington Ln	P 81
Germantown 150 E. Chelten Av	P 26, 41, K
Wister 5230 Belfield Av at Armstrong Ln	41
Wayne Junction 2129 Windrim Av • 215-580-6892	$ 2, 23, 53, 75
Temple University 927 W. Berks St • 215-580-5440	$
Jefferson Station Market St between 10th St & 12th St	$ L B3 17, 23, 33, 38, 44, 45, 47, 47M, 48, 61, 62, 78, NJ Transit Buses
Suburban Station 16th St & JFK Blvd	$ L B T 2, 4, 16, 17, 27, 31, 32, 33, 38, 44, 48, 62, 78, 124, 125
William H. Gray III 30th St Station 30th St & Market St	$ L T 9, 30, 31, 44, 49, 62, 78, 124, 125, LUCY Amtrak, NJ Transit Atlantic City Line

P – **Parking available**

$ – **Sales Office** (hours vary, visit **www.septa.org/stations** for details)

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Mondays through Fridays (Except Major Holidays)

TO CENTER CITY

Fare Zone	Train Number	703	705	7503	707	709	711	713	715	717	719	6721	7537	725	727	729	731	733	735	737
	Stations	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
2	**Chestnut Hill East**	6:02	7:00	7:25	8:02	9:01	9:57	11:01	11:57	1:01	2:02	3:08	4:07	5:08	6:02	7:02	8:02	9:02	10:02	11:02
2	**Gravers**	6:04	7:02	7:27	8:04	9:03	9:59	11:03	11:59	1:03	2:04	3:10	4:09	5:10	6:04	7:04	8:04	9:04	10:04	11:04
2	**Wyndmoor**	6:06	7:04	7:29	8:06	9:05	10:01	11:05	12:01	1:05	2:06	3:12	4:11	5:12	6:06	7:06	8:06	9:06	10:06	11:06
2	**Mount Airy**	6:08	7:06	7:31	8:08	9:07	10:03	11:07	12:03	1:07	2:08	3:14	4:13	5:14	6:08	7:08	8:08	9:08	10:08	11:08
2	**Sedgwick**	6:09	7:08	7:33	8:09	9:08	10:04	11:08	12:04	1:08	2:09	3:15	4:14	5:15	6:09	7:09	8:09	9:09	10:09	11:09
2	**Stenton**	6:11	7:10	7:34	8:11	9:10	10:06	11:10	12:06	1:10	2:11	3:17	4:16	5:17	6:11	7:11	8:11	9:11	10:11	11:11
2	**Washington Ln**	6:13	7:12	7:37	8:13	9:12	10:08	11:12	12:08	1:12	2:13	3:19	4:19	5:19	6:13	7:13	8:13	9:13	10:13	11:13
1	**Germantown**	6:16	7:15	7:40	8:16	9:15	10:11	11:15	12:11	1:15	2:16	3:22	4:22	5:22	6:16	7:16	8:16	9:16	10:16	11:16
1	**Wister**	6:18	7:17	7:43	8:18	9:17	10:13	11:17	12:13	1:17	2:18	3:24	4:24	5:24	6:18	7:18	8:18	9:18	10:18	11:18
1	**Wayne Junction** ♿	6:23	7:23	7:48	8:23	9:23	10:18	11:23	12:18	1:23	2:23	3:30	4:29	5:29	6:23	7:23	8:23	9:23	10:23	11:23
C	**Temple University** ♿	6:29	7:29	7:54	8:29	9:29	10:24	11:29	12:24	1:29	2:29	**D3:36**	4:35	5:35	6:29	7:29	8:29	9:29	10:29	11:29
C	**Jefferson Station** ♿	6:35	7:35	8:00	8:35	9:35	10:30	11:35	12:30	1:35	2:35	**D3:42**	4:41	5:41	6:35	7:35	8:35	9:35	10:35	11:35
C	**Suburban Station** ♿	6:40	7:40	8:05	8:40	9:40	10:35	11:40	12:35	1:40	2:40	**D3:47**	4:46	5:46	6:40	7:40	8:40	9:40	10:40	11:40
C	**Gray 30th St Station** ♿	6:45	7:45	8:10	8:45	9:45	10:40	11:45	12:40	1:45	2:45	3:52	4:51	5:51	6:45	7:45	8:45	9:45	10:45	11:45
	(See Destination Codes)	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
	Train continues to	**TRE**	**TRE**	**MAL**	**TRE**	**TRE**	**TRE**	**TRE**	**TRE**	**TRE**	**TRE**	–	**WAY**	**TRE**	**TRE**	**TRE**	**TRE**	**TRE**	**TRE**	**TRE**

TO CHESTNUT HILL EAST

Fare Zone	Train Number	700	702	3702	746	706	708	710	712	714	716	5734	718	720	6750	722	6756	726	728	730	732	734
	Stations	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
C	**Gray 30th St Station** ♿	5:48	6:39	7:53	8:40	9:47	10:47	11:47	12:39	1:47	2:39	3:40	4:02	4:53	5:20	5:53	6:54	7:47	8:48	9:51	10:53	11:47
C	**Suburban Station** ♿	5:53	6:44	7:58	8:45	9:52	10:52	11:52	12:44	1:52	2:44	3:45	4:07	4:58	5:25	5:58	6:59	7:52	8:53	9:56	10:58	11:52
C	**Jefferson Station** ♿	5:58	6:49	8:03	8:50	9:57	10:57	11:57	12:49	1:57	2:49	3:50	4:12	5:03	5:30	6:03	7:04	7:57	8:58	10:01	11:03	11:57
C	**Temple University** ♿	6:03	6:54	8:07	8:55	10:02	11:02	12:02	12:54	2:02	2:54	3:55	4:17	5:08	5:35	6:08	7:08	8:02	9:03	10:06	11:08	12:02
1	**Wayne Junction** ♿	**D6:11**	**D7:02**	**D8:15**	**D9:03**	**D10:10**	**D11:10**	**D12:10**	**D1:02**	**D2:10**	**D3:02**	**D4:03**	**D4:25**	**D5:16**	**D5:43**	**D6:16**	**D7:18**	**D8:10**	**D9:11**	**D10:14**	**D11:16**	**D12:10**
1	**Wister**	**D6:14**	**D7:05**	**D8:18**	**D9:06**	**D10:13**	**D11:13**	**D12:13**	**D1:05**	**D2:13**	**D3:05**	**D4:06**	**D4:28**	**D5:19**	**D5:46**	**D6:19**	**D7:21**	**D8:13**	**D9:14**	**D10:17**	**D11:19**	**D12:13**
1	**Germantown**	**D6:17**	**D7:08**	**D8:21**	**D9:09**	**D10:16**	**D11:16**	**D12:16**	**D1:08**	**D2:16**	**D3:08**	**D4:09**	**D4:31**	**D5:22**	**D5:49**	**D6:22**	**D7:23**	**D8:16**	**D9:17**	**D10:20**	**D11:22**	**D12:16**
2	**Washington Ln**	**D6:20**	**D7:11**	**D8:24**	**D9:12**	**D10:19**	**D11:19**	**D12:19**	**D1:11**	**D2:19**	**D3:11**	**D4:12**	**D4:34**	**D5:25**	**D5:52**	**D6:25**	**D7:26**	**D8:19**	**D9:20**	**D10:23**	**D11:25**	**D12:19**
2	**Stenton**	**D6:22**	**D7:13**	**D8:26**	**D9:14**	**D10:21**	**D11:21**	**D12:21**	**D1:13**	**D2:21**	**D3:13**	**D4:15**	**D4:36**	**D5:27**	**D5:54**	**D6:27**	**D7:28**	**D8:21**	**D9:22**	**D10:25**	**D11:27**	**D12:21**
2	**Sedgwick**	**D6:24**	**D7:15**	**D8:28**	**D9:16**	**D10:23**	**D11:23**	**D12:23**	**D1:15**	**D2:23**	**D3:15**	**D4:16**	**D4:38**	**D5:29**	**D5:56**	**D6:29**	**D7:30**	**D8:23**	**D9:24**	**D10:27**	**D11:29**	**D12:23**
2	**Mount Airy**	**D6:26**	**D7:17**	**D8:30**	**D9:18**	**D10:25**	**D11:25**	**D12:25**	**D1:17**	**D2:25**	**D3:17**	**D4:18**	**D4:40**	**D5:31**	**D5:58**	**D6:31**	**D7:32**	**D8:25**	**D9:26**	**D10:29**	**D11:31**	**D12:25**
2	**Wyndmoor**	**D6:28**	**D7:19**	**D8:33**	**D9:20**	**D10:27**	**D11:27**	**D12:27**	**D1:19**	**D2:27**	**D3:19**	**D4:21**	**D4:42**	**D5:33**	**D6:00**	**D6:33**	**D7:34**	**D8:27**	**D9:28**	**D10:31**	**D11:33**	**D12:27**
2	**Gravers**	**D6:30**	**D7:21**	**D8:35**	**D9:22**	**D10:29**	**D11:29**	**D12:29**	**D1:21**	**D2:29**	**D3:21**	**D4:22**	**D4:44**	**D5:35**	**D6:02**	**D6:35**	**D7:36**	**D8:29**	**D9:30**	**D10:33**	**D11:35**	**D12:29**
2	**Chestnut Hill East**	6:36	7:27	8:41	9:26	10:36	11:33	12:36	1:25	2:36	3:27	4:26	4:48	5:41	6:08	6:41	7:42	8:35	9:36	10:39	11:41	12:35
		AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	AM

♿ – **Accessible station**

D – Train stops to discharge or pick up passengers, but may depart ahead of schedule.

Saturdays, Sundays and Major Holidays

TO CENTER CITY

Fare Zone	Train Number / Stations	7205	7209	7213	7217	7221	7225	7229	7233	7237
		AM	AM	AM	PM	PM	PM	PM	PM	PM
2	**Chestnut Hill East**	6:31	8:31	10:31	12:31	2:31	4:31	6:31	8:31	10:31
2	**Gravers**	6:33	8:33	10:33	12:33	2:33	4:33	6:33	8:33	10:33
2	**Wyndmoor**	6:35	8:35	10:35	12:35	2:35	4:35	6:35	8:35	10:35
2	**Mount Airy**	6:37	8:37	10:37	12:37	2:37	4:37	6:37	8:37	10:37
2	**Sedgwick**	6:39	8:39	10:39	12:39	2:39	4:39	6:39	8:39	10:39
2	**Stenton**	6:41	8:41	10:41	12:41	2:41	4:41	6:41	8:41	10:41
2	**Washington Ln**	6:43	8:43	10:43	12:43	2:43	4:43	6:43	8:43	10:43
1	**Germantown**	6:46	8:46	10:46	12:46	2:46	4:46	6:46	8:46	10:46
1	**Wister**	6:49	8:49	10:49	12:49	2:49	4:49	6:49	8:49	10:49
1	**Wayne Junction** ♿	6:52	8:52	10:52	12:52	2:52	4:52	6:52	8:52	10:52
C	**Temple University** ♿	6:58	8:58	10:58	12:58	2:58	4:58	6:58	8:58	10:58
C	**Jefferson Station** ♿	7:04	9:04	11:04	1:04	3:04	5:04	7:04	9:04	11:04
C	**Suburban Station** ♿	7:09	9:09	11:09	1:09	3:09	5:09	7:09	9:09	11:09
C	**Gray 30th St Station** ♿	7:14	9:14	11:14	1:14	3:14	5:14	7:14	9:14	11:14
C	**Penn Medicine Station** ♿	7:17	9:17	11:17	1:17	3:17	5:17	7:17	9:17	11:17
	(See Destination Codes)	AM	AM	AM	PM	PM	PM	PM	PM	PM
	Train continues to	**WIL**	**WIL**	**WIL**	**WIL**	**WIL**	**WIL**	**WIL**	**WIL**	**MHK**

TO CHESTNUT HILL EAST

Fare Zone	Train Number / Stations	6704	2708	2712	2716	2720	2724	2728	2732	2736	2740
		AM	AM	AM	AM	PM	PM	PM	PM	PM	PM
C	**Penn Medicine Station** ♿	–	7:12	9:12	11:12	1:12	3:12	5:12	7:12	9:12	11:12
C	**Gray 30th St Station** ♿	5:15	7:15	9:15	11:15	1:15	3:15	5:15	7:15	9:15	11:15
C	**Suburban Station** ♿	5:20	7:20	9:20	11:20	1:20	3:20	5:20	7:20	9:20	11:20
C	**Jefferson Station** ♿	5:25	7:25	9:25	11:25	1:25	3:25	5:25	7:25	9:25	11:25
C	**Temple University** ♿	5:30	7:30	9:30	11:30	1:30	3:30	5:30	7:30	9:30	11:30
1	**Wayne Junction** ♿	**D5:36**	**D7:36**	**D9:36**	**D11:36**	**D1:36**	**D3:36**	**D5:36**	**D7:36**	**D9:36**	**D11:36**
1	**Wister**	**D5:40**	**D7:40**	**D9:40**	**D11:40**	**D1:40**	**D3:40**	**D5:40**	**D7:40**	**D9:40**	**D11:40**
1	**Germantown**	**D5:42**	**D7:42**	**D9:42**	**D11:42**	**D1:42**	**D3:42**	**D5:42**	**D7:42**	**D9:42**	**D11:42**
2	**Washington Ln**	**D5:45**	**D7:45**	**D9:45**	**D11:45**	**D1:45**	**D3:45**	**D5:45**	**D7:45**	**D9:45**	**D11:45**
2	**Stenton**	**D5:47**	**D7:47**	**D9:47**	**D11:47**	**D1:47**	**D3:47**	**D5:47**	**D7:47**	**D9:47**	**D11:47**
2	**Sedgwick**	**D5:49**	**D7:49**	**D9:49**	**D11:49**	**D1:49**	**D3:49**	**D5:49**	**D7:49**	**D9:49**	**D11:49**
2	**Mount Airy**	**D5:51**	**D7:51**	**D9:51**	**D11:51**	**D1:51**	**D3:51**	**D5:51**	**D7:51**	**D9:51**	**D11:51**
2	**Wyndmoor**	**D5:53**	**D7:53**	**D9:53**	**D11:53**	**D1:53**	**D3:53**	**D5:53**	**D7:53**	**D9:53**	**D11:53**
2	**Gravers**	**D5:55**	**D7:55**	**D9:55**	**D11:55**	**D1:55**	**D3:55**	**D5:55**	**D7:55**	**D9:55**	**D11:55**
2	**Chestnut Hill East**	5:59	7:59	9:59	11:59	1:59	3:59	5:59	7:59	9:59	11:59
		AM	AM	AM	AM	PM	PM	PM	PM	PM	PM

♿ – **Accessible station**
D – Train stops to discharge or pick up passengers, but may depart ahead of schedule.

Travel Tips

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Destination Codes

AIR	Airport	**MHK**	Marcus Hook
BMR	Bryn Mawr	**NWK**	Newark, DE
CHW	Chestnut Hill West	**THO**	Thorndale
CYN	Cynwyd	**TRE**	Trenton Transit Center
ELW	Elwyn	**WAW**	Wawa
MAL	Malvern	**WAY**	Wayne
MED	Media	**WIL**	Wilmington

Safety Tips

- **Never** pass between cars when a train is moving
- **Never** attempt to board a moving train
- **Always** wait for the train to come to a complete stop **before** exiting
- **Never** ride in the vestibule or on the steps of a moving train
- **Never** lean against the train doors

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Chestnut Hill West Line

To/From Center City Philadelphia

Effective September 2, 2025

SEPTA REGIONAL RAIL

- Chestnut Hill West
- Highland
- St. Martins
- Richard Allen Ln
- Carpenter
- Upsal
- Tulpehocken
- Chelten Av
- Queen Ln
- North Philadelphia
- William H. Gray III 30th St Station
- Suburban Station
- Jefferson Station
- Temple University

Customer Service: **215-580-7800**
TDD/TTY: **215-580-7853**
www.septa.org

Penn Medicine
800.789.PENN PennMedicine.org

Station Locations & Connecting Services

Chestnut Hill West 8606 Germantown Av	P 23, 51, 77, 94, 97
Highland 8452 St. Martins Ln	P
St. Martins 320 W. Willow Grove Av	P
Richard Allen Ln 7210 Cresheim Rd	P
Carpenter 310 Carpenter Ln	P
Upsal 6505 Greene St	P 71
Tulpehocken 333 W. Tulpehocken St	P 53, 65
Chelten Av 359 W. Chelten Av	P 26, 41
Queen Ln 551 W. Queen Ln	P K
North Philadelphia 2900 N. Broad St	P B 4, 16
William H. Gray III 30th St Station 30th St & Market St	$ L T 9, 30, 31, 44, 49, 62, 78, 124, 125, LUCY Amtrak, NJ Transit Atlantic City Line
Suburban Station 16th St & JFK Blvd	$ L B T 2, 4, 16, 17, 27, 31, 32, 33, 38, 44, 48, 62, 78, 124, 125
Jefferson Station Market St between 10th St & 12th St	$ L B3 17, 23, 33, 38, 44, 45, 47, 47M, 48, 61, 62, 78, NJ Transit Buses
Temple University 927 W. Berks St • 215-580-5440	$

P – **Parking available**

$ – **Sales Office** (hours vary, visit **www.septa.org/stations** for details)

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Mondays through Fridays (Except Major Holidays)

TO CENTER CITY

Fare Zone	Train Number	800	802	806	9808	810	814	818	9820	822	826	830	834	838	842	846	850	854	858	862	866	9870
	Stations	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
2	**Chestnut Hill West** ♿	5:28	5:58	6:58	7:28	7:58	8:58	9:58	10:28	10:58	11:58	12:58	1:58	2:58	3:58	4:58	5:58	6:58	7:58	8:58	9:58	10:58
2	**Highland**	**F5:30**	**F6:00**	**F7:00**	**F7:30**	**F8:00**	**F9:00**	**F10:00**	**F10:30**	**F11:00**	**F12:00**	**F1:00**	**F2:00**	**F3:00**	**F4:00**	**F5:00**	**F6:00**	**F7:00**	**F8:00**	**F9:00**	**F10:00**	**F11:00**
2	**St. Martins**	5:32	6:02	7:02	7:32	8:02	9:02	10:02	10:32	11:02	12:02	1:02	2:02	3:02	4:02	5:02	6:02	7:02	8:02	9:02	10:02	11:02
2	**Richard Allen Ln** ♿	5:33	6:03	7:03	7:33	8:03	9:03	10:03	10:33	11:03	12:03	1:03	2:03	3:03	4:03	5:03	6:03	7:03	8:03	9:03	10:03	11:03
2	**Carpenter**	5:35	6:05	7:05	7:35	8:05	9:05	10:05	10:35	11:05	12:05	1:05	2:05	3:05	4:05	5:05	6:05	7:05	8:05	9:05	10:05	11:05
2	**Upsal**	5:37	6:07	7:07	7:37	8:07	9:07	10:07	10:37	11:07	12:07	1:07	2:07	3:07	4:07	5:07	6:07	7:07	8:07	9:07	10:07	11:07
1	**Tulpehocken**	5:39	6:09	7:09	7:39	8:09	9:09	10:09	10:39	11:09	12:09	1:09	2:09	3:09	4:09	5:09	6:09	7:09	8:09	9:09	10:09	11:09
1	**Chelten Av**	5:41	6:11	7:11	7:41	8:11	9:11	10:11	10:41	11:11	12:11	1:11	2:11	3:11	4:11	5:11	6:11	7:11	8:11	9:11	10:11	11:11
1	**Queen Ln** ♿	5:43	6:13	7:13	7:43	8:13	9:13	10:13	10:43	11:13	12:13	1:13	2:13	3:13	4:13	5:13	6:13	7:13	8:13	9:13	10:13	11:13
1	**North Philadelphia**	**D5:49**	**D6:19**	**D7:19**	**D7:49**	**D8:19**	**D9:19**	**D10:19**	**D10:49**	**D11:19**	**D12:19**	**D1:19**	**D2:19**	**D3:19**	**D4:19**	**D5:19**	**D6:19**	**D7:19**	**D8:19**	**D9:19**	**D10:19**	**D11:19**
C	**Gray 30th St Station** ♿	**D6:00**	6:30	7:30	**D8:00**	8:30	9:30	10:30	**D11:00**	11:30	12:30	1:30	2:30	3:30	4:30	5:30	6:30	7:30	8:30	9:30	10:30	**D11:30**
C	**Suburban Station** ♿	**D6:05**	6:35	7:35	**D8:05**	8:35	9:35	10:35	**D11:05**	11:35	12:35	1:35	2:35	3:35	4:35	5:35	6:35	7:35	8:35	9:35	10:35	**D11:35**
C	**Jefferson Station** ♿	**D6:10**	6:40	7:40	**D8:10**	8:40	9:40	10:40	**D11:10**	11:40	12:40	1:40	2:40	3:40	4:40	5:40	6:40	7:40	8:40	9:40	10:40	**D11:40**
C	**Temple University** ♿	6:14	6:44	7:44	8:14	8:44	9:44	10:44	11:14	11:44	12:44	1:44	2:44	3:44	4:44	5:44	6:44	7:44	8:44	9:44	10:44	11:45
	(See Destination Codes)	AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
	Train continues to	—	**FOX**	**FOX**	—	**FOX**	**FOX**	**FOX**	—	**FOX**	**FOX**	**FOX**	**FOX**	**FOX**	**FOX**	**FOX**	**FOX**	**FOX**	**FOX**	**FOX**	**FOX**	—

TO CHESTNUT HILL WEST

Fare Zone	Train Number	801	803	805	809	811	815	817	821	825	829	833	837	841	845	5847	849	853	857	861	865	869
	Stations	AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
C	**Temple University** ♿	5:46	6:16	6:46	7:46	8:16	9:16	9:46	10:46	11:46	12:46	1:46	2:46	3:46	4:46	5:28	5:46	6:46	7:46	8:46	9:46	10:46
C	**Jefferson Station** ♿	5:52	6:22	6:52	7:52	8:22	9:22	9:52	10:52	11:52	12:52	1:52	2:52	3:52	4:52	5:34	5:52	6:52	7:52	8:52	9:52	10:52
C	**Suburban Station** ♿	5:57	6:27	6:57	7:57	8:27	9:27	9:57	10:57	11:57	12:57	1:57	2:57	3:57	4:57	5:39	5:57	6:57	7:57	8:57	9:57	10:57
C	**Gray 30th St Station** ♿	6:02	6:32	7:02	8:02	8:32	9:32	10:02	11:02	12:02	1:02	2:02	3:02	4:02	5:02	5:44	6:02	7:02	8:02	9:02	10:02	11:02
1	**North Philadelphia**	**D6:12**	**D6:42**	**D7:12**	**D8:12**	**D8:42**	**D9:42**	**D10:12**	**D11:12**	**D12:12**	**D1:12**	**D2:12**	**D3:12**	**D4:12**	**D5:12**	**D5:54**	**D6:12**	**D7:12**	**D8:12**	**D9:12**	**D10:12**	**D11:12**
1	**Queen Ln** ♿	**D6:18**	**D6:48**	**D7:18**	**D8:18**	**D8:48**	**D9:48**	**D10:18**	**D11:18**	**D12:18**	**D1:18**	**D2:18**	**D3:18**	**D4:18**	**D5:18**	**D6:00**	**D6:18**	**D7:18**	**D8:18**	**D9:18**	**D10:18**	**D11:18**
1	**Chelten Av**	**D6:20**	**D6:50**	**D7:20**	**D8:20**	**D8:50**	**D9:50**	**D10:20**	**D11:20**	**D12:20**	**D1:20**	**D2:20**	**D3:20**	**D4:20**	**D5:20**	**D6:02**	**D6:20**	**D7:20**	**D8:20**	**D9:20**	**D10:20**	**D11:20**
1	**Tulpehocken**	**D6:21**	**D6:51**	**D7:21**	**D8:21**	**D8:51**	**D9:51**	**D10:21**	**D11:21**	**D12:21**	**D1:21**	**D2:21**	**D3:21**	**D4:21**	**D5:21**	**D6:03**	**D6:21**	**D7:21**	**D8:21**	**D9:21**	**D10:21**	**D11:21**
2	**Upsal**	**D6:23**	**D6:53**	**D7:23**	**D8:23**	**D8:53**	**D9:53**	**D10:23**	**D11:23**	**D12:23**	**D1:23**	**D2:23**	**D3:23**	**D4:23**	**D5:23**	**D6:05**	**D6:23**	**D7:23**	**D8:23**	**D9:23**	**D10:23**	**D11:23**
2	**Carpenter**	**D6:25**	**D6:55**	**D7:25**	**D8:25**	**D8:55**	**D9:55**	**D10:25**	**D11:25**	**D12:25**	**D1:25**	**D2:25**	**D3:25**	**D4:25**	**D5:25**	**D6:07**	**D6:25**	**D7:25**	**D8:25**	**D9:25**	**D10:25**	**D11:25**
2	**Richard Allen Ln** ♿	**D6:27**	**D6:57**	**D7:27**	**D8:27**	**D8:57**	**D9:57**	**D10:27**	**D11:27**	**D12:27**	**D1:27**	**D2:27**	**D3:27**	**D4:27**	**D5:27**	**D6:09**	**D6:27**	**D7:27**	**D8:27**	**D9:27**	**D10:27**	**D11:27**
2	**St. Martins**	**D6:29**	**D6:59**	**D7:29**	**D8:29**	**D8:59**	**D9:59**	**D10:29**	**D11:29**	**D12:29**	**D1:29**	**D2:29**	**D3:29**	**D4:29**	**D5:29**	**D6:11**	**D6:29**	**D7:29**	**D8:29**	**D9:29**	**D10:29**	**D11:29**
2	**Highland**	**D6:33**	**D7:03**	**D7:33**	**D8:33**	**D9:03**	**D10:03**	**D10:33**	**D11:33**	**D12:33**	**D1:33**	**D2:33**	**D3:33**	**D4:33**	**D5:33**	**D6:15**	**D6:33**	**D7:33**	**D8:33**	**D9:33**	**D10:33**	**D11:33**
2	**Chestnut Hill West** ♿	6:38	7:08	7:38	8:38	9:08	10:08	10:38	11:38	12:38	1:38	2:38	3:38	4:38	5:38	6:20	6:38	7:38	8:38	9:38	10:38	11:38
		AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM

♿ – **Accessible station**

D – Train stops to discharge or pick up passengers, but may depart ahead of schedule.

F – Train stops to discharge passengers on notice to conductor and pick up passengers standing on the platform in position visible to engineer.

Saturdays, Sundays and Major Holidays

TO CENTER CITY

Fare Zone	Train Number / Stations	8312	8320	8328	8336	8344	8352	8360	8368	8376
	Stations	AM	AM	AM	PM	PM	PM	PM	PM	PM
2	**Chestnut Hill West** ♿	7:15	9:15	11:15	1:15	3:15	5:15	7:15	9:15	11:15
2	**Highland**	7:17	9:17	11:17	1:17	3:17	5:17	7:17	9:17	11:17
2	**St. Martins**	7:19	9:19	11:19	1:19	3:19	5:19	7:19	9:19	11:19
2	**Richard Allen Ln** ♿	7:21	9:21	11:21	1:21	3:21	5:21	7:21	9:21	11:21
2	**Carpenter**	7:23	9:23	11:23	1:23	3:23	5:23	7:23	9:23	11:23
2	**Upsal**	7:25	9:25	11:25	1:25	3:25	5:25	7:25	9:25	11:25
1	**Tulpehocken**	7:27	9:27	11:27	1:27	3:27	5:27	7:27	9:27	11:27
1	**Chelten Av**	7:29	9:29	11:29	1:29	3:29	5:29	7:29	9:29	11:29
1	**Queen Ln** ♿	7:31	9:31	11:31	1:31	3:31	5:31	7:31	9:31	11:31
1	**North Philadelphia**	7:35	9:35	11:35	1:35	3:35	5:35	7:35	9:35	11:35
C	**Gray 30th St Station** ♿	7:45	9:45	11:45	1:45	3:45	5:45	7:45	9:45	11:45
C	**Suburban Station** ♿	7:50	9:50	11:50	1:50	3:50	5:50	7:50	9:50	11:50
C	**Jefferson Station** ♿	7:55	9:55	11:55	1:55	3:55	5:55	7:55	9:55	11:55
C	**Temple University** ♿	8:00	10:00	12:00	2:00	4:00	6:00	8:00	10:00	12:00
	(See Destination Codes)	AM	AM	PM	PM	PM	PM	PM	PM	AM
	Train continues to	**WTR**	**WTR**	**WTR**	**WTR**	**WTR**	**WTR**	**WTR**	**WTR**	**WTR**

TO CHESTNUT HILL WEST

Fare Zone	Train Number / Stations	3807	3811	3815	3819	3823	3827	3831	3835	3839
	Stations	AM	AM	AM	PM	PM	PM	PM	PM	PM
C	**Temple University** ♿	6:09	8:09	10:09	12:09	2:09	4:09	6:09	8:09	10:09
C	**Jefferson Station** ♿	6:15	8:15	10:15	12:15	2:15	4:15	6:15	8:15	10:15
C	**Suburban Station** ♿	6:20	8:20	10:20	12:20	2:20	4:20	6:20	8:20	10:20
C	**Gray 30th St Station** ♿	6:24	8:24	10:24	12:24	2:24	4:24	6:24	8:24	10:24
1	**North Philadelphia**	**D6:34**	**D8:34**	**D10:34**	**D12:34**	**D2:34**	**D4:34**	**D6:34**	**D8:34**	**D10:34**
1	**Queen Ln** ♿	**D6:40**	**D8:40**	**D10:40**	**D12:40**	**D2:40**	**D4:40**	**D6:40**	**D8:40**	**D10:40**
1	**Chelten Av**	**D6:41**	**D8:41**	**D10:41**	**D12:41**	**D2:41**	**D4:41**	**D6:41**	**D8:41**	**D10:41**
1	**Tulpehocken**	**D6:42**	**D8:42**	**D10:42**	**D12:42**	**D2:42**	**D4:42**	**D6:42**	**D8:42**	**D10:42**
2	**Upsal**	**D6:44**	**D8:44**	**D10:44**	**D12:44**	**D2:44**	**D4:44**	**D6:44**	**D8:44**	**D10:44**
2	**Carpenter**	**D6:46**	**D8:46**	**D10:46**	**D12:46**	**D2:46**	**D4:46**	**D6:46**	**D8:46**	**D10:46**
2	**Richard Allen Ln** ♿	**D6:47**	**D8:47**	**D10:47**	**D12:47**	**D2:47**	**D4:47**	**D6:47**	**D8:47**	**D10:47**
2	**St. Martins**	**D6:49**	**D8:49**	**D10:49**	**D12:49**	**D2:49**	**D4:49**	**D6:49**	**D8:49**	**D10:49**
2	**Highland**	**D6:51**	**D8:51**	**D10:51**	**D12:51**	**D2:51**	**D4:51**	**D6:51**	**D8:51**	**D10:51**
2	**Chestnut Hill West** ♿	6:55	8:55	10:55	12:55	2:55	4:55	6:55	8:55	10:55
		AM	AM	AM	PM	PM	PM	PM	PM	PM

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Destination Codes

CHE	Chestnut Hill East	**LAN**	Lansdale
DOY	Doylestown	**MIQ**	Miquon
ELM	Elm Street	**NTC**	Norristown Transit Center
FOX	Fox Chase	**NSH**	Neshaminy Falls
GLN	Glenside	**WAR**	Warminster
JNK	Jenkintown-Wyncote	**WTR**	West Trenton

Safety Tips

- **Never** pass between cars when a train is moving
- **Never** attempt to board a moving train
- **Always** wait for the train to come to a complete stop **before** exiting
- **Never** ride in the vestibule or on the steps of a moving train
- **Never** lean against the train doors

For more information, visit **www.septa.org/safety**.

Cynwyd Line

To/From Center City Philadelphia

Effective September 2, 2025

SEPTA REGIONAL RAIL

Stations & Connecting Services

Cynwyd 1 E. Montgomery Av	P 44, 52
Bala 1 Bala Av	P 1, 44, 52, 65
Wynnefield Av 5024 Wynnefield Av	P 40
William H. Gray III 30th St Station 30th St & Market St	$ L T 9, 30, 31, 44, 49, 62, 78, 124, 125, LUCY Amtrak, NJT Atlantic City Line
Suburban Station 16th St & JFK Blvd	$ L B T 2, 4, 16, 17, 27, 31, 32, 33, 38, 44, 48, 62, 78, 124, 125

P – **Parking available**

$ – **Sales Office** (hours vary, visit **www.septa.org/stations**)

Travel Tips

Schedule Times: Indicate when trains depart the station.

Fare Payment Options: Contactless, SEPTA Key, Quick Trip, or cash. Visit **www.septa.org/fares** for more information.

Regional Rail Major Holidays: New Year's Day, Martin Luther King Jr. Day, Memorial Day, July 4th, Labor Day, Thanksgiving Day, Christmas Day (Special Schedule). *Please note: Holidays may be observed on another day.*

Disclaimer: SEPTA does not assume responsibility for inconvenience, experience or damage resulting from errors in timetables, delayed trains, failure to make connections or for shortage of equipment. Information is subject to change.

Severe Weather Schedule: During extreme weather conditions, trains may operate on a special schedule. Visit **www.septa.org** for more information.

Customer Service: **215-580-7800**
TDD/TTY: **215-580-7853**
www.septa.org

Penn Medicine
800.789.PENN PennMedicine.org

Mondays–Fridays (Except Major Holidays)

TO CENTER CITY

Fare Zone	Train Number / Stations	1052	1056	1060	1072	1082	1084
		AM	AM	AM	PM	PM	PM
2	**Cynwyd** ♿	6:00	7:28	8:46	12:36	3:52	5:15
2	**Bala** ♿	6:02	7:30	8:48	12:38	3:54	5:17
1	**Wynnefield Av** ♿	6:05	7:33	8:51	12:41	3:57	5:20
C	**Gray 30th St Station** ♿	**D6:17**	**D7:45**	**D9:03**	**D12:53**	**D4:09**	**D5:32**
C	**Suburban Station** ♿	6:22	7:50	9:08	12:58	4:14	5:37
		AM	AM	AM	PM	PM	PM

TO CYNWYD

Fare Zone	Train Number / Stations	1055	1059	1071	1081	1083	1085
		AM	AM	PM	PM	PM	PM
C	**Suburban Station** ♿	6:46	8:10	12:00	3:16	4:37	5:57
C	**Gray 30th St Station** ♿	6:51	8:15	12:05	3:21	4:42	6:02
1	**Wynnefield Av** ♿	**D7:02**	**D8:26**	**D12:16**	**D3:32**	**D4:53**	**D6:13**
2	**Bala** ♿	**D7:05**	**D8:29**	**D12:19**	**D3:35**	**D4:56**	**D6:16**
2	**Cynwyd** ♿	7:08	8:31	12:21	3:37	4:58	6:18
		AM	AM	PM	PM	PM	PM

♿ – **Accessible station**
D – Train stops to discharge or pick up passengers, but may depart ahead of schedule.

Routes 40 and 44 provide additional service along the Cynwyd Line.
For details, consult the Route 40 and 44 schedules.

Safety Tips

- **Never** pass between cars when a train is moving
- **Never** attempt to board a moving train
- **Always** wait for the train to come to a complete stop **before** exiting
- **Never** ride in the vestibule or on the steps of a moving train
- **Never** lean against the train doors

For more information, visit **www.septa.org/safety**.

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Revised September 5, 2025

Lansdale/ Doylestown Line

To/From Center City Philadelphia

Effective September 2, 2025

SEPTA REGIONAL RAIL

- Doylestown
- Delaware Valley University
- New Britain
- Chalfont
- Link Belt
- Colmar
- Fortuna
- 9th St
- Lansdale
- Pennbrook
- North Wales
- Gwynedd Valley
- Penllyn
- Ambler
- Fort Washington
- Oreland
- North Hills
- Glenside
- Jenkintown-Wyncote
- Fern Rock Transit Center
- Wayne Junction
- North Broad
- Temple University
- Jefferson Station
- Suburban Station
- William H. Gray III 30th St Station
- Penn Medicine Station

Customer Service: **215-580-7800**
TDD/TTY: **215-580-7853**
www.septa.org

Penn Medicine
800.789.PENN PennMedicine.org

Station Locations & Connecting Services

Doylestown 130 S. Clinton St • 215-348-4234	$ P 55, Trans-Bridge Buses to New Hope & New York City
Delaware Valley University 700 E. Butler Av	P
New Britain 98 S. Tamenend Av	P
Chalfont 13 Sunset Av	P
Link Belt 3367 E. Walnut St	
Colmar 2891 Walnut St	P
Fortuna 101 Cowpath Rd	P 132
9th St Lansdale 141 W. 9th St	P
Lansdale 80 W. Main St • 215-580-6700	$ P 96, 132
Pennbrook 1114 Church Rd	P 94
North Wales 605 Beaver St	P 96
Gwynedd Valley 521 Plymouth Rd	P
Penllyn 908 Pershing Rd	P 94
Ambler 35 W. Butler Pk • 215-580-6702	$ P 94, 95
Fort Washington 7299 Station Av	P 94, 95, 201
Oreland 1502 Bruce Rd	P
North Hills 85 Station Av	P
Glenside 49 W. Glenside Av	P 22, 77
Jenkintown-Wyncote 50 Greenwood Av • 215-580-6838	$ P 77
Fern Rock Transit Center 900 Nedro Av	P B 4, 28, 57, 70
Wayne Junction 2129 Windrim Av • 215-580-6892	$ 2, 23, 53, 75
North Broad 2693 N. Broad St	B 4, 16, 54
Temple University 927 W. Berks St • 215-580-5440	$
Jefferson Station Market St between 10th St & 12th St	$ L B3 17, 23, 33, 38, 44, 45, 47, 47M, 48, 61, 62, 78, NJ Transit Buses
Suburban Station 16th St & JFK Blvd	$ L B T 2, 4, 16, 17, 27, 31, 32, 33, 38, 44, 48, 62, 78, 124, 125
William H. Gray III 30th St Station 30th St & Market St	$ L T 9, 30, 31, 44, 49, 62, 78, 124, 125, LUCY Amtrak, NJ Transit Atlantic City Line
Penn Medicine Station 3149 Convention Blvd • 215-580-6565	$ 40, LUCY

P – **Parking available**

$ – **Sales Office** (hours vary, visit **www.septa.org/stations** for details)

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Mondays through Fridays (Except Major Holidays)

TO CENTER CITY

Fare Zone	Train Number / Stations	503	6595	5205	6589	6505	6591	6593	6507	5211	6511	6513	5215	5217	6519
		AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM
4	**Doylestown** ♿	5:07	–	6:11	6:34	–	6:57	–	7:34	8:11	9:11	10:11	11:11	12:11	1:11
4	**Delaware Valley University** ♿	5:11	–	6:15	6:38	–	7:01	–	7:38	8:15	9:15	10:15	11:15	12:15	1:15
4	**New Britain** ♿	**F5:13**	–	**F6:17**	**F6:40**	–	**F7:03**	–	**F7:40**	**F8:17**	**F9:17**	**F10:17**	**F11:17**	**F12:17**	**F1:17**
4	**Chalfont** ♿	5:16	–	6:20	6:43	–	7:06	–	7:43	8:20	9:20	10:20	11:20	12:20	1:20
4	**Link Belt** ♿	**F5:20**	–	**F6:23**	**F6:46**	–	**F7:09**	–	**F7:47**	**F8:23**	**F9:26**	**F10:23**	**F11:23**	**F12:23**	**F1:23**
4	**Colmar** ♿	5:21	–	6:25	6:48	–	7:11	–	7:48	8:25	9:28	10:25	11:25	12:25	1:25
4	**Fortuna** ♿	5:23	–	6:26	6:49	–	7:12	–	7:50	8:26	9:30	10:26	11:26	12:26	1:26
4	**9th St Lansdale** ♿	5:25	–	6:28	6:51	–	7:14	–	7:52	8:28	9:32	10:28	11:28	12:28	1:28
4	**Lansdale** ♿	5:30	6:11	6:38	6:56	7:09	7:23	7:42	8:01	8:38	9:38	10:38	11:38	12:38	1:38
4	**Pennbrook** ♿	5:35	6:14	6:41	7:00	7:12	7:27	7:45	8:04	8:42	9:41	10:41	11:41	12:41	1:41
4	**North Wales** ♿	5:37	6:17	6:44	7:03	7:15	7:30	7:48	8:07	8:45	9:44	10:44	11:44	12:44	1:44
3	**Gwynedd Valley**	5:41	6:20	6:47	7:06	7:18	7:33	7:51	8:11	8:48	9:47	10:47	11:47	12:47	1:47
3	**Penllyn**	5:43	6:23	6:50	7:09	7:21	7:36	7:54	8:13	8:51	9:50	10:50	11:50	12:50	1:50
3	**Ambler** ♿	5:46	6:26	6:53	7:12	7:24	7:39	7:57	8:17	8:54	9:53	10:53	11:53	12:53	1:53
3	**Fort Washington** ♿ (Rt. 201)	5:49	6:29	6:56	7:15	7:27	7:43	8:00	8:19	8:57	9:56	10:56	11:56	12:56	1:56
3	**Oreland**	5:53	6:33	7:00	–	7:31	–	8:04	8:24	9:02	10:00	11:00	12:00	1:00	2:00
3	**North Hills**	5:55	6:35	7:02	–	7:33	–	8:06	8:26	9:04	10:02	11:02	12:02	1:02	2:02
3	**Glenside**	5:59	6:38	7:05	–	7:36	–	8:09	8:31	9:07	10:05	11:05	12:05	1:05	2:05
3	**Jenkintown-Wyncote**	6:02	6:41	7:08	–	7:39	–	8:12	8:35	9:10	10:08	11:08	12:08	1:08	2:08
1	**Fern Rock Transit Center** ♿	6:09	–	7:15	–	–	–	8:16	–	9:17	10:15	11:15	12:15	1:15	2:15
1	**Wayne Junction** ♿	6:12	–	7:18	–	–	–	8:20	–	9:20	10:18	11:18	12:18	1:18	2:18
1	**North Broad** ♿	–	–	7:23	–	–	–	8:26	–	9:25	10:23	11:23	12:23	1:23	2:23
C	**Temple University** ♿	6:19	**D6:56**	7:24	**D7:37**	**D7:54**	**D8:05**	**D8:30**	**D8:51**	9:26	**D10:24**	**D11:24**	12:24	1:24	**D2:24**
C	**Jefferson Station** ♿	6:26	**D7:02**	7:30	**D7:43**	**D8:00**	**D8:11**	**D8:36**	**D8:57**	9:32	**D10:30**	**D11:30**	12:30	1:30	**D2:30**
C	**Suburban Station** ♿	6:31	**D7:07**	7:35	**D7:48**	**D8:05**	**D8:16**	**D8:41**	**D9:02**	9:37	**D10:35**	**D11:35**	12:35	1:35	**D2:35**
C	**Gray 30th St Station** ♿	6:35	7:11	7:40	7:53	8:10	8:21	8:46	9:07	9:42	10:39	11:39	12:39	1:39	2:39
C	**Penn Medicine Station**	–	–	7:43	–	–	–	–	–	9:45	–	–	12:42	1:42	–
	(See Destination Codes)	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM
	Train continues to	**MAL**	–	**NWK**	–	–	–	–	–	**MHK**	–	–	**WIL**	**WIL**	–

TO CENTER CITY

Fare Zone	Train Number / Stations	5321	5447	5347	5847	6527	5227	5399	5229	5231	6533	6535	5239	6543
		PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
4	**Doylestown** ♿	2:11	–	3:11	4:11	–	5:05	–	6:05	7:13	7:41	8:11	9:11	10:56
4	**Delaware Valley University** ♿	2:15	–	3:15	4:15	–	5:09	–	6:12	7:19	7:49	8:15	9:15	11:00
4	**New Britain** ♿	**F2:17**	–	**F3:17**	**F4:17**	–	**F5:11**	–	**F6:14**	**F7:22**	**F7:51**	**F8:17**	**F9:17**	**F11:02**
4	**Chalfont** ♿	2:20	–	3:20	4:20	–	5:14	–	6:17	7:24	7:54	8:20	9:20	11:05
4	**Link Belt** ♿	**F2:23**	–	**F3:23**	**F4:23**	–	**F5:21**	–	**F6:23**	**F7:28**	**F7:57**	**F8:23**	**F9:23**	**F11:08**
4	**Colmar** ♿	2:25	–	3:25	4:25	–	5:23	–	6:25	7:29	7:59	8:25	9:25	11:10
4	**Fortuna** ♿	2:26	–	3:26	4:26	–	5:25	–	6:27	7:31	8:01	8:26	9:26	11:11
4	**9th St Lansdale** ♿	2:28	–	3:28	4:28	–	5:27	–	6:29	7:33	8:03	8:28	9:28	11:13
4	**Lansdale** ♿	2:38	2:55	3:38	4:41	5:10	5:36	5:46	6:38	7:38	8:13	8:38	9:38	11:18
4	**Pennbrook** ♿	2:41	2:58	3:41	4:44	5:13	5:39	5:49	6:41	7:41	8:16	8:41	9:41	11:22
4	**North Wales** ♿	2:44	3:01	3:44	4:47	5:16	5:42	5:52	6:44	7:44	8:19	8:44	9:44	11:24
3	**Gwynedd Valley**	2:47	3:04	3:47	4:50	5:19	5:45	5:55	6:47	7:47	8:22	8:47	9:47	11:28
3	**Penllyn**	2:50	3:06	3:50	4:53	5:22	5:47	5:58	6:50	7:50	8:25	8:50	9:50	11:30
3	**Ambler** ♿	2:53	3:10	3:53	4:56	5:25	5:50	6:01	6:53	7:53	8:28	8:53	9:53	11:33
3	**Fort Washington** ♿ (Rt. 201)	2:56	3:13	3:56	4:59	5:28	5:52	6:04	6:56	7:56	8:31	8:56	9:56	11:36
3	**Oreland**	3:00	3:17	4:00	5:03	5:32	5:56	6:08	7:00	8:00	8:35	9:00	10:00	11:39
3	**North Hills**	3:02	3:19	4:02	5:05	5:34	5:58	6:10	7:02	8:02	8:37	9:02	10:02	11:41
3	**Glenside**	3:05	3:22	4:05	5:08	5:37	6:01	6:13	7:05	8:05	8:40	9:05	10:05	11:43
3	**Jenkintown-Wyncote**	3:08	3:25	4:08	5:11	5:40	6:03	6:16	7:08	8:08	8:43	9:08	10:08	11:46
1	**Fern Rock Transit Center** ♿	3:15	3:32	4:15	5:18	5:46	6:10	–	7:15	8:15	8:50	9:15	10:15	11:52
1	**Wayne Junction** ♿	3:18	3:35	4:18	5:21	5:50	6:13	–	7:18	8:18	8:53	9:18	10:18	11:55
1	**North Broad** ♿	3:23	–	4:23	5:26	5:55	6:18	–	7:23	8:23	8:58	9:23	10:23	12:01
C	**Temple University** ♿	**D3:24**	3:43	4:24	5:28	**D5:57**	6:19	**D6:28**	7:24	8:24	**D8:59**	**D9:24**	10:24	**D12:02**
C	**Jefferson Station** ♿	**D3:30**	3:50	4:30	5:34	**D6:03**	6:25	**D6:34**	7:30	8:30	**D9:05**	**D9:30**	10:30	**D12:08**
C	**Suburban Station** ♿	**D3:35**	3:55	4:35	5:39	**D6:08**	6:30	**D6:39**	7:35	8:35	**D9:10**	**D9:35**	10:35	**D12:13**
C	**Gray 30th St Station** ♿	**D3:39**	3:59	4:39	5:44	6:13	6:35	6:43	7:39	8:39	9:15	9:39	10:39	12:17
C	**Penn Medicine Station**	3:42	4:02	4:42	–	–	6:38	6:46	7:42	8:42	–	–	10:42	–
	(See Destination Codes)	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	AM
	Train continues to	–	**AIR**	**WAW**	**CHW**	–	**NWK**	–	**WIL**	**MHK**	–	–	**MHK**	–

♿ – **Accessible station**

D – Train stops to discharge or pick up passengers, but may depart ahead of schedule.

F – Train stops to discharge passengers on notice to conductor and pick up passengers standing on the platform in position visible to engineer.

Mondays through Fridays (Except Major Holidays)

TO LANSDALE/DOYLESTOWN

Fare Zone	Train Number	514	516	2500	512	3504	7504	6508	6510	6512	2514	6516	6590	2518	6520
	Stations	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM
C	**Penn Medicine Station** ♿	–	–	7:01	–	8:49	–	–	–	–	1:01	–	–	3:09	–
C	**Gray 30th St Station** ♿	5:49	6:25	7:04	8:02	8:52	9:12	10:12	11:04	12:04	1:04	2:04	2:48	3:12	3:48
C	**Suburban Station** ♿	5:54	6:30	7:09	8:07	8:57	9:17	10:16	11:09	12:09	1:09	2:09	2:53	3:16	3:53
C	**Jefferson Station** ♿	5:59	6:35	7:14	8:12	9:02	9:22	10:20	11:14	12:14	1:14	2:14	2:58	3:20	3:58
C	**Temple University** ♿	6:03	6:39	7:18	8:17	9:06	9:27	10:24	11:18	12:18	1:18	2:18	3:03	3:24	4:03
1	**North Broad** ♿	6:05	6:41	7:20	8:19	9:09	9:29	**D10:26**	11:20	12:20	1:20	2:20	3:05	3:26	4:05
1	**Wayne Junction** ♿	6:11	6:46	7:26	8:26	9:13	9:35	**D10:31**	11:26	12:26	1:26	2:26	3:10	3:31	4:10
1	**Fern Rock Transit Center** ♿	6:15	6:50	7:30	8:31	9:17	9:38	**D10:33**	11:30	12:30	1:30	2:30	3:13	3:33	4:12
3	**Jenkintown-Wyncote**	6:21	6:57	7:37	8:39	9:23	9:44	10:39	11:37	12:37	1:37	2:37	3:18	3:39	4:18
3	**Glenside**	**D6:24**	–	**D7:39**	**D8:42**	**D9:26**	**D9:47**	**D10:41**	**D11:39**	**D12:39**	**D1:39**	**D2:39**	**D3:21**	**D3:41**	**D4:21**
3	**North Hills**	**D6:26**	–	**D7:41**	**D8:44**	**D9:28**	**D9:49**	**D10:43**	**D11:41**	**D12:41**	**D1:41**	**D2:41**	**D3:23**	**D3:43**	**D4:23**
3	**Oreland**	**D6:28**	–	**D7:43**	**D8:46**	**D9:30**	**D9:51**	**D10:45**	**D11:43**	**D12:43**	**D1:43**	**D2:43**	**D3:25**	**D3:45**	**D4:25**
3	**Fort Washington** ♿ (Rt. 201)	**CD6:31**	**D7:04**	**CD7:46**	**CD8:49**	**CD9:33**	**CD9:54**	**CD10:48**	**CD11:46**	**CD12:46**	**CD1:46**	**CD2:46**	**D3:29**	**CD3:48**	**D4:29**
3	**Ambler** ♿	**D6:34**	**D7:06**	**D7:49**	**D8:52**	**D9:35**	**D9:57**	**D10:51**	**D11:49**	**D12:49**	**D1:49**	**D2:49**	**D3:32**	**D3:51**	**D4:32**
3	**Penllyn**	**D6:37**	–	**D7:52**	**D8:55**	**D9:39**	**D10:00**	**D10:54**	**D11:52**	**D12:52**	**D1:52**	**D2:52**	**D3:35**	**D3:54**	**D4:35**
3	**Gwynedd Valley**	**D6:40**	–	**D7:55**	**D8:57**	**D9:41**	**D10:03**	**D10:57**	**D11:55**	**D12:55**	**D1:55**	**D2:55**	**D3:38**	**D3:57**	**D4:38**
4	**North Wales** ♿	**D6:43**	**D7:16**	**D7:59**	**D9:01**	**D9:45**	**D10:07**	**D11:00**	**D11:58**	**D12:59**	**D1:58**	**D2:59**	**D3:41**	**D4:00**	**D4:42**
4	**Pennbrook** ♿	**D6:46**	**D7:19**	**D8:01**	**D9:03**	**D9:48**	**D10:09**	**D11:03**	**D12:01**	**D1:01**	**D2:01**	**D3:01**	**D3:44**	**D4:03**	**D4:45**
4	**Lansdale** ♿	**D6:53**	7:22	**D8:06**	**D9:09**	9:54	**D10:14**	**D11:08**	**D12:06**	**D1:06**	**D2:06**	**D3:06**	3:50	**D4:08**	4:50
4	**9th St Lansdale** ♿	**D6:56**	–	**D8:09**	**D9:12**	–	**D10:16**	**D11:11**	**D12:09**	**D1:09**	**D2:09**	**D3:09**	–	**D4:11**	–
4	**Fortuna** ♿	**D6:58**	–	**D8:11**	**D9:14**	–	**D10:18**	**D11:13**	**D12:11**	**D1:11**	**D2:11**	**D3:11**	–	**D4:13**	–
4	**Colmar** ♿	**D7:00**	–	**D8:13**	**D9:16**	–	**D10:20**	**D11:15**	**D12:13**	**D1:13**	**D2:13**	**D3:13**	–	**D4:15**	–
4	**Link Belt** ♿	**D7:03**	–	**D8:16**	**D9:19**	–	**D10:23**	**D11:18**	**D12:16**	**D1:16**	**D2:16**	**D3:16**	–	**D4:18**	–
4	**Chalfont** ♿	**D7:15**	–	**D8:25**	**D9:27**	–	**D10:30**	**D11:26**	**D12:24**	**D1:24**	**D2:23**	**D3:24**	–	**D4:25**	–
4	**New Britain** ♿	**D7:18**	–	**D8:29**	**D9:31**	–	**D10:34**	**D11:30**	**D12:28**	**D1:28**	**D2:27**	**D3:28**	–	**D4:29**	–
4	**Delaware Valley University** ♿	**D7:20**	–	**D8:31**	**D9:33**	–	**D10:36**	**D11:33**	**D12:31**	**D1:30**	**D2:29**	**D3:30**	–	**D4:31**	–
4	**Doylestown** ♿	7:36	–	8:36	9:40	–	10:43	11:39	12:37	1:37	2:36	3:37	–	4:38	–
		AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM

TO LANSDALE/DOYLESTOWN

Fare Zone	Train Number	3592	6592	6594	6596	2522	542	2524	7572	3526	2528	2530	6532	4574	4578
	Stations	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	AM
C	**Penn Medicine Station** ♿	4:09	–	–	–	5:09	–	6:08	–	7:09	8:09	9:01	–	11:27	12:27
C	**Gray 30th St Station** ♿	4:12	4:29	4:45	4:57	5:12	5:48	6:11	6:45	7:12	8:12	9:04	10:42	11:30	12:30
C	**Suburban Station** ♿	4:16	4:34	4:50	5:02	5:16	5:53	6:16	6:50	7:16	8:16	9:09	10:46	11:35	12:35
C	**Jefferson Station** ♿	4:20	4:39	4:55	5:07	5:20	5:58	6:21	6:55	7:20	8:20	9:14	10:50	11:40	12:40
C	**Temple University** ♿	4:25	4:43	5:00	5:12	5:24	6:03	6:26	7:00	7:24	8:24	9:18	10:54	11:45	12:45
1	**North Broad** ♿	–	–	5:02	–	–	6:05	6:28	7:03	7:26	8:26	9:20	10:56	–	12:47
1	**Wayne Junction** ♿	–	–	5:07	–	–	6:13	6:33	7:08	7:31	8:31	9:26	11:01	11:51	12:52
1	**Fern Rock Transit Center** ♿	–	4:51	5:09	–	–	6:16	6:35	7:12	7:33	8:33	9:30	11:03	11:55	12:55
3	**Jenkintown-Wyncote**	–	4:58	5:15	5:26	–	6:21	6:41	7:19	7:39	8:39	9:37	11:09	12:02	1:02
3	**Glenside**	–	**D5:01**	**D5:16**	**D5:28**	–	**D6:23**	**D6:44**	**D7:22**	**D7:41**	**D8:41**	**D9:39**	**D11:11**	**D12:05**	**D1:05**
3	**North Hills**	–	**D5:03**	**D5:18**	**D5:30**	–	**D6:25**	**D6:46**	**D7:24**	**D7:43**	**D8:43**	**D9:41**	**D11:13**	**D12:07**	**D1:07**
3	**Oreland**	–	**D5:05**	**D5:20**	**D5:32**	–	**D6:27**	**D6:48**	**D7:26**	**D7:45**	**D8:45**	**D9:43**	**D11:15**	**D12:08**	**D1:09**
3	**Fort Washington** ♿ (Rt. 201)	**D4:46**	**D5:08**	**D5:24**	**D5:36**	**CD5:46**	**D6:31**	**D6:52**	**D7:29**	**D7:48**	**D8:48**	**D9:46**	**D11:18**	**D12:11**	**D1:12**
3	**Ambler** ♿	**D4:49**	**D5:11**	**D5:26**	**D5:38**	**D5:49**	**D6:34**	**D6:55**	**D7:31**	**D7:51**	**D8:51**	**D9:49**	**D11:21**	**D12:13**	**D1:14**
3	**Penllyn**	**D4:52**	**D5:14**	**D5:29**	**D5:41**	**D5:52**	**D6:37**	**D6:58**	**D7:34**	**D7:54**	**D8:54**	**D9:52**	**D11:24**	**D12:16**	**D1:16**
3	**Gwynedd Valley**	**D4:55**	**D5:17**	**D5:32**	**D5:44**	**D5:55**	**D6:40**	**D7:01**	**D7:37**	**D7:57**	**D8:57**	**D9:55**	**D11:27**	**D12:17**	**D1:18**
4	**North Wales** ♿	**D4:58**	**D5:20**	**D5:35**	**D5:48**	**D5:58**	**D6:43**	**D7:04**	**D7:41**	**D8:00**	**D9:00**	**D9:58**	**D11:30**	**D12:22**	**D1:22**
4	**Pennbrook** ♿	**D5:01**	**D5:23**	**D5:38**	**D5:50**	**D6:01**	**D6:46**	**D7:07**	**D7:43**	**D8:03**	**D9:03**	**D10:01**	**D11:33**	**D12:25**	**D1:26**
4	**Lansdale** ♿	**D5:07**	5:29	**D5:42**	5:54	**D6:06**	**D6:50**	**D7:13**	7:47	**D8:08**	**D9:08**	**D10:06**	**D11:38**	**D12:28**	1:32
4	**9th St Lansdale** ♿	**D5:10**	–	**D5:45**	–	**D6:09**	**D6:53**	**D7:16**	–	**D8:11**	**D9:11**	**D10:09**	**D11:41**	**D12:32**	–
4	**Fortuna** ♿	**D5:13**	–	**D5:48**	–	**D6:11**	**D6:56**	**D7:18**	–	**D8:13**	**D9:13**	**D10:11**	**D11:43**	**D12:33**	–
4	**Colmar** ♿	**D5:16**	–	**D5:51**	–	**D6:13**	**D6:59**	**D7:20**	–	**D8:15**	**D9:15**	**D10:13**	**D11:45**	**D12:35**	–
4	**Link Belt** ♿	**D5:19**	–	**D5:54**	–	**D6:16**	**D7:02**	**D7:23**	–	**D8:18**	**D9:18**	**D10:16**	**D11:48**	**D12:38**	–
4	**Chalfont** ♿	**D5:26**	–	**D5:58**	–	**D6:22**	**D7:06**	**D7:30**	–	**D8:28**	**D9:27**	**D10:23**	**D11:55**	**D12:45**	–
4	**New Britain** ♿	**D5:30**	–	**D6:02**	–	**D6:26**	**D7:10**	**D7:34**	–	**D8:32**	**D9:31**	**D10:28**	**D11:59**	**D12:50**	–
4	**Delaware Valley University** ♿	**D5:33**	–	**D6:05**	–	**D6:28**	**D7:13**	**D7:36**	–	**D8:34**	**D9:33**	**D10:31**	**D12:01**	**D12:53**	–
4	**Doylestown** ♿	5:40	–	6:12	–	6:36	7:20	7:43	–	8:38	9:38	10:36	12:08	12:57	–
		PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	AM	AM	AM

♿ – **Accessible station**

C – Connecting bus service meets this train. **Route 201** operates to/from Fort Washington Office Center. For details, consult the Route 201 schedule.

D – Train stops to discharge or pick up passengers, but may depart ahead of schedule.

Saturdays, Sundays and Major Holidays

TO CENTER CITY

Fare Zone	Stations / Train Number	5301	5305	5309	5313	5317	5321	5325	5329	5333	5337	5341	5345	5349	5353	5357	5361	5365	5369
		AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
4	**Doylestown** ♿	5:23	6:23	7:23	8:23	9:23	10:23	11:23	12:23	1:23	2:23	3:23	4:23	5:23	6:23	7:23	8:23	9:23	10:23
4	**Delaware Valley University** ♿	5:27	6:27	7:27	8:27	9:27	10:27	11:27	12:27	1:27	2:27	3:27	4:27	5:27	6:27	7:27	8:27	9:27	10:27
4	**New Britain** ♿	5:29	6:29	7:29	8:29	9:29	10:29	11:29	12:29	1:29	2:29	3:29	4:29	5:29	6:29	7:29	8:29	9:29	10:29
4	**Chalfont** ♿	5:32	6:32	7:32	8:32	9:32	10:32	11:32	12:32	1:32	2:32	3:32	4:32	5:32	6:32	7:32	8:32	9:32	10:32
4	**Colmar** ♿	5:36	6:36	7:36	8:36	9:36	10:36	11:36	12:36	1:36	2:36	3:36	4:36	5:36	6:36	7:36	8:36	9:36	10:36
4	**Fortuna** ♿	5:38	6:38	7:38	8:38	9:38	10:38	11:38	12:38	1:38	2:38	3:38	4:38	5:38	6:38	7:38	8:38	9:38	10:38
4	**9th St Lansdale** ♿	5:40	6:40	7:40	8:40	9:40	10:40	11:40	12:40	1:40	2:40	3:40	4:40	5:40	6:40	7:40	8:40	9:40	10:40
4	**Lansdale** ♿	5:45	6:45	7:45	8:45	9:45	10:45	11:45	12:45	1:45	2:45	3:45	4:45	5:45	6:45	7:45	8:45	9:45	10:45
4	**Pennbrook** ♿	5:48	6:48	7:48	8:48	9:48	10:48	11:48	12:48	1:48	2:48	3:48	4:48	5:48	6:48	7:48	8:48	9:48	10:48
4	**North Wales** ♿	5:51	6:51	7:51	8:51	9:51	10:51	11:51	12:51	1:51	2:51	3:51	4:51	5:51	6:51	7:51	8:51	9:51	10:51
3	**Gwynedd Valley**	5:55	6:55	7:55	8:55	9:55	10:55	11:55	12:55	1:55	2:55	3:55	4:55	5:55	6:55	7:55	8:55	9:55	10:55
3	**Penllyn**	5:57	6:57	7:57	8:57	9:57	10:57	11:57	12:57	1:57	2:57	3:57	4:57	5:57	6:57	7:57	8:57	9:57	10:57
3	**Ambler** ♿	6:00	7:00	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00
3	**Fort Washington** ♿	6:03	7:03	8:03	9:03	10:03	11:03	12:03	1:03	2:03	3:03	4:03	5:03	6:03	7:03	8:03	9:03	10:03	11:03
3	**Oreland**	6:06	7:06	8:06	9:06	10:06	11:06	12:06	1:06	2:06	3:06	4:06	5:06	6:06	7:06	8:06	9:06	10:06	11:06
3	**North Hills**	6:08	7:08	8:08	9:08	10:08	11:08	12:08	1:08	2:08	3:08	4:08	5:08	6:08	7:08	8:08	9:08	10:08	11:08
3	**Glenside**	6:11	7:11	8:11	9:11	10:11	11:11	12:11	1:11	2:11	3:11	4:11	5:11	6:11	7:11	8:11	9:11	10:11	11:11
3	**Jenkintown-Wyncote**	6:14	7:14	8:14	9:14	10:14	11:14	12:14	1:14	2:14	3:14	4:14	5:14	6:14	7:14	8:14	9:14	10:14	11:14
1	**Fern Rock Transit Center** ♿	6:19	7:19	8:19	9:19	10:19	11:19	12:19	1:19	2:19	3:19	4:19	5:19	6:19	7:19	8:19	9:19	10:19	11:19
1	**Wayne Junction** ♿	6:23	7:23	8:23	9:23	10:23	11:23	12:23	1:23	2:23	3:23	4:23	5:23	6:23	7:23	8:23	9:23	10:23	11:23
1	**North Broad** ♿	6:28	7:28	8:28	9:28	10:28	11:28	12:28	1:28	2:28	3:28	4:28	5:28	6:28	7:28	8:28	9:28	10:28	11:28
C	**Temple University** ♿	6:30	7:30	8:30	9:30	10:30	11:30	12:30	1:30	2:30	3:30	4:30	5:30	6:30	7:30	8:30	9:30	10:30	11:30
C	**Jefferson Station** ♿	6:36	7:36	8:36	9:36	10:36	11:36	12:36	1:36	2:36	3:36	4:36	5:36	6:36	7:36	8:36	9:36	10:36	11:36
C	**Suburban Station** ♿	6:41	7:41	8:41	9:41	10:41	11:41	12:41	1:41	2:41	3:41	4:41	5:41	6:41	7:41	8:41	9:41	10:41	11:41
C	**Gray 30th St Station** ♿	6:46	7:46	8:46	9:46	10:46	11:46	12:46	1:46	2:46	3:46	4:46	5:46	6:46	7:46	8:46	9:46	10:46	11:46
C	**Penn Medicine Station**	6:49	7:49	8:49	9:49	10:49	11:49	12:49	1:49	2:49	3:49	4:49	5:49	6:49	7:49	8:49	9:49	10:49	11:49
	(See Destination Codes)	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
	Train continues to	**WAW**	**WAW**	**WAW**	**WAW**	**WAW**	**WAW**	**WAW**	**WAW**	**WAW**	**WAW**	**WAW**	**WAW**	**WAW**	**WAW**	**WAW**	**WAW**	**WAW**	**WAW**

TO DOYLESTOWN

Fare Zone	Stations / Train Number	3506	3510	3514	3518	3522	3526	3530	3534	3538	3542	3546	3550	3554	3558	3562	3566	3570	3574
		AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
C	**Penn Medicine Station** ♿	6:36	7:36	8:36	9:36	10:36	11:36	12:36	1:36	2:36	3:36	4:36	5:36	6:36	7:36	8:36	9:36	10:36	11:36
C	**Gray 30th St Station** ♿	6:39	7:39	8:39	9:39	10:39	11:39	12:39	1:39	2:39	3:39	4:39	5:39	6:39	7:39	8:39	9:39	10:39	11:39
C	**Suburban Station** ♿	6:44	7:44	8:44	9:44	10:44	11:44	12:44	1:44	2:44	3:44	4:44	5:44	6:44	7:44	8:44	9:44	10:44	11:44
C	**Jefferson Station** ♿	6:49	7:49	8:49	9:49	10:49	11:49	12:49	1:49	2:49	3:49	4:49	5:49	6:49	7:49	8:49	9:49	10:49	11:49
C	**Temple University** ♿	6:54	7:54	8:54	9:54	10:54	11:54	12:54	1:54	2:54	3:54	4:54	5:54	6:54	7:54	8:54	9:54	10:54	11:54
1	**North Broad** ♿	6:56	7:56	8:56	9:56	10:56	11:56	12:56	1:56	2:56	3:56	4:56	5:56	6:56	7:56	8:56	9:56	10:56	11:56
1	**Wayne Junction** ♿	7:01	8:01	9:01	10:01	11:01	12:01	1:01	2:01	3:01	4:01	5:01	6:01	7:01	8:01	9:01	10:01	11:01	12:01
1	**Fern Rock Transit Center** ♿	7:05	8:05	9:05	10:05	11:05	12:05	1:05	2:05	3:05	4:05	5:05	6:05	7:05	8:05	9:05	10:05	11:05	12:05
3	**Jenkintown-Wyncote**	7:11	8:11	9:11	10:11	11:11	12:11	1:11	2:11	3:11	4:11	5:11	6:11	7:11	8:11	9:11	10:11	11:11	12:11
3	**Glenside**	**D7:14**	**D8:14**	**D9:14**	**D10:14**	**D11:14**	**D12:14**	**D1:14**	**D2:14**	**D3:14**	**D4:14**	**D5:14**	**D6:14**	**D7:14**	**D8:14**	**D9:14**	**D10:14**	**D11:14**	**D12:14**
3	**North Hills**	**D7:16**	**D8:16**	**D9:16**	**D10:16**	**D11:16**	**D12:16**	**D1:16**	**D2:16**	**D3:16**	**D4:16**	**D5:16**	**D6:16**	**D7:16**	**D8:16**	**D9:16**	**D10:16**	**D11:16**	**D12:16**
3	**Oreland**	**D7:18**	**D8:18**	**D9:18**	**D10:18**	**D11:18**	**D12:18**	**D1:18**	**D2:18**	**D3:18**	**D4:18**	**D5:18**	**D6:18**	**D7:18**	**D8:18**	**D9:18**	**D10:18**	**D11:18**	**D12:18**
3	**Fort Washington** ♿	**D7:21**	**D8:21**	**D9:21**	**D10:21**	**D11:21**	**D12:21**	**D1:21**	**D2:21**	**D3:21**	**D4:21**	**D5:21**	**D6:21**	**D7:21**	**D8:21**	**D9:21**	**D10:21**	**D11:21**	**D12:21**
3	**Ambler** ♿	**D7:24**	**D8:24**	**D9:24**	**D10:24**	**D11:24**	**D12:24**	**D1:24**	**D2:24**	**D3:24**	**D4:24**	**D5:24**	**D6:24**	**D7:24**	**D8:24**	**D9:24**	**D10:24**	**D11:24**	**D12:24**
3	**Penllyn**	**D7:27**	**D8:27**	**D9:27**	**D10:27**	**D11:27**	**D12:27**	**D1:27**	**D2:27**	**D3:27**	**D4:27**	**D5:27**	**D6:27**	**D7:27**	**D8:27**	**D9:27**	**D10:27**	**D11:27**	**D12:27**
3	**Gwynedd Valley**	**D7:29**	**D8:29**	**D9:29**	**D10:29**	**D11:29**	**D12:29**	**D1:29**	**D2:29**	**D3:29**	**D4:29**	**D5:29**	**D6:29**	**D7:29**	**D8:29**	**D9:29**	**D10:29**	**D11:29**	**D12:29**
4	**North Wales** ♿	**D7:33**	**D8:33**	**D9:33**	**D10:33**	**D11:33**	**D12:33**	**D1:33**	**D2:33**	**D3:33**	**D4:33**	**D5:33**	**D6:33**	**D7:33**	**D8:33**	**D9:33**	**D10:33**	**D11:33**	**D12:33**
4	**Pennbrook** ♿	**D7:36**	**D8:36**	**D9:36**	**D10:36**	**D11:36**	**D12:36**	**D1:36**	**D2:36**	**D3:36**	**D4:36**	**D5:36**	**D6:36**	**D7:36**	**D8:36**	**D9:36**	**D10:36**	**D11:36**	**D12:36**
4	**Lansdale** ♿	**D7:41**	**D8:41**	**D9:41**	**D10:41**	**D11:41**	**D12:41**	**D1:41**	**D2:41**	**D3:41**	**D4:41**	**D5:41**	**D6:41**	**D7:41**	**D8:41**	**D9:41**	**D10:41**	**D11:41**	**D12:41**
4	**9th St Lansdale** ♿	**D7:46**	**D8:46**	**D9:46**	**D10:46**	**D11:46**	**D12:46**	**D1:46**	**D2:46**	**D3:46**	**D4:46**	**D5:46**	**D6:46**	**D7:46**	**D8:46**	**D9:46**	**D10:46**	**D11:46**	**D12:46**
4	**Fortuna** ♿	**D7:47**	**D8:47**	**D9:47**	**D10:47**	**D11:47**	**D12:47**	**D1:47**	**D2:47**	**D3:47**	**D4:47**	**D5:47**	**D6:47**	**D7:47**	**D8:47**	**D9:47**	**D10:47**	**D11:47**	**D12:47**
4	**Colmar** ♿	**D7:49**	**D8:49**	**D9:49**	**D10:49**	**D11:49**	**D12:49**	**D1:49**	**D2:49**	**D3:49**	**D4:49**	**D5:49**	**D6:49**	**D7:49**	**D8:49**	**D9:49**	**D10:49**	**D11:49**	**D12:49**
4	**Chalfont** ♿	**D7:54**	**D8:54**	**D9:54**	**D10:54**	**D11:54**	**D12:54**	**D1:54**	**D2:54**	**D3:54**	**D4:54**	**D5:54**	**D6:54**	**D7:54**	**D8:54**	**D9:54**	**D10:54**	**D11:54**	**D12:54**
4	**New Britain** ♿	**D7:57**	**D8:57**	**D9:57**	**D10:57**	**D11:57**	**D12:57**	**D1:57**	**D2:57**	**D3:57**	**D4:57**	**D5:57**	**D6:57**	**D7:57**	**D8:57**	**D9:57**	**D10:57**	**D11:57**	**D12:57**
4	**Delaware Valley University** ♿	**D7:59**	**D8:59**	**D9:59**	**D10:59**	**D11:59**	**D12:59**	**D1:59**	**D2:59**	**D3:59**	**D4:59**	**D5:59**	**D6:59**	**D7:59**	**D8:59**	**D9:59**	**D10:59**	**D11:59**	**D12:59**
4	**Doylestown** ♿	8:03	9:03	10:03	11:03	12:03	1:03	2:03	3:03	4:03	5:03	6:03	7:03	8:03	9:03	10:03	11:03	12:03	1:03
		AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	AM	AM

♿ – **Accessible station**

D – Train stops to discharge or pick up passengers, but may depart ahead of schedule.

Travel Tips

Schedule Times: Indicate when trains depart the station.

Fare Payment Options: Contactless, SEPTA Key, Quick Trip Ticket, or cash. Visit **www.septa.org/fares** for more information.

QuietRide Car: Available on all weekday trains (Monday–Friday 4:00 AM to 7:00 PM) with 3 or more cars open for passenger service. The first car will be designated as your QuietRide Car.

Regional Rail Major Holidays: New Year's Day, Martin Luther King Jr. Day, Memorial Day, July 4th, Labor Day, Thanksgiving Day, Christmas Day (Special Schedule). *Please note: Holidays may be observed on another day.*

Disclaimer: SEPTA does not assume responsibility for inconvenience, experience or damage resulting from errors in timetables, delayed trains, failure to make connections or for shortage of equipment. Information is subject to change.

Severe Weather Schedule: During extreme weather conditions, trains may operate on a special schedule. Visit **www.septa.org/alerts** for more information.

Destination Codes

AIR	Airport	**MHK**	Marcus Hook
BMR	Bryn Mawr	**NWK**	Newark, DE
CHW	Chestnut Hill West	**THO**	Thorndale
CYN	Cynwyd	**TRE**	Trenton Transit Center
ELW	Elwyn	**WAW**	Wawa
MAL	Malvern	**WAY**	Wayne
MED	Media	**WIL**	Wilmington

Safety Tips

- **Never** pass between cars when a train is moving
- **Never** attempt to board a moving train
- **Always** wait for the train to come to a complete stop **before** exiting
- **Never** ride in the vestibule or on the steps of a moving train
- **Never** lean against the train doors

For more information, visit **www.septa.org/safety**.

Media/Wawa Line

To/From Center City Philadelphia

Effective September 2, 2025

SEPTA REGIONAL RAIL

- Wawa
- Elwyn
- Media
- Moylan-Rose Valley
- Wallingford
- Swarthmore
- Morton
- Secane
- Primos
- Clifton-Aldan
- Gladstone
- Lansdowne
- Fernwood-Yeadon
- Angora
- 49th St
- Penn Medicine Station
- William H. Gray III 30th St Station
- Suburban Station
- Jefferson Station
- Temple University

Customer Service: **215-580-7800**
TDD/TTY: **215-580-7853**
www.septa.org

Wawa®

Station Locations & Connecting Services

Wawa 1490 Baltimore Pike	P 111, 114
Elwyn 149 Elwyn Rd	P 117
Media 309 Media Station Rd • 610-566-4070	$ P
Moylan-Rose Valley 4 Manchester Rd	P
Wallingford 141 E. Possum Hollow Rd	P
Swarthmore 2 S. Chester Rd	P 109
Morton-Rutledge 2 S. Morton Av	P 107
Secane 1297 Providence Rd	P
Primos 446 S. Oak Av	P 107
Clifton-Aldan 1 Springfield Rd	P D2
Gladstone 198 Walsh Rd	P
Lansdowne 45 S. Lansdowne Av	P 109, 113, 115
Fernwood-Yeadon 413 S. Church Ln	68, 108
Angora 1099 S. 58th St	T2 46, 63
49th St 49th St & Chester Av	T3 64
Penn Medicine Station 3149 Convention Blvd • 215-580-6565	$ 40, LUCY
William H. Gray III 30th St Station 30th St & Market St	$ L T 9, 30, 31, 44, 49, 62, 78, 124, 125, LUCY Amtrak, NJ Transit Atlantic City Line
Suburban Station 16th St & JFK Blvd	$ L B T 2, 4, 16, 17, 27, 31, 32, 33, 38, 44, 48, 62, 78, 124, 125
Jefferson Station Market St between 10th St & 12th St	$ L B3 17, 23, 33, 38, 44, 45, 47, 47M, 48, 61, 62, 78, NJ Transit Buses
Temple University 927 W. Berks St • 215-580-5440	$

P – **Parking available**

$ – **Sales Office** (hours vary, visit **www.septa.org/stations** for details)

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Mondays through Fridays (Except Major Holidays)

TO CENTER CITY

Fare Zone	Train Number / Stations	3200	302	304	3206	9366	3208	3702	9368	3476	3504	3212	3214	9316	3218	3220	3222	3224	306	3226	334	3228	3230	3232	3234	3236	366
		AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
3	**Wawa** ♿	4:43	—	5:41	6:00	6:28	6:48	—	7:25	—	8:08	9:08	10:08	11:08	12:08	1:08	2:08	3:03	—	4:08	—	5:08	6:03	7:08	8:08	9:08	11:08
3	**Elwyn** ♿	4:49	—	5:47	6:06	6:35	6:54	—	7:31	—	8:14	9:14	10:14	11:14	12:14	1:14	2:14	3:14	—	4:14	—	5:14	6:14	7:14	8:14	9:14	11:14
3	**Media** ♿	4:52	5:17	5:50	6:09	6:39	6:57	7:16	7:37	7:58	8:17	9:17	10:17	11:17	12:17	1:17	2:17	3:17	3:58	4:17	4:39	5:17	6:17	7:17	8:17	9:17	11:17
3	**Moylan-Rose Valley**	4:54	5:20	5:52	6:12	6:42	6:59	7:19	7:41	8:01	8:18	9:18	10:18	11:18	12:18	1:18	2:18	3:18	4:01	4:18	4:42	5:18	6:18	7:18	8:18	9:18	11:18
3	**Wallingford**	4:56	5:22	5:54	6:14	6:44	7:01	7:21	7:45	8:03	8:20	9:20	10:20	11:20	12:20	1:20	2:20	3:20	4:03	4:20	4:44	5:20	6:20	7:20	8:20	9:20	11:20
3	**Swarthmore** ♿	4:59	5:25	5:57	6:17	6:47	7:04	7:24	7:49	8:06	8:23	9:23	10:23	11:23	12:23	1:23	2:23	3:23	4:06	4:23	4:47	5:23	6:23	7:23	8:23	9:23	11:23
2	**Morton-Rutledge** ♿	5:01	5:28	6:00	6:20	6:50	7:07	7:27	7:52	8:09	8:26	9:26	10:26	11:26	12:26	1:26	2:26	3:26	4:08	4:26	4:50	5:26	6:26	7:26	8:26	9:26	11:26
2	**Secane** ♿	5:04	5:31	6:03	6:22	6:54	7:10	7:30	7:55	8:12	8:29	9:29	10:29	11:29	12:29	1:29	2:29	3:29	4:11	4:29	4:53	5:29	6:29	7:29	8:29	9:29	11:29
2	**Primos** ♿	5:06	5:33	6:05	6:24	6:56	7:12	7:32	7:58	8:14	8:31	9:31	10:31	11:31	12:31	1:31	2:31	3:31	4:13	4:31	4:55	5:31	6:31	7:31	8:31	9:31	11:31
2	**Clifton-Aldan**	5:08	5:35	6:07	6:26	6:58	7:14	7:34	—	8:16	8:33	9:33	10:33	11:33	12:33	1:33	2:33	3:33	4:15	4:33	4:57	5:33	6:33	7:33	8:33	9:33	11:33
2	**Gladstone**	5:10	5:37	6:09	6:28	7:00	7:16	7:36	—	8:18	8:35	9:35	10:35	11:35	12:35	1:35	2:35	3:35	4:17	4:35	4:59	5:35	6:35	7:35	8:35	9:35	11:35
2	**Lansdowne**	5:12	5:39	6:11	6:30	7:02	7:19	7:38	—	8:20	8:37	9:37	10:37	11:37	12:37	1:37	2:37	3:37	4:19	4:37	5:01	5:37	6:37	7:37	8:37	9:37	11:37
2	**Fernwood-Yeadon**	5:14	5:41	6:13	6:32	—	7:22	7:40	—	8:22	8:39	9:39	10:39	11:39	12:39	1:39	2:39	3:39	4:21	4:39	5:03	5:39	6:39	7:39	8:39	9:39	11:39
1	**Angora**	5:16	5:43	6:15	6:34	—	7:24	7:42	—	8:24	8:41	9:41	10:41	11:41	12:41	1:41	2:41	3:41	4:24	4:41	5:05	5:41	6:41	7:41	8:41	9:41	11:41
1	**49th St** ♿	5:19	5:46	6:17	6:36	—	7:28	7:44	—	8:27	8:44	9:44	10:44	11:44	12:44	1:44	2:44	3:44	4:27	4:44	5:08	5:44	6:44	7:44	8:44	9:44	11:44
C	**Penn Medicine Station** ♿	5:24	5:51	**D6:24**	6:41	**D7:13**	7:35	7:50	**D8:09**	8:32	8:49	9:49	10:49	**D11:49**	12:49	1:49	2:49	3:49	4:32	4:49	5:13	5:49	6:49	7:49	8:49	9:49	11:49
C	**Gray 30th St Station** ♿	5:27	5:54	**D6:27**	6:44	**D7:16**	7:38	7:53	**D8:12**	8:35	8:52	9:52	10:52	**D11:52**	12:52	1:52	2:52	3:52	4:35	4:52	5:16	5:52	6:52	7:52	8:52	9:52	11:52
C	**Suburban Station** ♿	5:32	5:59	**D6:32**	6:49	**D7:21**	7:43	7:58	**D8:17**	8:40	8:57	9:57	10:57	**D11:57**	12:57	1:57	2:57	3:57	4:40	4:57	5:21	5:57	6:57	7:57	8:57	9:57	11:57
C	**Jefferson Station** ♿	5:37	6:04	**D6:37**	6:54	**D7:26**	7:48	8:03	**D8:22**	8:45	9:02	10:02	11:02	**D12:02**	1:02	2:02	3:02	4:02	4:45	5:02	5:26	6:02	7:02	8:02	9:02	10:02	12:02
C	**Temple University** ♿	5:42	6:09	6:42	6:59	7:31	7:52	8:07	8:27	8:49	9:06	10:06	11:06	12:06	1:06	2:06	3:06	4:06	4:49	5:06	5:31	6:06	7:06	8:06	9:06	10:06	12:06
	(See Destination Codes)	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	AM
	Train continues to	**ELM**	**WTR**	—	**NTC**	—	**ELM**	**CHE**	—	**GLN**	**LAN**	**ELM**	**ELM**	—	**ELM**	**ELM**	**ELM**	**ELM**	**WTR**	**ELM**	**WTR**	**ELM**	**ELM**	**ELM**	**ELM**	**ELM**	**WTR**

TO MEDIA/WAWA

Fare Zone	Train Number / Stations	2303	303	2305	4307	2309	2311	2313	2315	9317	2319	381	2321	9345	5347	2323	9349	9351	2325	8351	2327	2357	2329	2331	2333	2335	8337
		AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
C	**Temple University** ♿	6:48	7:28	7:48	8:48	9:48	10:48	11:48	12:48	1:49	2:48	3:19	3:48	4:11	4:24	4:48	5:05	5:24	5:48	6:15	6:48	7:07	7:48	8:48	9:48	10:48	11:46
C	**Jefferson Station** ♿	6:54	7:34	7:54	8:54	9:54	10:54	11:54	12:54	1:55	2:54	3:25	3:54	4:16	4:30	4:54	5:11	5:30	5:54	6:22	6:54	7:13	7:54	8:54	9:54	10:54	11:52
C	**Suburban Station** ♿	6:59	7:39	7:59	8:59	9:59	10:59	11:59	12:59	2:00	2:59	3:30	3:59	4:21	4:35	4:59	5:16	5:35	5:59	6:27	6:59	7:18	7:59	8:59	9:59	10:59	11:57
C	**Gray 30th St Station** ♿	7:03	7:44	8:03	9:03	10:03	11:03	12:03	1:03	2:03	3:03	3:34	4:03	4:25	4:39	5:03	5:20	5:40	6:03	6:31	7:03	7:22	8:03	9:03	10:03	11:03	12:02
C	**Penn Medicine Station** ♿	7:06	7:49	8:06	9:06	10:06	11:06	12:06	1:06	2:06	3:06	3:37	4:06	4:28	4:42	5:06	5:23	5:43	6:06	6:34	7:06	7:25	8:06	9:06	10:06	11:06	12:05
1	**49th St** ♿	7:10	7:53	8:10	9:10	10:10	11:10	12:10	1:10	2:11	3:10	3:41	4:10	—	4:46	5:10	—	5:48	6:10	6:38	7:10	7:29	8:10	9:10	10:10	11:10	12:09
1	**Angora**	7:12	7:55	8:12	9:12	10:12	11:12	12:12	1:12	2:13	3:12	3:43	4:12	—	4:48	5:12	—	5:50	6:12	6:40	7:12	7:31	8:12	9:12	10:12	11:12	12:11
2	**Fernwood-Yeadon**	7:14	7:57	8:14	9:14	10:14	11:14	12:14	1:14	2:15	3:14	3:45	4:14	—	4:50	5:14	—	5:52	6:14	6:42	7:14	7:33	8:14	9:14	10:14	11:14	12:13
2	**Lansdowne**	7:16	7:59	8:16	9:16	10:16	11:16	12:16	1:16	2:17	3:16	3:47	4:16	—	4:52	5:16	—	5:54	6:16	6:44	7:16	7:35	8:16	9:16	10:16	11:16	12:15
2	**Gladstone**	7:18	8:01	8:18	9:18	10:18	11:18	12:18	1:18	2:19	3:18	3:49	4:18	—	4:54	5:18	—	5:57	6:18	6:46	7:18	7:36	8:18	9:18	10:18	11:18	12:17
2	**Clifton-Aldan**	7:20	8:03	8:20	9:20	10:20	11:20	12:20	1:20	2:21	3:20	3:51	4:20	—	4:56	5:20	—	5:59	6:20	6:48	7:20	7:38	8:20	9:20	10:20	11:20	12:19
2	**Primos** ♿	**D7:22**	**D8:05**	**D8:22**	**D9:22**	**D10:22**	**D11:22**	12:22	**D1:22**	**D2:23**	**D3:22**	**D3:53**	**D4:22**	**D4:40**	**D4:58**	**D5:22**	**D5:35**	**D6:01**	**D6:22**	**D6:50**	**D7:22**	**D7:40**	**D8:22**	**D9:22**	**D10:22**	**D11:22**	**D12:21**
2	**Secane** ♿	**D7:24**	**D8:07**	**D8:24**	**D9:24**	**D10:24**	**D11:24**	**D12:24**	**D1:24**	**D2:25**	**D3:24**	**D3:55**	**D4:24**	**D4:43**	**D5:00**	**D5:24**	**D5:38**	**D6:04**	**D6:24**	**D6:52**	**D7:24**	**D7:43**	**D8:24**	**D9:24**	**D10:24**	**D11:24**	**D12:23**
2	**Morton-Rutledge** ♿	**D7:26**	**D8:09**	**D8:26**	**D9:26**	**D10:26**	**D11:26**	**D12:26**	**D1:26**	**D2:27**	**D3:26**	**D3:57**	**D4:26**	**D4:46**	**D5:03**	**D5:26**	**D5:41**	**D6:07**	**D6:26**	**D6:54**	**D7:26**	**D7:45**	**D8:26**	**D9:26**	**D10:26**	**D11:26**	**D12:25**
3	**Swarthmore** ♿	**D7:29**	**D8:12**	**D8:29**	**D9:29**	**D10:29**	**D11:29**	**D12:29**	**D1:29**	**D2:30**	**D3:29**	**D4:00**	**D4:29**	**D4:50**	**D5:06**	**D5:29**	**D5:44**	**D6:10**	**D6:29**	**D6:56**	**D7:29**	**D7:47**	**D8:29**	**D9:29**	**D10:29**	**D11:29**	**D12:27**
3	**Wallingford**	**D7:32**	**D8:15**	**D8:32**	**D9:32**	**D10:32**	**D11:32**	**D12:32**	**D1:32**	**D2:33**	**D3:32**	**D4:03**	**D4:32**	**D4:53**	**D5:09**	**D5:32**	**D5:47**	**D6:12**	**D6:32**	**D6:58**	**D7:32**	**D7:49**	**D8:32**	**D9:32**	**D10:32**	**D11:32**	**D12:29**
3	**Moylan-Rose Valley**	**D7:35**	**D8:18**	**D8:35**	**D9:35**	**D10:35**	**D11:35**	**D12:35**	**D1:35**	**D2:35**	**D3:35**	**D4:06**	**D4:35**	**D4:55**	**D5:12**	**D5:35**	**D5:50**	**D6:16**	**D6:35**	**D7:01**	**D7:35**	**D7:52**	**D8:35**	**D9:35**	**D10:35**	**D11:35**	**D12:32**
3	**Media** ♿	**D7:37**	8:23	**D8:37**	**D9:37**	**D10:37**	**D11:37**	**D12:37**	**D1:37**	**D2:37**	**D3:37**	4:10	**D4:37**	**D4:59**	**D5:14**	**D5:37**	**D5:53**	6:21	**D6:37**	7:07	**D7:37**	**D7:53**	**D8:37**	**D9:37**	**D10:37**	**D11:37**	**D12:34**
3	**Elwyn** ♿	**D7:42**	—	**D8:42**	**D9:42**	**D10:42**	**D11:42**	**D12:42**	**D1:42**	**D2:41**	**D3:42**	—	**D4:42**	**D5:03**	**D5:18**	**D5:42**	**D5:57**	—	**D6:42**	—	**D7:42**	**D7:57**	**D8:42**	**D9:42**	**D10:42**	**D11:42**	**D12:37**
3	**Wawa** ♿	7:48	—	8:48	9:48	10:48	11:48	12:48	1:48	2:48	3:48	—	4:48	5:12	5:28	5:54	6:07	—	6:48	—	7:48	8:07	8:48	9:48	10:48	11:48	12:47
		AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	AM

♿ – **Accessible station**

D – Train stops to discharge or pick up passengers, but may depart ahead of schedule.

Saturdays, Sundays and Major Holidays

TO CENTER CITY

Fare Zone	Train Number / Stations	3506	3510	3514	3518	3522	3526	3530	3534	3538	3542	3546	3550	3554	3558	3562	3566	3570	3574
		AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
3	**Wawa** ♿	5:59	6:59	7:59	8:59	9:59	10:59	11:59	12:59	1:59	2:59	3:59	4:59	5:59	6:59	7:59	8:59	9:59	10:59
3	**Elwyn** ♿	6:05	7:05	8:05	9:05	10:05	11:05	12:05	1:05	2:05	3:05	4:05	5:05	6:05	7:05	8:05	9:05	10:05	11:05
3	**Media** ♿	6:08	7:08	8:08	9:08	10:08	11:08	12:08	1:08	2:08	3:08	4:08	5:08	6:08	7:08	8:08	9:08	10:08	11:08
3	**Moylan-Rose Valley**	6:10	7:10	8:10	9:10	10:10	11:10	12:10	1:10	2:10	3:10	4:10	5:10	6:10	7:10	8:10	9:10	10:10	11:10
3	**Wallingford**	6:12	7:12	8:12	9:12	10:12	11:12	12:12	1:12	2:12	3:12	4:12	5:12	6:12	7:12	8:12	9:12	10:12	11:12
3	**Swarthmore** ♿	6:15	7:15	8:15	9:15	10:15	11:15	12:15	1:15	2:15	3:15	4:15	5:15	6:15	7:15	8:15	9:15	10:15	11:15
2	**Morton-Rutledge** ♿	6:17	7:17	8:17	9:17	10:17	11:17	12:17	1:17	2:17	3:17	4:17	5:17	6:17	7:17	8:17	9:17	10:17	11:17
2	**Secane** ♿	6:19	7:19	8:19	9:19	10:19	11:19	12:19	1:19	2:19	3:19	4:19	5:19	6:19	7:19	8:19	9:19	10:19	11:19
2	**Primos** ♿	6:21	7:21	8:21	9:21	10:21	11:21	12:21	1:21	2:21	3:21	4:21	5:21	6:21	7:21	8:21	9:21	10:21	11:21
2	**Clifton-Aldan**	6:23	7:23	8:23	9:23	10:23	11:23	12:23	1:23	2:23	3:23	4:23	5:23	6:23	7:23	8:23	9:23	10:23	11:23
2	**Gladstone**	6:25	7:25	8:25	9:25	10:25	11:25	12:25	1:25	2:25	3:25	4:25	5:25	6:25	7:25	8:25	9:25	10:25	11:25
2	**Lansdowne**	6:26	7:26	8:26	9:26	10:26	11:26	12:26	1:26	2:26	3:26	4:26	5:26	6:26	7:26	8:26	9:26	10:26	11:26
2	**Fernwood-Yeadon**	6:28	7:28	8:28	9:28	10:28	11:28	12:28	1:28	2:28	3:28	4:28	5:28	6:28	7:28	8:28	9:28	10:28	11:28
1	**Angora**	6:30	7:30	8:30	9:30	10:30	11:30	12:30	1:30	2:30	3:30	4:30	5:30	6:30	7:30	8:30	9:30	10:30	11:30
1	**49th St** ♿	6:32	7:32	8:32	9:32	10:32	11:32	12:32	1:32	2:32	3:32	4:32	5:32	6:32	7:32	8:32	9:32	10:32	11:32
C	**Penn Medicine Station** ♿	6:36	7:36	8:36	9:36	10:36	11:36	12:36	1:36	2:36	3:36	4:36	5:36	6:36	7:36	8:36	9:36	10:36	11:36
C	**Gray 30th St Station** ♿	6:39	7:39	8:39	9:39	10:39	11:39	12:39	1:39	2:39	3:39	4:39	5:39	6:39	7:39	8:39	9:39	10:39	11:39
C	**Suburban Station** ♿	6:44	7:44	8:44	9:44	10:44	11:44	12:44	1:44	2:44	3:44	4:44	5:44	6:44	7:44	8:44	9:44	10:44	11:44
C	**Jefferson Station** ♿	6:49	7:49	8:49	9:49	10:49	11:49	12:49	1:49	2:49	3:49	4:49	5:49	6:49	7:49	8:49	9:49	10:49	11:49
C	**Temple University** ♿	6:54	7:54	8:54	9:54	10:54	11:54	12:54	1:54	2:54	3:54	4:54	5:54	6:54	7:54	8:54	9:54	10:54	11:54
	(See Destination Codes)	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
	Train continues to	**DOY**	**DOY**	**DOY**	**DOY**	**DOY**	**DOY**	**DOY**	**DOY**	**DOY**	**DOY**	**DOY**	**DOY**	**DOY**	**DOY**	**DOY**	**DOY**	**DOY**	**DOY**

TO MEDIA/WAWA

Fare Zone	Train Number / Stations	5301	5305	5309	5313	5317	5321	5325	5329	5333	5337	5341	5345	5349	5353	5357	5361	5365	5369
		AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
C	**Temple University** ♿	6:30	7:30	8:30	9:30	10:30	11:30	12:30	1:30	2:30	3:30	4:30	5:30	6:30	7:30	8:30	9:30	10:30	11:30
C	**Jefferson Station** ♿	6:36	7:36	8:36	9:36	10:36	11:36	12:36	1:36	2:36	3:36	4:36	5:36	6:36	7:36	8:36	9:36	10:36	11:36
C	**Suburban Station** ♿	6:41	7:41	8:41	9:41	10:41	11:41	12:41	1:41	2:41	3:41	4:41	5:41	6:41	7:41	8:41	9:41	10:41	11:41
C	**Gray 30th St Station** ♿	6:46	7:46	8:46	9:46	10:46	11:46	12:46	1:46	2:46	3:46	4:46	5:46	6:46	7:46	8:46	9:46	10:46	11:46
C	**Penn Medicine Station** ♿	6:49	7:49	8:49	9:49	10:49	11:49	12:49	1:49	2:49	3:49	4:49	5:49	6:49	7:49	8:49	9:49	10:49	11:49
1	**49th St** ♿	6:53	7:53	8:53	9:53	10:53	11:53	12:53	1:53	2:53	3:53	4:53	5:53	6:53	7:53	8:53	9:53	10:53	11:53
1	**Angora**	6:55	7:55	8:55	9:55	10:55	11:55	12:55	1:55	2:55	3:55	4:55	5:55	6:55	7:55	8:55	9:55	10:55	11:55
2	**Fernwood-Yeadon**	6:57	7:57	8:57	9:57	10:57	11:57	12:57	1:57	2:57	3:57	4:57	5:57	6:57	7:57	8:57	9:57	10:57	11:57
2	**Lansdowne**	6:59	7:59	8:59	9:59	10:59	11:59	12:59	1:59	2:59	3:59	4:59	5:59	6:59	7:59	8:59	9:59	10:59	11:59
2	**Gladstone**	7:00	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00
2	**Clifton-Aldan**	7:02	8:02	9:02	10:02	11:02	12:02	1:02	2:02	3:02	4:02	5:02	6:02	7:02	8:02	9:02	10:02	11:02	12:02
2	**Primos** ♿	**D7:04**	**D8:04**	**D9:04**	**D10:04**	**D11:04**	**D12:04**	**D1:04**	**D2:04**	**D3:04**	**D4:04**	**D5:04**	**D6:04**	**D7:04**	**D8:04**	**D9:04**	**D10:04**	**D11:04**	**D12:04**
2	**Secane** ♿	**D7:06**	**D8:06**	**D9:06**	**D10:06**	**D11:06**	**D12:06**	**D1:06**	**D2:06**	**D3:06**	**D4:06**	**D5:06**	**D6:06**	**D7:06**	**D8:06**	**D9:06**	**D10:06**	**D11:06**	**D12:06**
2	**Morton-Rutledge** ♿	**D7:08**	**D8:08**	**D9:08**	**D10:08**	**D11:08**	**D12:08**	**D1:08**	**D2:08**	**D3:08**	**D4:08**	**D5:08**	**D6:08**	**D7:08**	**D8:08**	**D9:08**	**D10:08**	**D11:08**	**D12:08**
3	**Swarthmore** ♿	**D7:10**	**D8:10**	**D9:10**	**D10:10**	**D11:10**	**D12:10**	**D1:10**	**D2:10**	**D3:10**	**D4:10**	**D5:10**	**D6:10**	**D7:10**	**D8:10**	**D9:10**	**D10:10**	**D11:10**	**D12:10**
3	**Wallingford**	**D7:12**	**D8:12**	**D9:12**	**D10:12**	**D11:12**	**D12:12**	**D1:12**	**D2:12**	**D3:12**	**D4:12**	**D5:12**	**D6:12**	**D7:12**	**D8:12**	**D9:12**	**D10:12**	**D11:12**	**D12:12**
3	**Moylan-Rose Valley**	**D7:14**	**D8:14**	**D9:14**	**D10:14**	**D11:14**	**D12:14**	**D1:14**	**D2:14**	**D3:14**	**D4:14**	**D5:14**	**D6:14**	**D7:14**	**D8:14**	**D9:14**	**D10:14**	**D11:14**	**D12:14**
3	**Media** ♿	**D7:16**	**D8:16**	**D9:16**	**D10:16**	**D11:16**	**D12:16**	**D1:16**	**D2:16**	**D3:16**	**D4:16**	**D5:16**	**D6:16**	**D7:16**	**D8:16**	**D9:16**	**D10:16**	**D11:16**	**D12:16**
3	**Elwyn** ♿	**D7:21**	**D8:21**	**D9:21**	**D10:21**	**D11:21**	**D12:21**	**D1:21**	**D2:21**	**D3:21**	**D4:21**	**D5:21**	**D6:21**	**D7:21**	**D8:21**	**D9:21**	**D10:21**	**D11:21**	**D12:21**
3	**Wawa** ♿	7:31	8:31	9:31	10:31	11:31	12:31	1:31	2:31	3:31	4:31	5:31	6:31	7:31	8:31	9:31	10:31	11:31	12:31
		AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	AM

♿ – **Accessible station**
D – Train stops to discharge or pick up passengers, but may depart ahead of schedule.

Travel Tips

Schedule Times: Indicate when trains depart the station.

Fare Payment Options: Contactless, SEPTA Key, Quick Trip Ticket, or cash. Visit **www.septa.org/fares** for more information.

QuietRide Car: Available on all weekday trains (Monday–Friday 4:00 AM to 7:00 PM) with 3 or more cars open for passenger service. The first car will be designated as your QuietRide Car.

Regional Rail Major Holidays: New Year's Day, Martin Luther King Jr. Day, Memorial Day, July 4th, Labor Day, Thanksgiving Day, Christmas Day (Special Schedule). *Please note: Holidays may be observed on another day.*

Disclaimer: SEPTA does not assume responsibility for inconvenience, experience or damage resulting from errors in timetables, delayed trains, failure to make connections or for shortage of equipment. Information is subject to change.

Severe Weather Schedule: During extreme weather conditions, trains may operate on a special schedule. Visit **www.septa.org/alerts** for more information.

Destination Codes

CHE	Chestnut Hill East	**LAN**	Lansdale
DOY	Doylestown	**LNK**	Link Belt
ELM	Elm Street	**NTC**	Norristown Transit Center
FOX	Fox Chase	**NSH**	Neshaminy Falls
GLN	Glenside	**WAR**	Warminster
JNK	Jenkintown-Wyncote	**WTR**	West Trenton

Safety Tips

- **Never** pass between cars when a train is moving
- **Never** attempt to board a moving train
- **Always** wait for the train to come to a complete stop **before** exiting
- **Never** ride in the vestibule or on the steps of a moving train
- **Never** lean against the train doors

For more information, visit **www.septa.org/safety**.

Fox Chase Line

To/From Center City Philadelphia

Effective September 2, 2025

SEPTA REGIONAL RAIL

- Fox Chase
- Ryers
- Cheltenham
- Lawndale
- Olney
- Wayne Junction
- Temple University
- Jefferson Station
- Suburban Station
- William H. Gray III 30th St Station

Customer Service: **215-580-7800**
TDD/TTY: **215-580-7853**
www.septa.org

Penn Medicine
800.789.PENN PennMedicine.org

Station Locations & Connecting Services

Fox Chase 440 Rhawn St	P 18, 24, 28
Ryers 701 Cottman Av	P 70, 77
Cheltenham 589 Hasbrook Av	P
Lawndale 105 Devereaux Av	
Olney 5411 N. Mascher St	P 8
Wayne Junction 2129 Windrim Av • 215-580-6892	$ 2, 23, 53, 75
Temple University 927 W. Berks St • 215-580-5440	$
Jefferson Station Market St between 10th St & 12th St	$ L B3 17, 23, 33, 38, 44, 45, 47, 47M, 48, 61, 62, 78, NJ Transit Buses
Suburban Station 16th St & JFK Blvd	$ L B T 2, 4, 16, 17, 27, 31, 32, 33, 38, 44, 48, 62, 78, 124, 125
William H. Gray III 30th St Station 30th St & Market St	$ L T 9, 30, 31, 44, 49, 62, 78, 124, 125, LUCY Amtrak, NJ Transit Atlantic City Line

P – **Parking available**

$ – **Sales Office** (hours vary, visit **www.septa.org/stations** for details)

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Mondays through Fridays (Except Major Holidays)

TO CENTER CITY

Fare Zone	Train Number	801	803	805	6807	809	811	8419	815	817	821	825	829	833	837	841	845	849	853	857	861	865	869	8337
	Stations	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
2	**Fox Chase** ♿	5:25	5:55	6:25	6:55	7:23	7:53	8:23	8:55	9:25	10:25	11:25	12:25	1:25	2:25	3:25	4:25	5:25	6:25	7:25	8:25	9:25	10:25	11:25
2	**Ryers** ♿	5:28	5:58	6:28	6:58	7:26	7:56	8:26	8:58	9:28	10:28	11:28	12:28	1:28	2:28	3:28	4:28	5:28	6:28	7:28	8:28	9:28	10:28	11:28
2	**Cheltenham** ♿	5:29	5:59	6:29	6:59	7:28	7:58	8:27	8:59	9:29	10:29	11:29	12:29	1:29	2:29	3:29	4:29	5:29	6:29	7:29	8:29	9:29	10:29	11:29
2	**Lawndale** ♿	5:31	6:01	6:31	7:01	7:30	8:00	8:29	9:01	9:31	10:31	11:31	12:31	1:31	2:31	3:31	4:31	5:31	6:31	7:31	8:31	9:31	10:31	11:31
1	**Olney** ♿	5:35	6:05	6:35	7:05	7:34	8:04	8:33	9:05	9:35	10:35	11:35	12:35	1:35	2:35	3:35	4:35	5:35	6:35	7:35	8:35	9:35	10:35	11:35
1	**Wayne Junction** ♿	5:40	6:10	6:40	7:10	7:40	8:10	8:38	9:10	9:40	10:40	11:40	12:40	1:40	2:40	3:40	4:40	5:40	6:40	7:40	8:40	9:40	10:40	11:40
C	**Temple University** ♿	5:46	6:16	6:46	**D7:16**	7:46	8:16	8:43	9:16	9:46	10:46	11:46	12:46	1:46	2:46	3:46	4:46	5:46	6:46	7:46	8:46	9:46	10:46	11:46
C	**Jefferson Station** ♿	5:52	6:22	6:52	**D7:22**	7:52	8:22	8:50	9:22	9:52	10:52	11:52	12:52	1:52	2:52	3:52	4:52	5:52	6:52	7:52	8:52	9:52	10:52	11:52
C	**Suburban Station** ♿	5:57	6:27	6:57	**D7:27**	7:57	8:27	8:55	9:27	9:57	10:57	11:57	12:57	1:57	2:57	3:57	4:57	5:57	6:57	7:57	8:57	9:57	10:57	11:57
C	**Gray 30th St Station** ♿	6:02	6:32	7:02	7:32	8:02	8:32	8:59	9:32	10:02	11:02	12:02	1:02	2:02	3:02	4:02	5:02	6:02	7:02	8:02	9:02	10:02	11:02	12:02
	(See Destination Codes)	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	AM
	Train continues to	**CHW**	**CHW**	**CHW**	–	**CHW**	**CHW**	**AIR**	**CHW**	**CHW**	**CHW**	**CHW**	**CHW**	**CHW**	**CHW**	**CHW**	**CHW**	**CHW**	**CHW**	**CHW**	**CHW**	**CHW**	**CHW**	**WAW**

TO FOX CHASE

Fare Zone	Train Number	802	806	810	814	818	822	826	830	834	838	842	6844	846	850	854	858	862	866
	Stations	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
C	**Gray 30th St Station** ♿	6:30	7:30	8:30	9:30	10:30	11:30	12:30	1:30	2:30	3:30	4:30	4:58	5:30	6:30	7:30	8:30	9:30	10:30
C	**Suburban Station** ♿	6:35	7:35	8:35	9:35	10:35	11:35	12:35	1:35	2:35	3:35	4:35	5:03	5:35	6:35	7:35	8:35	9:35	10:35
C	**Jefferson Station** ♿	6:40	7:40	8:40	9:40	10:40	11:40	12:40	1:40	2:40	3:40	4:40	5:08	5:40	6:40	7:40	8:40	9:40	10:40
C	**Temple University** ♿	6:44	7:44	8:44	9:44	10:44	11:44	12:44	1:44	2:44	3:44	4:44	5:12	5:44	6:44	7:44	8:44	9:44	10:44
1	**Wayne Junction** ♿	**D6:50**	**D7:50**	**D8:50**	**D9:50**	**D10:50**	**D11:50**	**D12:50**	**D1:50**	**D2:50**	**D3:50**	**D4:50**	**D5:18**	**D5:50**	**D6:50**	**D7:50**	**D8:50**	**D9:50**	**D10:50**
1	**Olney** ♿	**D6:55**	**D7:55**	**D8:55**	**D9:55**	**D10:55**	**D11:55**	**D12:55**	**D1:55**	**D2:55**	**D3:55**	**D4:55**	**D5:21**	**D5:55**	**D6:55**	**D7:55**	**D8:55**	**D9:55**	**D10:55**
2	**Lawndale** ♿	**D6:57**	**D7:57**	**D8:57**	**D9:57**	**D10:57**	**D11:57**	**D12:57**	**D1:57**	**D2:57**	**D3:57**	**D4:57**	**D5:24**	**D5:57**	**D6:57**	**D7:57**	**D8:57**	**D9:57**	**D10:57**
2	**Cheltenham** ♿	**D7:01**	**D8:01**	**D9:01**	**D10:01**	**D11:01**	**D12:01**	**D1:01**	**D2:01**	**D3:01**	**D4:01**	**D5:01**	**D5:31**	**D6:01**	**D7:01**	**D8:01**	**D9:01**	**D10:01**	**D11:01**
2	**Ryers** ♿	**D7:02**	**D8:02**	**D9:02**	**D10:02**	**D11:02**	**D12:02**	**D1:02**	**D2:02**	**D3:02**	**D4:02**	**D5:02**	**D5:33**	**D6:02**	**D7:02**	**D8:02**	**D9:02**	**D10:02**	**D11:02**
2	**Fox Chase** ♿	7:05	8:05	9:05	10:05	11:05	12:05	1:05	2:05	3:05	4:05	5:05	5:38	6:05	7:05	8:05	9:05	10:05	11:05
		AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM

♿ – **Accessible station**
D – Train stops to discharge or pick up passengers, but may depart ahead of schedule.

Saturdays, Sundays and Major Holidays

TO CENTER CITY

Fare Zone	Train Number	8507	8515	8523	8531	8539	8547	8555	8563	8571
	Stations	AM	AM	AM	AM	PM	PM	PM	PM	PM
2	**Fox Chase** ♿	5:34	7:34	9:34	11:34	1:34	3:34	5:34	7:34	9:34
2	**Ryers** ♿	5:37	7:37	9:37	11:37	1:37	3:37	5:37	7:37	9:37
2	**Cheltenham** ♿	5:39	7:39	9:39	11:39	1:39	3:39	5:39	7:39	9:39
2	**Lawndale** ♿	5:41	7:41	9:41	11:41	1:41	3:41	5:41	7:41	9:41
1	**Olney** ♿	5:44	7:44	9:44	11:44	1:44	3:44	5:44	7:44	9:44
1	**Wayne Junction** ♿	5:49	7:49	9:49	11:49	1:49	3:49	5:49	7:49	9:49
C	**Temple University** ♿	5:54	7:54	9:54	11:54	1:54	3:54	5:54	7:54	9:54
C	**Jefferson Station** ♿	6:00	8:00	10:00	12:00	2:00	4:00	6:00	8:00	10:00
C	**Suburban Station** ♿	6:05	8:05	10:05	12:05	2:05	4:05	6:05	8:05	10:05
C	**Gray 30th St Station** ♿	6:10	8:10	10:10	12:10	2:10	4:10	6:10	8:10	10:10
	(See Destination Codes)	AM	AM	AM	PM	PM	PM	PM	PM	PM
	Saturday train continues to	**THO**	**THO**	**THO**	**THO**	**THO**	**THO**	**THO**	**THO**	**THO**
	Sunday train continues to	**MAL**	**MAL**	**MAL**	**MAL**	**MAL**	**MAL**	**MAL**	**MAL**	**MAL**

TO FOX CHASE

Fare Zone	Train Number	5814	5822	5830	5838	5846	5854	5862	5870	5878
	Stations	AM	AM	AM	PM	PM	PM	PM	PM	PM
C	**Gray 30th St Station** ♿	6:25	8:25	10:25	12:25	2:25	4:25	6:25	8:25	10:25
C	**Suburban Station** ♿	6:30	8:30	10:30	12:30	2:30	4:30	6:30	8:30	10:30
C	**Jefferson Station** ♿	6:35	8:35	10:35	12:35	2:35	4:35	6:35	8:35	10:35
C	**Temple University** ♿	6:40	8:40	10:40	12:40	2:40	4:40	6:40	8:40	10:40
1	**Wayne Junction** ♿	**D6:47**	**D8:47**	**D10:47**	**D12:47**	**D2:47**	**D4:47**	**D6:47**	**D8:47**	**D10:47**
1	**Olney** ♿	**D6:52**	**D8:52**	**D10:52**	**D12:52**	**D2:52**	**D4:52**	**D6:52**	**D8:52**	**D10:52**
2	**Lawndale** ♿	**D6:55**	**D8:55**	**D10:55**	**D12:55**	**D2:55**	**D4:55**	**D6:55**	**D8:55**	**D10:55**
2	**Cheltenham** ♿	**D6:57**	**D8:57**	**D10:57**	**D12:57**	**D2:57**	**D4:57**	**D6:57**	**D8:57**	**D10:57**
2	**Ryers** ♿	**D6:59**	**D8:59**	**D10:59**	**D12:59**	**D2:59**	**D4:59**	**D6:59**	**D8:59**	**D10:59**
2	**Fox Chase** ♿	7:05	9:05	11:05	1:05	3:05	5:05	7:05	9:05	11:05
		AM	AM	AM	PM	PM	PM	PM	PM	PM

♿ – **Accessible station**
D – Train stops to discharge or pick up passengers, but may depart ahead of schedule.

Travel Tips

Schedule Times: Indicate when trains depart the station.

Fare Payment Options: Contactless, SEPTA Key, Quick Trip Ticket, or cash. Visit **www.septa.org/fares** for more information.

QuietRide Car: Available on all weekday trains (Monday–Friday 4:00 AM to 7:00 PM) with 3 or more cars open for passenger service. The first car will be designated as your QuietRide Car.

Regional Rail Major Holidays: New Year's Day, Martin Luther King Jr. Day, Memorial Day, July 4th, Labor Day, Thanksgiving Day, Christmas Day (Special Schedule). *Please note: Holidays may be observed on another day.*

Disclaimer: SEPTA does not assume responsibility for inconvenience, experience or damage resulting from errors in timetables, delayed trains, failure to make connections or for shortage of equipment. Information is subject to change.

Severe Weather Schedule: During extreme weather conditions, trains may operate on a special schedule. Visit **www.septa.org/alerts** for more information.

Destination Codes

AIR Airport
BMR Bryn Mawr
CHW Chestnut Hill West
CYN Cynwyd
ELW Elwyn
MAL Malvern
MED Media
MHK Marcus Hook
NWK Newark, DE
THO Thorndale
TRE Trenton Transit Center
WAW Wawa
WAY Wayne
WIL Wilmington

Safety Tips

- **Never** pass between cars when a train is moving
- **Never** attempt to board a moving train
- **Always** wait for the train to come to a complete stop **before** exiting
- **Never** ride in the vestibule or on the steps of a moving train
- **Never** lean against the train doors

For more information, visit **www.septa.org/safety**.

Manayunk/ Norristown Line

To/From Center City Philadelphia

Effective September 2, 2025

SEPTA REGIONAL RAIL

- Norristown - Elm St
- Main St
- Norristown Transit Center
- Conshohocken
- Spring Mill
- Miquon
- Ivy Ridge
- Manayunk
- Wissahickon
- East Falls
- Allegheny
- North Broad
- Temple University
- Jefferson Station
- Suburban Station
- William H. Gray III 30th St Station
- Penn Medicine Station

Customer Service: **215-580-7800**
TDD/TTY: **215-580-7853**
www.septa.org

Penn Medicine
800.789.PENN PennMedicine.org

Station Locations & Connecting Services

Norristown - Elm St 793 Markley St	P
Main St 305 W. Main St	P 90, 93, 131
Norristown Transit Center Lafayette St & Swede St • 215-580-4687	$ P M 90, 93, 96, 97, 98, 99, 131
Conshohocken 10 Washington St	P 95, 97
Spring Mill 98 Station Av (near Hector St)	P
Miquon 1096 River Rd	P
Ivy Ridge 4910 Umbria St	P 61, 62
Manayunk 117 Carson St	35, 61, 62
Wissahickon 5100 Rochelle Av	P 9, 27, 61, 62, 65
East Falls 3610 Midvale Av	P K
Allegheny 3235 N. 22nd St	33, 60
North Broad 2693 N. Broad St	B 4, 16, 54
Temple University 927 W. Berks St • 215-580-5440	$
Jefferson Station Market St between 10th St & 12th St	$ L B3 17, 23, 33, 38, 44, 45, 47, 47M, 48, 61, 62, 78, NJ Transit Buses
Suburban Station 16th St & JFK Blvd	$ L B T 2, 4, 16, 17, 27, 31, 32, 33, 38, 44, 48, 62, 78, 124, 125
William H. Gray III 30th St Station 30th St & Market St	$ L T 9, 30, 31, 44, 49, 62, 78, 124, 125, LUCY Amtrak, NJ Transit Atlantic City Line
Penn Medicine Station 3149 Convention Blvd • 215-580-6565	$ 40, LUCY

P – **Parking available**

$ – **Sales Office** (hours vary, visit **www.septa.org/stations** for details)

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Mondays through Fridays (Except Major Holidays)

TO CENTER CITY

Fare Zone	Train Number	203	2303	2547	2305	207	6209	2511	6251	6213	2309	2311	2313	2315	6217	2319	2321	2323	2553	2325	2555	2327	2357	2329	2331	2333	2335	2565
	Stations	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
3	**Norristown – Elm St** ♿	5:43	6:08	6:40	7:04	7:45	8:05	–	–	–	9:04	10:08	11:08	12:08	1:08	2:08	3:08	4:08	–	5:08	–	6:08	–	7:08	8:08	9:08	10:08	11:08
3	**Main St**	5:46	6:10	6:42	7:06	7:47	8:07	–	–	–	9:06	10:10	11:10	12:10	1:10	2:10	3:10	4:10	–	5:10	–	6:10	–	7:10	8:10	9:10	10:10	11:10
3	**Norristown Transit Center**	5:50	6:14	6:46	7:11	7:51	8:11	–	8:34	–	9:10	10:14	11:14	12:14	1:14	2:14	3:14	4:14	4:51	5:14	6:06	6:14	6:33	7:14	8:14	9:14	10:14	11:14
3	**Conshohocken** ♿	5:56	6:20	6:51	7:17	7:57	8:17	–	8:40	–	9:16	10:20	11:20	12:20	1:20	2:20	3:20	4:20	4:57	5:20	6:12	6:20	6:39	7:20	8:20	9:20	10:20	11:20
3	**Spring Mill** ♿	5:59	6:24	6:54	7:21	8:00	8:21	–	8:43	–	9:20	10:24	11:24	12:24	1:24	2:24	3:24	4:24	5:01	5:24	6:16	6:24	6:43	7:24	8:24	9:24	10:24	11:24
2	**Miquon**	6:03	6:27	6:58	7:24	8:04	8:24	8:29	8:47	9:10	9:23	10:27	11:27	12:27	1:27	2:27	3:27	4:27	5:04	5:27	6:19	6:27	6:46	7:27	8:27	9:27	10:27	11:27
2	**Ivy Ridge**	6:07	6:31	7:03	7:30	8:08	8:29	8:35	8:51	9:16	9:29	10:32	11:32	12:32	1:32	2:32	3:32	4:32	5:08	5:32	6:24	6:32	6:50	7:32	8:32	9:32	10:32	11:32
2	**Manayunk**	6:10	6:34	7:05	7:33	8:12	8:32	8:38	8:55	9:19	9:34	10:34	11:34	12:34	1:34	2:34	3:34	4:34	5:11	5:34	6:26	6:34	6:53	7:34	8:34	9:34	10:34	11:34
1	**Wissahickon**	6:13	6:37	7:07	7:36	8:14	–	8:41	8:57	9:22	9:37	10:37	11:37	12:37	1:37	2:37	3:37	4:37	5:14	5:37	6:29	6:37	6:56	7:37	8:37	9:37	10:37	11:37
1	**East Falls**	6:15	6:39	7:10	7:39	8:17	–	8:43	9:00	9:24	9:39	10:39	11:39	12:39	1:39	2:39	3:39	4:39	5:16	5:39	6:31	6:39	6:58	7:39	8:39	9:39	10:39	11:39
1	**Allegheny**	6:18	6:42	7:12	7:42	–	–	8:46	–	9:27	9:42	10:42	11:42	12:42	1:42	2:42	3:42	4:42	5:19	5:42	6:34	6:42	7:01	7:42	8:42	9:42	10:42	11:42
1	**North Broad** ♿	6:22	6:46	7:16	7:46	–	–	8:50	–	9:31	9:46	10:46	11:46	12:46	1:46	2:46	3:46	4:46	5:23	5:46	6:38	6:46	7:05	7:46	8:46	9:46	10:46	11:46
C	**Temple University** ♿	6:24	6:48	7:18	7:48	8:26	**D8:41**	8:52	**D9:09**	**D9:33**	9:48	10:48	11:48	12:48	**D1:50**	2:48	3:48	4:48	5:25	5:48	6:40	6:48	7:07	7:48	8:48	9:48	10:48	11:48
C	**Jefferson Station** ♿	6:31	6:54	7:24	7:54	8:32	**D8:47**	8:58	**D9:15**	**D9:39**	9:54	10:54	11:54	12:54	**D1:56**	2:54	3:54	4:54	5:31	5:54	6:46	6:54	7:13	7:54	8:54	9:54	10:54	11:54
C	**Suburban Station** ♿	6:36	6:59	7:29	7:59	8:37	**D8:52**	9:03	**D9:20**	**D9:44**	9:59	10:59	11:59	12:59	**D2:01**	2:59	3:59	4:59	5:36	5:59	6:51	6:59	7:18	7:59	8:59	9:59	10:59	11:59
C	**Gray 30th St Station** ♿	6:41	7:03	7:33	8:03	8:42	8:58	9:08	9:24	9:49	10:03	11:03	12:03	1:03	2:05	3:03	4:03	5:03	5:41	6:03	6:56	7:03	7:22	8:03	9:03	10:03	11:03	12:04
C	**Penn Medicine Station** ♿	6:44	7:06	–	8:06	8:45	–	–	–	–	10:06	11:06	12:06	1:06	–	3:06	4:06	5:06	–	6:06	–	7:06	7:25	8:06	9:06	10:06	11:06	–
	(See Destination Codes)	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	AM
	Train continues to	**MHK**	**WAW**	**MAL**	**WAW**	**WIL**	–	**MAL**	–	–	**WAW**	**WAW**	**WAW**	**WAW**	–	**WAW**	**WAW**	**WAW**	**MAL**	**WAW**	**MAL**	**WAW**	**WAW**	**WAW**	**WAW**	**WAW**	**WAW**	**MAL**

TO MANAYUNK/NORRISTOWN

Fare Zone	Train Number	3200	206	3206	7204	4210	3208	7206	5210	3212	3214	5216	3218	3220	3222	6242	3224	220	3226	5250	6256	3228	3230	3232	3234	3236	6238	6240
	Stations	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	AM
C	**Penn Medicine Station** ♿	5:24	6:09	6:41	–	7:27	7:35	–	–	9:49	10:49	–	12:49	1:49	2:49	–	3:49	4:17	4:49	–	–	5:49	6:49	7:49	8:49	9:49	–	–
C	**Gray 30th St Station** ♿	5:27	6:12	6:44	7:17	7:30	7:38	7:54	8:42	9:52	10:52	11:46	12:52	1:52	2:52	3:23	3:52	4:20	4:52	5:05	5:24	5:52	6:52	7:52	8:52	9:52	11:11	12:11
C	**Suburban Station** ♿	5:32	6:17	6:49	7:22	7:35	7:43	7:59	8:47	9:57	10:57	11:51	12:57	1:57	2:57	3:28	3:57	4:24	4:57	5:10	5:29	5:57	6:57	7:57	8:57	9:57	11:16	12:16
C	**Jefferson Station** ♿	5:37	6:22	6:54	7:27	7:40	7:48	8:04	8:52	10:02	11:02	11:56	1:02	2:02	3:02	3:33	4:02	4:29	5:02	5:15	5:34	6:02	7:02	8:02	9:02	10:02	11:21	12:21
C	**Temple University** ♿	5:42	6:26	6:59	7:32	7:45	7:52	8:09	8:56	10:06	11:06	12:00	1:06	2:06	3:06	3:37	4:06	4:33	5:06	5:19	5:38	6:06	7:06	8:06	9:06	10:06	11:25	12:25
1	**North Broad** ♿	5:44	6:28	7:00	–	–	7:54	–	8:58	10:08	11:08	12:02	1:08	2:08	3:08	–	4:08	4:35	–	–	5:40	6:08	7:08	8:08	9:08	10:08	11:27	12:27
1	**Allegheny**	5:47	6:31	**D7:03**	–	**D7:50**	7:58	**D8:14**	9:00	10:11	11:11	12:05	1:11	2:11	3:11	**D3:42**	4:11	4:39	–	–	5:44	6:11	7:11	8:11	9:11	10:11	11:31	12:31
1	**East Falls**	5:50	6:33	**D7:06**	–	**D7:52**	8:02	**D8:16**	9:02	10:13	11:13	12:07	1:13	2:13	3:13	**D3:44**	4:13	4:42	**D5:13**	**D5:27**	5:47	6:13	7:13	8:13	9:13	10:13	11:33	12:33
1	**Wissahickon**	5:52	6:36	**D7:09**	–	**D7:54**	8:05	**D8:18**	9:05	10:16	11:16	12:10	1:16	2:16	3:16	**D3:46**	4:16	4:44	**D5:16**	**D5:29**	5:49	6:16	7:16	8:16	9:16	10:16	11:35	12:35
2	**Manayunk**	5:55	6:39	**D7:12**	**D7:43**	**D7:56**	8:08	**D8:20**	9:08	10:19	11:19	12:13	1:19	2:19	3:19	**D3:49**	4:19	4:47	**D5:19**	**D5:32**	5:52	6:19	7:19	8:19	9:19	10:19	11:37	12:37
2	**Ivy Ridge**	5:57	6:41	**D7:14**	**D7:45**	**D7:58**	8:10	**D8:22**	9:10	10:21	11:21	12:15	1:21	2:21	3:21	**D3:51**	4:21	4:50	**D5:21**	**D5:35**	5:55	6:21	7:21	8:21	9:21	10:21	11:39	12:39
2	**Miquon**	6:02	6:46	**D7:19**	**D7:50**	8:04	8:15	8:32	9:15	10:26	11:26	12:20	1:26	2:26	3:26	**D3:56**	4:26	4:55	**D5:26**	**D5:40**	6:00	6:26	7:26	8:26	9:26	10:26	11:44	12:44
3	**Spring Mill** ♿	**D6:05**	**D6:49**	**D7:24**	**D7:53**	–	**D8:18**	–	**D9:18**	**D10:29**	**D11:29**	**D12:23**	**D1:29**	**D2:29**	**D3:29**	**D3:59**	**D4:29**	**D4:58**	**D5:29**	**D5:43**	**D6:03**	**D6:29**	**D7:29**	**D8:29**	**D9:29**	**D10:29**	**D11:47**	**D12:47**
3	**Conshohocken** ♿	**D6:08**	**D6:51**	**D7:27**	**D7:55**	–	**D8:21**	–	**D9:20**	**D10:31**	**D11:31**	**D12:25**	**D1:31**	**D2:31**	**D3:31**	**D4:01**	**D4:31**	**D5:03**	**D5:31**	**D5:46**	**D6:06**	**D6:31**	**D7:31**	**D8:31**	**D9:31**	**D10:31**	**D11:49**	**D12:49**
3	**Norristown Transit Center**	**D6:16**	**D6:59**	7:35	8:03	–	**D8:30**	–	**D9:30**	**D10:40**	**D11:40**	**D12:34**	**D1:40**	**D2:40**	**D3:40**	4:11	**D4:40**	**D5:15**	**D5:40**	5:56	**D6:16**	**D6:40**	**D7:40**	**D8:40**	**D9:40**	**D10:40**	**D11:56**	**D12:56**
3	**Main St**	**D6:19**	**D7:18**	–	–	–	**D8:33**	–	**D9:33**	**D10:44**	**D11:44**	**D12:38**	**D1:44**	**D2:44**	**D3:44**	–	**D4:44**	**D5:18**	**D5:44**	–	**D6:19**	**D6:44**	**D7:44**	**D8:44**	**D9:44**	**D10:44**	**D11:59**	**D12:59**
3	**Norristown – Elm St** ♿	6:22	7:22	–	–	–	8:37	–	9:39	10:48	11:48	12:42	1:48	2:48	3:48	–	4:48	5:22	5:48	–	6:23	6:48	7:48	8:48	9:48	10:48	12:03	1:03
		AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	AM	AM

♿ – **Accessible station**

D – Train stops to discharge or pick up passengers, but may depart ahead of schedule.

Saturdays, Sundays and Major Holidays

TO CENTER CITY

Fare Zone	Train Number	2409	2413	2417	2421	2425	2429	2433	2437	2441	2445	2449	2453	2457	2461	2465	2469	2473	2477	6281
	Stations	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
3	**Norristown – Elm St** ♿	5:33	6:33	7:33	8:33	9:33	10:33	11:33	12:33	1:33	2:33	3:33	4:33	5:33	6:33	7:33	8:33	9:33	10:33	11:33
3	**Main St**	5:35	6:35	7:35	8:35	9:35	10:35	11:35	12:35	1:35	2:35	3:35	4:35	5:35	6:35	7:35	8:35	9:35	10:35	11:35
3	**Norristown Transit Center**	5:39	6:39	7:39	8:39	9:39	10:39	11:39	12:39	1:39	2:39	3:39	4:39	5:39	6:39	7:39	8:39	9:39	10:39	11:39
3	**Conshohocken** ♿	5:45	6:45	7:45	8:45	9:45	10:45	11:45	12:45	1:45	2:45	3:45	4:45	5:45	6:45	7:45	8:45	9:45	10:45	11:45
3	**Spring Mill** ♿	5:48	6:48	7:48	8:48	9:48	10:48	11:48	12:48	1:48	2:48	3:48	4:48	5:48	6:48	7:48	8:48	9:48	10:48	11:48
2	**Miquon**	5:52	6:52	7:52	8:52	9:52	10:52	11:52	12:52	1:52	2:52	3:52	4:52	5:52	6:52	7:52	8:52	9:52	10:52	11:52
2	**Ivy Ridge**	5:56	6:56	7:56	8:56	9:56	10:56	11:56	12:56	1:56	2:56	3:56	4:56	5:56	6:56	7:56	8:56	9:56	10:56	11:56
2	**Manayunk**	5:58	6:58	7:58	8:58	9:58	10:58	11:58	12:58	1:58	2:58	3:58	4:58	5:58	6:58	7:58	8:58	9:58	10:58	11:58
1	**Wissahickon**	6:01	7:01	8:01	9:01	10:01	11:01	12:01	1:01	2:01	3:01	4:01	5:01	6:01	7:01	8:01	9:01	10:01	11:01	12:01
1	**East Falls**	6:03	7:03	8:03	9:03	10:03	11:03	12:03	1:03	2:03	3:03	4:03	5:03	6:03	7:03	8:03	9:03	10:03	11:03	12:03
1	**Allegheny**	6:08	7:08	8:08	9:08	10:08	11:08	12:08	1:08	2:08	3:08	4:08	5:08	6:08	7:08	8:08	9:08	10:08	11:08	12:08
1	**North Broad** ♿	6:11	7:11	8:11	9:11	10:11	11:11	12:11	1:11	2:11	3:11	4:11	5:11	6:11	7:11	8:11	9:11	10:11	11:11	12:11
C	**Temple University** ♿	6:14	7:14	8:14	9:14	10:14	11:14	12:14	1:14	2:14	3:14	4:14	5:14	6:14	7:14	8:14	9:14	10:14	11:14	**D12:14**
C	**Jefferson Station** ♿	6:20	7:20	8:20	9:20	10:20	11:20	12:20	1:20	2:20	3:20	4:20	5:20	6:20	7:20	8:20	9:20	10:20	11:20	**D12:20**
C	**Suburban Station** ♿	6:25	7:25	8:25	9:25	10:25	11:25	12:25	1:25	2:25	3:25	4:25	5:25	6:25	7:25	8:25	9:25	10:25	11:25	**D12:25**
C	**Gray 30th St Station** ♿	6:30	7:30	8:30	9:30	10:30	11:30	12:30	1:30	2:30	3:30	4:30	5:30	6:30	7:30	8:30	9:30	10:30	11:30	12:30
C	**Penn Medicine Station** ♿	6:33	7:33	8:33	9:33	10:33	11:33	12:33	1:33	2:33	3:33	4:33	5:33	6:33	7:33	8:33	9:33	10:33	11:33	–
	(See Destination Codes)	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	AM
	Train continues to	**AIR**	**AIR**	**AIR**	**AIR**	**AIR**	**AIR**	**AIR**	**AIR**	**AIR**	**AIR**	**AIR**	**AIR**	**AIR**	**AIR**	**AIR**	**AIR**	**AIR**	**AIR**	–

TO MANAYUNK/NORRISTOWN

Fare Zone	Train Number	4204	4208	4212	4216	4220	4224	4228	4232	4236	4240	4244	4248	4252	4256	4260	4264	4268	4272	4276
	Stations	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
C	**Penn Medicine Station** ♿	5:57	6:57	7:57	8:57	9:57	10:57	11:57	12:57	1:57	2:57	3:57	4:57	5:57	6:57	7:57	8:57	9:57	10:57	11:57
C	**Gray 30th St Station** ♿	6:00	7:00	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00
C	**Suburban Station** ♿	6:05	7:05	8:05	9:05	10:05	11:05	12:05	1:05	2:05	3:05	4:05	5:05	6:05	7:05	8:05	9:05	10:05	11:05	12:05
C	**Jefferson Station** ♿	6:10	7:10	8:10	9:10	10:10	11:10	12:10	1:10	2:10	3:10	4:10	5:10	6:10	7:10	8:10	9:10	10:10	11:10	12:10
C	**Temple University** ♿	6:15	7:15	8:15	9:15	10:15	11:15	12:15	1:15	2:15	3:15	4:15	5:15	6:15	7:15	8:15	9:15	10:15	11:15	12:15
1	**North Broad** ♿	6:16	7:16	8:16	9:16	10:16	11:16	12:16	1:16	2:16	3:16	4:16	5:16	6:16	7:16	8:16	9:16	10:16	11:16	12:16
1	**Allegheny**	6:20	7:20	8:20	9:20	10:20	11:20	12:20	1:20	2:20	3:20	4:20	5:20	6:20	7:20	8:20	9:20	10:20	11:20	12:20
1	**East Falls**	6:22	7:22	8:22	9:22	10:22	11:22	12:22	1:22	2:22	3:22	4:22	5:22	6:22	7:22	8:22	9:22	10:22	11:22	12:22
1	**Wissahickon**	6:24	7:24	8:24	9:24	10:24	11:24	12:24	1:24	2:24	3:24	4:24	5:24	6:24	7:24	8:24	9:24	10:24	11:24	12:24
2	**Manayunk**	6:26	7:26	8:26	9:26	10:26	11:26	12:26	1:26	2:26	3:26	4:26	5:26	6:26	7:26	8:26	9:26	10:26	11:26	12:26
2	**Ivy Ridge**	6:28	7:28	8:28	9:28	10:28	11:28	12:28	1:28	2:28	3:28	4:28	5:28	6:28	7:28	8:28	9:28	10:28	11:28	12:28
2	**Miquon**	6:33	7:33	8:33	9:33	10:33	11:33	12:33	1:33	2:33	3:33	4:33	5:33	6:33	7:33	8:33	9:33	10:33	11:33	12:33
3	**Spring Mill** ♿	**D6:35**	**D7:35**	**D8:35**	**D9:35**	**D10:35**	**D11:35**	**D12:35**	**D1:35**	**D2:35**	**D3:35**	**D4:35**	**D5:35**	**D6:35**	**D7:35**	**D8:35**	**D9:35**	**D10:35**	**D11:35**	**D12:35**
3	**Conshohocken** ♿	**D6:39**	**D7:39**	**D8:39**	**D9:39**	**D10:39**	**D11:39**	**D12:39**	**D1:39**	**D2:39**	**D3:39**	**D4:39**	**D5:39**	**D6:39**	**D7:39**	**D8:39**	**D9:39**	**D10:39**	**D11:39**	**D12:39**
3	**Norristown Transit Center**	**D6:49**	**D7:49**	**D8:49**	**D9:49**	**D10:49**	**D11:49**	**D12:49**	**D1:49**	**D2:49**	**D3:49**	**D4:49**	**D5:49**	**D6:49**	**D7:49**	**D8:49**	**D9:49**	**D10:49**	**D11:49**	**D12:49**
3	**Main St**	**D6:52**	**D7:52**	**D8:52**	**D9:52**	**D10:52**	11:52	**D12:52**	**D1:52**	**D2:52**	**D3:52**	4:52	5:52	6:52	**D7:52**	**D8:52**	**D9:52**	**D10:52**	**D11:52**	**D12:52**
3	**Norristown – Elm St** ♿	6:57	7:57	8:57	9:57	10:57	11:57	12:57	1:57	2:57	3:57	4:57	5:57	6:57	7:57	8:57	9:57	10:57	11:57	12:57
		AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	AM

♿ – **Accessible station**
D – Train stops to discharge or pick up passengers, but may depart ahead of schedule.

Travel Tips

Schedule Times: Indicate when trains depart the station.

Fare Payment Options: Contactless, SEPTA Key, Quick Trip Ticket, or cash. Visit **www.septa.org/fares** for more information.

QuietRide Car: Available on all weekday trains (Monday–Friday 4:00 AM to 7:00 PM) with 3 or more cars open for passenger service. The first car will be designated as your QuietRide Car.

Regional Rail Major Holidays: New Year's Day, Martin Luther King Jr. Day, Memorial Day, July 4th, Labor Day, Thanksgiving Day, Christmas Day (Special Schedule). *Please note: Holidays may be observed on another day.*

Disclaimer: SEPTA does not assume responsibility for inconvenience, experience or damage resulting from errors in timetables, delayed trains, failure to make connections or for shortage of equipment. Information is subject to change.

Severe Weather Schedule: During extreme weather conditions, trains may operate on a special schedule. Visit **www.septa.org/alerts** for more information.

Destination Codes

AIR	Airport	**MHK**	Marcus Hook
BMR	Bryn Mawr	**NWK**	Newark, DE
CHW	Chestnut Hill West	**THO**	Thorndale
CYN	Cynwyd	**TRE**	Trenton Transit Center
ELW	Elwyn	**WAW**	Wawa
MAL	Malvern	**WAY**	Wayne
MED	Media	**WIL**	Wilmington

Safety Tips

- **Never** pass between cars when a train is moving
- **Never** attempt to board a moving train
- **Always** wait for the train to come to a complete stop **before** exiting
- **Never** ride in the vestibule or on the steps of a moving train
- **Never** lean against the train doors

For more information, visit **www.septa.org/safety**.

Paoli/ Thorndale Line

To/From Center City Philadelphia

Effective September 2, 2025

SEPTA REGIONAL RAIL

- Thorndale
- Downingtown
- Whitford
- Exton
- Malvern
- Paoli
- Daylesford
- Berwyn
- Devon
- Strafford
- Wayne
- St. Davids
- Radnor
- Villanova
- Rosemont
- Bryn Mawr
- Haverford
- Ardmore
- Wynnewood
- Narberth
- Merion
- Overbrook
- William H. Gray III 30th St Station
- Suburban Station
- Jefferson Station
- Temple University

Customer Service: **215-580-7800**
TDD/TTY: **215-580-7853**
www.septa.org

Penn Medicine
800.789.PENN PennMedicine.org

Station Locations & Connecting Services

Thorndale 201 S. Bailey Rd	P 135
Downingtown 159 Viaduct Av	P 135
Whitford 401 Spackman Ln	P
Exton 445 Walkertown Rd	P 135
Malvern 15 N. Warren Av • 610-408-9290	$ P 92
Paoli 13 N. Valley Rd • 610-296-2100	$ P 92, 106, 204, 206
Daylesford 1301 Lancaster Av	P 106
Berwyn 654 E. Lancaster Av • 610-644-0607	$ P 106
Devon 1 N. Devon Blvd • 610-688-2493	$ P 106
Strafford 97 Old Eagle School Rd • 610-688-2493	$ P
Wayne 145 N. Wayne Av • 610-688-0193	$ P 106
St. Davids 53 Chamounix Rd	P
Radnor 291 King of Prussia Rd • 610-688-0192	$ P 106
Villanova 308 N. Spring Mill Rd • 610-525-4546	$ P
Rosemont 43 Airdale Rd • 610-525-2324	$ P 105, 106
Bryn Mawr 54 N. Bryn Mawr Av • 610-525-2505	$ P 105, 106
Haverford 43 Haverford Station Rd • 610-642-0573	$ P 105, 106
Ardmore 39 Station Av • 610-642-4292	$ P 44, 103, 105, 106
Wynnewood 67 E. Wynnewood Rd • 610-642-0118	$ P 105
Narberth 211 Elmwood Av • 610-664-3676	$ P 44
Merion 293 Idris Rd • 610-644-0524	$ P
Overbrook 2195 N. 63rd St • 215-878-7111	$ P 63, 65
William H. Gray III 30th St Station 30th St & Market St	$ L T 9, 30, 31, 44, 49, 62, 78, 124, 125, LUCY Amtrak, NJ Transit Atlantic City Line
Suburban Station 16th St & JFK Blvd	$ L B T 2, 4, 16, 17, 27, 31, 32, 33, 38, 44, 48, 62, 78, 124, 125
Jefferson Station Market St between 10th St & 12th St	$ L B3 17, 23, 33, 38, 44, 45, 47, 47M, 48, 61, 62, 78, NJ Transit Buses
Temple University 927 W. Berks St • 215-580-5440	$

P – **Parking available**

$ – **Sales Office** (hours vary, visit **www.septa.org/stations** for details)

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Mondays through Fridays (Except Major Holidays)

TO CENTER CITY

Fare Zone	Train Number	514	516	5300	9590	9502	512	9510	9592	5304	5210	5318	9540	5322	9544	9546	5216
	Stations	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM
4	**Thorndale** ♿	4:37	5:13	6:13	6:38	–	–	–	7:18	–	–	–	8:22	–	9:34	–	–
4	**Downingtown**	4:41	5:17	6:17	6:42	–	–	–	7:22	–	–	–	8:26	–	9:38	–	–
4	**Whitford**	4:48	5:24	6:24	6:49	–	–	–	7:29	–	–	–	8:33	–	9:45	–	–
4	**Exton** ♿	4:50	5:26	6:26	6:52	–	–	–	7:32	–	–	–	8:35	–	9:47	–	–
4	**Malvern**	4:56	5:32	6:32	6:59	6:52	–	7:22	7:39	–	7:49	8:22	8:42	9:22	9:54	10:22	10:54
4	**Paoli** ♿ (Rts. 204, 206)	4:59	5:35	6:35	7:03	6:55	–	7:26	7:43	–	7:52	8:26	8:45	9:26	9:58	10:26	10:58
3	**Daylesford**	5:02	5:38	6:38	7:06	6:58	–	7:29	7:46	–	7:55	8:29	8:48	9:29	10:01	10:29	11:01
3	**Berwyn** ♿	5:05	5:41	6:41	7:09	7:01	–	7:32	7:49	–	7:58	8:31	8:50	9:31	10:03	10:31	11:03
3	**Devon**	5:07	5:43	6:43	7:12	7:03	–	7:35	7:52	–	8:00	8:33	8:52	9:33	10:05	10:33	11:05
3	**Strafford** ♿	5:10	5:46	6:46	7:15	7:06	–	7:38	7:55	–	8:03	8:35	8:55	9:35	10:07	10:35	11:07
3	**Wayne** ♿	5:13	5:49	6:49	7:18	7:09	7:24	7:41	7:58	–	8:06	8:38	8:57	9:38	10:09	10:38	11:09
3	**St. Davids**	5:15	5:51	6:51	–	7:11	7:26	7:43	–	–	8:08	8:40	8:59	9:40	10:11	10:40	11:11
3	**Radnor** ♿	5:17	5:53	6:53	–	7:13	7:28	7:45	–	–	8:10	8:42	9:01	9:42	10:13	10:42	11:13
3	**Villanova**	5:19	5:55	6:55	–	7:15	7:31	7:47	–	–	8:12	8:44	9:03	9:44	10:15	10:44	11:15
3	**Rosemont**	5:22	5:58	6:58	–	7:18	7:33	7:50	–	–	8:15	8:46	9:06	9:46	10:17	10:46	11:17
3	**Bryn Mawr**	5:24	6:00	7:00	–	7:20	7:36	7:53	–	7:58	8:17	8:49	9:09	9:49	10:20	10:49	11:20
2	**Haverford**	5:26	6:02	7:02	–	7:22	7:39	–	–	8:00	8:19	8:52	9:12	9:52	10:23	10:52	11:23
2	**Ardmore**	5:28	6:04	7:04	–	7:24	7:41	–	–	8:03	8:21	8:54	9:14	9:54	10:25	10:54	11:25
2	**Wynnewood**	5:30	6:06	7:06	–	7:26	7:44	–	–	8:06	8:23	8:57	9:17	9:57	10:27	10:57	11:27
2	**Narberth**	5:32	6:08	7:08	–	7:28	7:46	–	–	8:08	8:25	8:59	9:19	9:59	10:29	10:59	11:29
2	**Merion**	5:34	6:10	7:10	–	7:30	7:48	–	–	8:10	8:27	9:01	9:22	10:01	10:31	11:01	11:31
1	**Overbrook** ♿	5:37	6:13	7:13	–	7:33	7:50	–	–	8:13	8:30	9:03	9:25	10:03	10:34	11:03	11:34
C	**Gray 30th St Station** ♿	5:49	6:25	7:25	**D7:39**	**D7:47**	8:02	**D8:12**	**D8:19**	8:25	8:42	9:15	**D9:37**	10:15	**D10:46**	**D11:15**	11:46
C	**Suburban Station** ♿	5:54	6:30	7:30	**D7:44**	**D7:52**	8:07	**D8:17**	**D8:24**	8:30	8:47	9:20	**D9:42**	10:20	**D10:51**	**D11:20**	11:51
C	**Jefferson Station** ♿	5:59	6:35	7:35	**D7:49**	**D7:57**	8:12	**D8:22**	**D8:29**	8:35	8:52	9:25	**D9:47**	10:25	**D10:56**	**D11:25**	11:56
C	**Temple University** ♿	6:03	6:39	7:39	7:54	8:02	8:17	8:27	8:34	8:40	8:56	9:30	9:51	10:30	11:01	11:30	12:00
	(See Destination Codes)	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	PM
	Train continues to	**DOY**	**LAN**	**WTR**	–	–	**DOY**	–	–	**WTR**	**ELM**	**WTR**	–	**WTR**	–	–	**ELM**

TO CENTER CITY

Fare Zone	Train Number	9552	9556	9560	5330	5734	5336	5438	5250	5440	542	5344	5348	5352	5356	9564	9566
	Stations	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
4	**Thorndale** ♿	11:34	–	1:34	–	–	–	3:36	–	–	–	5:07	–	7:07	8:07	–	10:26
4	**Downingtown**	11:38	–	1:39	–	–	–	3:41	–	–	–	5:11	–	7:11	8:11	–	10:30
4	**Whitford**	11:45	–	1:45	–	–	–	3:47	–	–	–	5:18	–	7:18	8:18	–	10:35
4	**Exton** ♿	11:47	–	1:47	–	–	–	3:49	–	–	–	5:20	–	7:20	8:20	–	10:37
4	**Malvern**	11:54	12:54	1:54	2:19	2:47	3:23	3:56	4:18	4:33	–	5:26	6:26	7:26	8:26	9:37	10:42
4	**Paoli** ♿ (Rts. 204, 206)	11:58	12:58	1:58	2:23	2:51	3:27	4:00	4:22	4:36	4:59	5:30	6:30	7:30	8:30	9:41	10:45
3	**Daylesford**	12:01	1:01	2:01	2:26	2:54	3:30	4:03	4:24	4:39	5:02	5:33	6:33	7:33	8:33	9:44	10:48
3	**Berwyn** ♿	12:03	1:03	2:03	2:28	2:56	3:32	4:05	4:26	4:42	5:04	5:35	6:35	7:35	8:35	9:46	10:50
3	**Devon**	12:05	1:05	2:05	2:30	2:58	3:34	4:07	4:28	4:44	5:06	5:37	6:37	7:37	8:37	9:48	10:52
3	**Strafford** ♿	12:07	1:07	2:07	2:33	3:00	3:36	4:09	4:30	4:47	5:08	5:39	6:39	7:39	8:39	9:50	10:54
3	**Wayne** ♿	12:09	1:09	2:09	2:35	3:03	3:39	4:11	4:32	4:50	5:10	5:42	6:42	7:42	8:42	9:53	10:56
3	**St. Davids**	12:11	1:11	2:11	2:37	3:05	3:41	4:13	4:34	4:52	5:13	5:44	6:44	7:44	8:44	9:55	10:58
3	**Radnor** ♿	12:13	1:13	2:13	2:40	3:07	3:43	4:15	4:36	4:54	5:15	5:46	6:46	7:46	8:46	9:57	11:00
3	**Villanova**	12:15	1:15	2:15	2:42	3:09	3:45	4:17	4:38	4:56	5:17	5:48	6:48	7:48	8:48	9:59	11:02
3	**Rosemont**	12:17	1:17	2:17	2:45	3:11	3:47	4:19	4:40	4:59	5:20	5:50	6:50	7:50	8:50	10:01	11:05
3	**Bryn Mawr**	12:20	1:20	2:20	2:48	3:14	3:50	4:22	4:42	5:01	5:23	5:53	6:53	7:53	8:53	10:04	11:08
2	**Haverford**	12:23	1:23	2:23	2:51	3:17	3:53	4:25	–	5:03	5:25	5:55	6:55	7:55	8:55	10:07	11:11
2	**Ardmore**	12:25	1:25	2:25	2:53	3:19	3:55	4:27	–	5:05	5:27	5:56	6:56	7:56	8:56	10:09	11:13
2	**Wynnewood**	12:27	1:27	2:27	2:56	3:22	3:58	4:29	–	5:07	5:29	5:58	6:58	7:58	8:58	10:11	11:15
2	**Narberth**	12:29	1:29	2:29	2:58	3:24	4:00	4:31	–	5:09	5:31	6:00	7:00	8:00	9:00	10:13	11:17
2	**Merion**	12:31	1:31	2:31	3:00	3:26	4:02	4:33	–	5:11	5:33	6:02	7:02	8:02	9:02	10:15	11:19
1	**Overbrook** ♿	12:34	1:34	2:34	3:03	3:28	4:04	4:36	4:51	5:14	5:36	6:04	7:04	8:04	9:04	10:18	11:21
C	**Gray 30th St Station** ♿	**D12:46**	**D1:46**	**D2:46**	3:16	3:40	4:16	4:48	5:05	5:26	5:48	6:16	7:16	8:16	9:16	**D10:30**	**D11:31**
C	**Suburban Station** ♿	**D12:51**	**D1:51**	**D2:51**	3:21	3:45	4:21	4:53	5:10	5:31	5:53	6:21	7:21	8:21	9:21	**D10:35**	**D11:36**
C	**Jefferson Station** ♿	**D12:56**	**D1:56**	**D2:56**	3:26	3:50	4:26	4:58	5:15	5:36	5:58	6:26	7:26	8:26	9:26	**D10:40**	**D11:41**
C	**Temple University** ♿	1:01	2:01	3:01	3:30	3:55	4:30	5:02	5:19	5:40	6:03	6:30	7:30	8:30	9:30	10:44	11:45
	(See Destination Codes)	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
	Train continues to	–	–	–	**WTR**	**CHE**	**WTR**	**GLN**	**NTC**	**WAR**	**DOY**	**WTR**	**WTR**	**WTR**	**WTR**	–	–

♿ – **Accessible station**

D – Train stops to discharge or pick up passengers, but may depart ahead of schedule.

Mondays through Fridays (Except Major Holidays)

TO PAOLI/THORNDALE

Fare Zone	Train Number	3591	503	3501	2547	9501	7503	2511	9509	9513	9517	9521	9525	9527	9529	9531	9533
	Stations	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM
C	**Temple University** ♿	6:05	6:19	6:52	7:18	7:40	7:54	8:52	9:40	10:40	11:40	12:40	1:40	2:10	2:40	3:06	3:29
C	**Jefferson Station** ♿	6:12	6:26	6:59	7:24	7:46	8:00	8:58	9:46	10:46	11:46	12:46	1:46	2:16	2:46	3:12	3:35
C	**Suburban Station** ♿	6:17	6:31	7:04	7:29	7:51	8:05	9:03	9:51	10:51	11:51	12:51	1:51	2:21	2:51	3:17	3:40
C	**Gray 30th St Station** ♿	6:21	6:35	7:08	7:33	7:56	8:10	9:08	9:56	10:56	11:56	12:56	1:56	2:26	2:56	3:22	3:45
1	**Overbrook** ♿	6:31	6:45	7:18	7:43	8:06	8:20	9:18	10:06	11:06	12:06	1:06	2:06	2:36	3:06	3:32	3:55
2	**Merion**	6:33	6:47	7:20	7:45	8:08	8:21	9:20	10:08	11:08	12:08	1:08	2:08	2:38	3:08	3:34	3:57
2	**Narberth**	6:35	6:50	7:22	7:47	8:10	8:23	9:22	10:10	11:10	12:10	1:10	2:10	2:40	3:10	3:36	3:59
2	**Wynnewood**	6:37	6:51	7:24	7:49	8:12	8:25	9:24	10:12	11:12	12:12	1:12	2:12	2:42	3:12	3:38	4:01
2	**Ardmore**	6:39	6:53	7:26	7:51	8:14	8:27	9:26	10:14	11:14	12:14	1:14	2:14	2:44	3:14	3:41	4:04
2	**Haverford**	6:41	6:56	7:28	7:53	8:16	8:29	9:28	10:16	11:16	12:16	1:16	2:16	2:46	3:16	3:43	4:06
3	**Bryn Mawr**	6:44	6:58	7:31	7:56	8:19	8:32	9:31	10:19	11:19	12:19	1:19	2:19	2:49	3:19	3:46	4:09
3	**Rosemont**	6:46	7:01	7:33	7:59	8:21	8:34	9:33	10:21	11:21	12:21	1:21	2:21	2:52	3:21	3:48	4:12
3	**Villanova**	6:49	7:03	7:36	8:01	8:24	8:37	9:36	10:24	11:24	12:24	1:24	2:24	2:54	3:24	3:51	4:15
3	**Radnor** ♿	6:51	7:05	7:38	8:03	8:26	8:39	9:38	10:26	11:26	12:26	1:26	2:26	2:56	3:26	3:53	4:17
3	**St. Davids**	6:53	7:07	7:40	8:05	8:28	8:41	9:41	10:28	11:28	12:28	1:28	2:28	2:58	3:28	3:55	4:19
3	**Wayne** ♿	6:55	7:10	7:42	8:07	8:30	8:43	9:42	10:30	11:30	12:30	1:30	2:30	3:00	3:30	3:57	4:22
3	**Strafford** ♿	6:57	7:12	7:44	8:10	8:32	8:45	9:44	10:32	11:32	12:32	1:32	2:32	3:02	3:32	4:00	4:24
3	**Devon**	7:00	7:14	7:47	8:12	8:35	8:49	9:47	10:35	11:35	12:35	1:35	2:35	3:05	3:35	4:03	4:27
3	**Berwyn** ♿	7:02	7:17	7:49	8:14	8:37	8:51	9:49	10:37	11:37	12:37	1:37	2:37	3:07	3:37	4:05	4:29
3	**Daylesford**	7:05	7:19	7:52	8:16	8:40	8:53	9:52	10:40	11:40	12:40	1:40	2:40	3:10	3:40	4:07	4:32
4	**Paoli** ♿ (Rts. 204, 206)	**CD7:08**	**D7:22**	**CD7:55**	8:18	**CD8:43**	**CD8:57**	**CD9:55**	**CD10:43**	**CD11:43**	**CD12:43**	**D1:43**	**D2:43**	**D3:13**	**D3:43**	**D4:12**	4:36
4	**Malvern**	**D7:12**	7:28	8:01	8:24	**D8:47**	9:03	10:01	**D10:47**	11:49	**D12:47**	1:49	**D2:47**	3:19	3:49	**D4:16**	–
4	**Exton** ♿	**D7:19**	–	–	–	**D8:53**	–	–	**D10:53**	–	**D12:53**	–	**D2:53**	–	–	**D4:23**	–
4	**Whitford**	**D7:21**	–	–	–	**D8:55**	–	–	**D10:55**	–	**D12:55**	–	**D2:55**	–	–	**D4:26**	–
4	**Downingtown**	**D7:27**	–	–	–	**D9:02**	–	–	**D11:02**	–	**D1:02**	–	**D3:02**	–	–	**D4:34**	–
4	**Thorndale** ♿	7:40	–	–	–	9:14	–	–	11:12	–	1:12	–	3:12	–	–	4:44	–
		AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM

TO PAOLI/THORNDALE

Fare Zone	Train Number	9551	9591	7537	9593	4539	9595	2553	3541	4571	2555	7547	3549	3553	3557	3561	2565
	Stations	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
C	**Temple University** ♿	3:59	4:23	4:35	4:56	5:00	5:22	5:25	5:50	6:09	6:40	7:04	8:00	8:52	9:52	10:52	11:48
C	**Jefferson Station** ♿	4:05	4:29	4:41	5:02	5:06	5:28	5:31	5:56	6:15	6:46	7:10	8:06	8:58	9:58	10:58	11:54
C	**Suburban Station** ♿	4:10	4:34	4:46	5:07	5:11	5:33	5:36	6:01	6:20	6:51	7:15	8:11	9:03	10:03	11:03	11:59
C	**Gray 30th St Station** ♿	4:15	4:39	4:51	5:12	5:16	5:38	5:41	6:06	6:25	6:56	7:20	8:16	9:08	10:08	11:08	12:04
1	**Overbrook** ♿	4:25	–	5:01	–	5:26	–	5:51	–	6:35	7:06	7:30	8:26	9:18	10:18	11:18	12:14
2	**Merion**	4:27	–	5:03	–	5:28	–	5:53	–	6:37	7:08	7:32	8:28	9:20	10:20	11:20	12:16
2	**Narberth**	4:29	–	5:06	–	5:30	–	5:56	–	6:39	7:11	7:34	8:30	9:22	10:22	11:22	12:18
2	**Wynnewood**	4:31	–	5:08	–	5:32	–	5:58	–	6:42	7:12	7:36	8:32	9:24	10:24	11:24	12:20
2	**Ardmore**	4:34	–	5:11	–	5:35	–	6:01	–	6:45	7:14	7:38	8:34	9:26	10:26	11:26	12:22
2	**Haverford**	4:36	–	5:13	–	5:38	–	6:03	–	6:47	7:16	7:40	8:36	9:28	10:28	11:28	12:24
3	**Bryn Mawr**	4:39	**D4:53**	5:16	–	5:41	–	6:06	**D6:20**	6:50	7:19	7:43	8:39	9:30	10:30	11:30	12:27
3	**Rosemont**	4:41	**D4:55**	5:18	–	5:43	–	6:08	**D6:22**	6:52	7:21	7:45	8:41	9:32	10:32	11:32	12:29
3	**Villanova**	4:43	**D4:58**	5:21	–	5:46	–	6:11	**D6:25**	6:55	7:23	7:48	8:43	9:35	10:35	11:35	12:32
3	**Radnor** ♿	4:46	**D5:00**	5:23	–	5:49	–	6:14	**D6:27**	6:57	7:25	7:50	8:45	9:37	10:37	11:37	12:34
3	**St. Davids**	4:48	**D5:03**	5:25	–	5:51	–	6:16	**D6:30**	6:59	7:27	7:52	8:47	9:39	10:39	11:39	12:36
3	**Wayne** ♿	4:50	**D5:05**	5:28	**D5:32**	5:54	**D5:58**	6:18	**D6:33**	7:01	7:29	7:54	8:49	9:41	10:41	11:41	12:38
3	**Strafford** ♿	4:53	**D5:08**	–	**D5:35**	–	**D6:01**	6:21	**D6:36**	7:03	7:31	7:56	8:51	9:43	10:43	11:43	12:40
3	**Devon**	4:56	**D5:11**	–	**D5:38**	–	**D6:04**	6:24	**D6:39**	7:06	7:34	7:59	8:54	9:46	10:46	11:46	12:43
3	**Berwyn** ♿	4:59	**D5:14**	–	**D5:41**	–	**D6:07**	6:27	**D6:42**	7:08	7:37	8:01	8:56	9:48	10:48	11:48	12:45
3	**Daylesford**	5:01	**D5:17**	–	**D5:44**	–	**D6:10**	6:30	**D6:45**	7:11	7:40	8:03	8:59	9:51	10:51	11:51	12:47
4	**Paoli** ♿ (Rts. 204, 206)	**D5:05**	**D5:23**	–	**D5:48**	–	**D6:14**	**D6:34**	**D6:49**	**D7:14**	**D7:43**	**D8:06**	**D9:03**	**D9:55**	**D10:55**	**D11:55**	**D12:50**
4	**Malvern**	5:11	**D5:27**	–	**D5:52**	–	**D6:18**	6:40	6:55	**D7:18**	7:47	8:12	**D9:07**	10:01	**D10:59**	12:01	12:56
4	**Exton** ♿	–	**D5:34**	–	**D5:58**	–	**D6:24**	–	–	**D7:24**	–	–	**D9:13**	–	**D11:05**	–	–
4	**Whitford**	–	**D5:37**	–	**D6:01**	–	**D6:27**	–	–	**D7:27**	–	–	**D9:15**	–	**D11:07**	–	–
4	**Downingtown**	–	**D5:43**	–	**D6:08**	–	**D6:34**	–	–	**D7:34**	–	–	**D9:23**	–	**D11:14**	–	–
4	**Thorndale** ♿	–	5:53	–	6:18	–	6:44	–	–	7:44	–	–	9:33	–	11:24	–	–
		PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	AM	AM

♿ – **Accessible station**

C – Connecting bus service meets this train. **Route 204** and **206** operate from Paoli Station. For details, consult the Route 204 or 206 schedule.

D – Train stops to discharge or pick up passengers, but may depart ahead of schedule.

Saturdays, Sundays and Major Holidays

TO CENTER CITY

Fare Zone	Train Number / Stations	5814	9518	5822	9526	5830	9534	5838	9542	5846	9550	5854	9558	5862	9566	5870	9574	5878	9582
		AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
4	**Thorndale ♿	–	6:19	–	8:19	–	10:19	–	12:19	–	2:19	–	4:19	–	6:19	–	8:19	–	10:19
4	**Downingtown	–	6:23	–	8:23	–	10:23	–	12:23	–	2:23	–	4:23	–	6:23	–	8:23	–	10:23
4	**Whitford	–	6:30	–	8:30	–	10:30	–	12:30	–	2:30	–	4:30	–	6:30	–	8:30	–	10:30
4	**Exton ♿	–	6:32	–	8:32	–	10:32	–	12:32	–	2:32	–	4:32	–	6:32	–	8:32	–	10:32
	↑ SEPTA Service from Thorndale, Downingtown, Whitford, and Exton Stations Operates SATURDAY ONLY ↑																		
4	Malvern	5:38	6:38	7:38	8:38	9:38	10:38	11:38	12:38	1:38	2:38	3:38	4:38	5:38	6:38	7:38	8:38	9:38	10:38
4	Paoli ♿ (Rt. 204)	5:41	6:41	7:41	8:41	9:41	10:41	11:41	12:41	1:41	2:41	3:41	4:41	5:41	6:41	7:41	8:41	9:41	10:41
3	Daylesford	5:44	6:44	7:44	8:44	9:44	10:44	11:44	12:44	1:44	2:44	3:44	4:44	5:44	6:44	7:44	8:44	9:44	10:44
3	Berwyn ♿	5:46	6:46	7:46	8:46	9:46	10:46	11:46	12:46	1:46	2:46	3:46	4:46	5:46	6:46	7:46	8:46	9:46	10:46
3	Devon	5:48	6:48	7:48	8:48	9:48	10:48	11:48	12:48	1:48	2:48	3:48	4:48	5:48	6:48	7:48	8:48	9:48	10:48
3	Strafford ♿	5:50	6:50	7:50	8:50	9:50	10:50	11:50	12:50	1:50	2:50	3:50	4:50	5:50	6:50	7:50	8:50	9:50	10:50
3	Wayne ♿	5:52	6:52	7:52	8:52	9:52	10:52	11:52	12:52	1:52	2:52	3:52	4:52	5:52	6:52	7:52	8:52	9:52	10:52
3	St. Davids	5:54	6:54	7:54	8:54	9:54	10:54	11:54	12:54	1:54	2:54	3:54	4:54	5:54	6:54	7:54	8:54	9:54	10:54
3	Radnor ♿	5:56	6:56	7:56	8:56	9:56	10:56	11:56	12:56	1:56	2:56	3:56	4:56	5:56	6:56	7:56	8:56	9:56	10:56
3	Villanova	5:58	6:58	7:58	8:58	9:58	10:58	11:58	12:58	1:58	2:58	3:58	4:58	5:58	6:58	7:58	8:58	9:58	10:58
3	Rosemont	6:00	7:00	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00
3	Bryn Mawr	6:03	7:03	8:03	9:03	10:03	11:03	12:03	1:03	2:03	3:03	4:03	5:03	6:03	7:03	8:03	9:03	10:03	11:03
2	Haverford	6:05	7:05	8:05	9:05	10:05	11:05	12:05	1:05	2:05	3:05	4:05	5:05	6:05	7:05	8:05	9:05	10:05	11:05
2	Ardmore	6:07	7:07	8:07	9:07	10:07	11:07	12:07	1:07	2:07	3:07	4:07	5:07	6:07	7:07	8:07	9:07	10:07	11:07
2	Wynnewood	6:09	7:09	8:09	9:09	10:09	11:09	12:09	1:09	2:09	3:09	4:09	5:09	6:09	7:09	8:09	9:09	10:09	11:09
2	Narberth	6:10	7:10	8:10	9:10	10:10	11:10	12:10	1:10	2:10	3:10	4:10	5:10	6:10	7:10	8:10	9:10	10:10	11:10
2	Merion	6:12	7:12	8:12	9:12	10:12	11:12	12:12	1:12	2:12	3:12	4:12	5:12	6:12	7:12	8:12	9:12	10:12	11:12
1	Overbrook ♿	6:14	7:14	8:14	9:14	10:14	11:14	12:14	1:14	2:14	3:14	4:14	5:14	6:14	7:14	8:14	9:14	10:14	11:14
C	**Gray 30th St Station ♿**	6:25	**D7:25**	8:25	**D9:25**	10:25	**D11:25**	12:25	**D1:25**	2:25	**D3:25**	4:25	**D5:25**	6:25	**D7:25**	8:25	**D9:25**	10:25	**D11:25**
C	**Suburban Station ♿**	6:30	**D7:30**	8:30	**D9:30**	10:30	**D11:30**	12:30	**D1:30**	2:30	**D3:30**	4:30	**D5:30**	6:30	**D7:30**	8:30	**D9:30**	10:30	**D11:30**
C	**Jefferson Station ♿**	6:35	**D7:35**	8:35	**D9:35**	10:35	**D11:35**	12:35	**D1:35**	2:35	**D3:35**	4:35	**D5:35**	6:35	**D7:35**	8:35	**D9:35**	10:35	**D11:35**
C	Temple University ♿	6:40	7:40	8:40	9:40	10:40	11:40	12:40	1:40	2:40	3:40	4:40	5:40	6:40	7:40	8:40	9:40	10:40	11:40
	(See Destination Codes)	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
	Train continues to	**FOX**	–	**FOX**	–	**FOX**	–	**FOX**	–	**FOX**	–	**FOX**	–	**FOX**	–	**FOX**	–	**FOX**	–

TO PAOLI/THORNDALE

Fare Zone	Train Number / Stations	8507	9511	8515	9519	8523	9527	8531	9535	8539	9543	8547	9551	8555	9559	8563	9567	8571	9575
		AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
C	Temple University ♿	5:54	6:54	7:54	8:54	9:54	10:54	11:54	12:54	1:54	2:54	3:54	4:54	5:54	6:54	7:54	8:54	9:54	10:54
C	**Jefferson Station ♿**	6:00	7:00	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00
C	**Suburban Station ♿**	6:05	7:05	8:05	9:05	10:05	11:05	12:05	1:05	2:05	3:05	4:05	5:05	6:05	7:05	8:05	9:05	10:05	11:05
C	**Gray 30th St Station ♿**	6:10	7:10	8:10	9:10	10:10	11:10	12:10	1:10	2:10	3:10	4:10	5:10	6:10	7:10	8:10	9:10	10:10	11:10
1	Overbrook ♿	6:19	7:19	8:19	9:19	10:19	11:19	12:19	1:19	2:19	3:19	4:19	5:19	6:19	7:19	8:19	9:19	10:19	11:19
2	Merion	6:21	7:21	8:21	9:21	10:21	11:21	12:21	1:21	2:21	3:21	4:21	5:21	6:21	7:21	8:21	9:21	10:21	11:21
2	Narberth	6:23	7:23	8:23	9:23	10:23	11:23	12:23	1:23	2:23	3:23	4:23	5:23	6:23	7:23	8:23	9:23	10:23	11:23
2	Wynnewood	6:25	7:25	8:25	9:25	10:25	11:25	12:25	1:25	2:25	3:25	4:25	5:25	6:25	7:25	8:25	9:25	10:25	11:25
2	Ardmore	6:27	7:27	8:27	9:27	10:27	11:27	12:27	1:27	2:27	3:27	4:27	5:27	6:27	7:27	8:27	9:27	10:27	11:27
2	Haverford	6:29	7:29	8:29	9:29	10:29	11:29	12:29	1:29	2:29	3:29	4:29	5:29	6:29	7:29	8:29	9:29	10:29	11:29
3	Bryn Mawr	6:31	7:31	8:31	9:31	10:31	11:31	12:31	1:31	2:31	3:31	4:31	5:31	6:31	7:31	8:31	9:31	10:31	11:31
3	Rosemont	6:33	7:33	8:33	9:33	10:33	11:33	12:33	1:33	2:33	3:33	4:33	5:33	6:33	7:33	8:33	9:33	10:33	11:33
3	Villanova	6:35	7:35	8:35	9:35	10:35	11:35	12:35	1:35	2:35	3:35	4:35	5:35	6:35	7:35	8:35	9:35	10:35	11:35
3	Radnor ♿	6:37	7:37	8:37	9:37	10:37	11:37	12:37	1:37	2:37	3:37	4:37	5:37	6:37	7:37	8:37	9:37	10:37	11:37
3	St. Davids	6:39	7:39	8:39	9:39	10:39	11:39	12:39	1:39	2:39	3:39	4:39	5:39	6:39	7:39	8:39	9:39	10:39	11:39
3	Wayne ♿	6:41	7:41	8:41	9:41	10:41	11:41	12:41	1:41	2:41	3:41	4:41	5:41	6:41	7:41	8:41	9:41	10:41	11:41
3	Strafford ♿	6:43	7:43	8:43	9:43	10:43	11:43	12:43	1:43	2:43	3:43	4:43	5:43	6:43	7:43	8:43	9:43	10:43	11:43
3	Devon	6:46	7:46	8:46	9:46	10:46	11:46	12:46	1:46	2:46	3:46	4:46	5:46	6:46	7:46	8:46	9:46	10:46	11:46
3	Berwyn ♿	6:48	7:48	8:48	9:48	10:48	11:48	12:48	1:48	2:48	3:48	4:48	5:48	6:48	7:48	8:48	9:48	10:48	11:48
3	Daylesford	6:50	7:50	8:50	9:50	10:50	11:50	12:50	1:50	2:50	3:50	4:50	5:50	6:50	7:50	8:50	9:50	10:50	11:50
4	Paoli ♿ (Rt. 204)	**D6:55**	**D7:55**	**D8:55**	**D9:55**	**D10:55**	**D11:55**	**D12:55**	**D1:55**	**D2:55**	**D3:55**	**D4:55**	**D5:55**	**D6:55**	**D7:55**	**D8:55**	**D9:55**	**D10:55**	**D11:55**
4	Malvern	**D6:58**	7:58	**D8:58**	9:58	**D10:58**	11:58	**D12:58**	1:58	**D2:58**	3:58	**D4:58**	5:58	**D6:58**	7:58	**D8:58**	9:58	**D10:58**	11:58
	↓ SEPTA Service to Thorndale, Downingtown, Whitford, and Exton Stations Operates SATURDAY ONLY ↓																		
4	**Exton ♿	**D7:04**	–	**D9:04**	–	**D11:04**	–	**D1:04**	–	**D3:04**	–	**D5:04**	–	**D7:04**	–	**D9:04**	–	**D11:04**	–
4	**Whitford	**D7:06**	–	**D9:06**	–	**D11:06**	–	**D1:06**	–	**D3:06**	–	**D5:06**	–	**D7:06**	–	**D9:06**	–	**D11:06**	–
4	**Downingtown	**D7:12**	–	**D9:12**	–	**D11:12**	–	**D1:12**	–	**D3:12**	–	**D5:12**	–	**D7:12**	–	**D9:12**	–	**D11:12**	–
4	**Thorndale ♿	7:22	–	9:22	–	11:22	–	1:22	–	3:22	–	5:22	–	7:22	–	9:22	–	11:22	–
		AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM

♿ – **Accessible station**
D – Train stops to discharge or pick up passengers, but may depart ahead of schedule.
Route 204 operates from Paoli Station. For details, consult the Route 204 schedule.

****No service to/from Exton, Whitford, Downingtown, and Thorndale on Sundays**

Travel Tips

Schedule Times: Indicate when trains depart the station.

Fare Payment Options: Contactless, SEPTA Key, Quick Trip Ticket, or cash. Visit **www.septa.org/fares** for more information.

QuietRide Car: Available on all weekday trains (Monday–Friday 4:00 AM to 7:00 PM) with 3 or more cars open for passenger service. The first car will be designated as your QuietRide Car.

Regional Rail Major Holidays: New Year's Day, Martin Luther King Jr. Day, Memorial Day, July 4th, Labor Day, Thanksgiving Day, Christmas Day (Special Schedule). *Please note: Holidays may be observed on another day.*

Disclaimer: SEPTA does not assume responsibility for inconvenience, experience or damage resulting from errors in timetables, delayed trains, failure to make connections or for shortage of equipment. Information is subject to change.

Severe Weather Schedule: During extreme weather conditions, trains may operate on a special schedule. Visit **www.septa.org/alerts** for more information.

Destination Codes

CHE	Chestnut Hill East	**LAN**	Lansdale
DOY	Doylestown	**MIQ**	Miquon
ELM	Elm Street	**NTC**	Norristown Transit Center
FOX	Fox Chase	**NSH**	Neshaminy Falls
GLN	Glenside	**WAR**	Warminster
JNK	Jenkintown-Wyncote	**WTR**	West Trenton

Safety Tips

- **Never** pass between cars when a train is moving
- **Never** attempt to board a moving train
- **Always** wait for the train to come to a complete stop **before** exiting
- **Never** ride in the vestibule or on the steps of a moving train
- **Never** lean against the train doors

For more information, visit **www.septa.org/safety**.

Trenton Line

To/From Center City Philadelphia

Effective September 2, 2025

SEPTA REGIONAL RAIL

- Trenton Transit Center
- Levittown
- Bristol
- Croydon
- Eddington
- Cornwells Heights
- Torresdale
- Holmesburg Junction
- Tacony
- Bridesburg
- North Philadelphia
- William H. Gray III 30th St Station
- Suburban Station
- Jefferson Station
- Temple University

Customer Service: **215-580-7800**
TDD/TTY: **215-580-7853**
www.septa.org

Penn Medicine
800.789.PENN PennMedicine.org

Station Locations & Connecting Services

Trenton Transit Center 83 S. Clinton Av	127 Amtrak, NJ Transit Northeast Corridor Line, River Line, NJ Transit Bus Routes
Levittown 8301 Bristol Pike • 215-946-4251	127, 128
Bristol 790 Washington St	129
Croydon 751 Bristol Pike	128
Eddington 1099 Street Rd	133
Cornwells Heights 799 Station Av	78, 133
Torresdale 9648 James St • 215-637-7575	19, 84
Holmesburg Junction 4783 Rhawn St • 215-331-9301	28, 84
Tacony 4938 Disston St	
Bridesburg 2202 Bridge St	73, 84
North Philadelphia 2900 N. Broad St	B 4, 16
William H. Gray III 30th St Station 30th St & Market St	L T 9, 30, 31, 44, 49, 62, 78, 124, 125, LUCY Amtrak, NJ Transit Atlantic City Line
Suburban Station 16th St & JFK Blvd	L B T 2, 4, 16, 17, 27, 31, 32, 33, 38, 44, 48, 62, 78, 124, 125
Jefferson Station Market St between 10th St & 12th St	L B3 17, 23, 33, 38, 44, 45, 47, 47M, 48, 61, 62, 78, NJ Transit Buses
Temple University 927 W. Berks St • 215-580-5440	

P – **Parking available**

$ – **Sales Office** (hours vary, visit **www.septa.org/stations** for details)

© **SEPTA** 09/25

Mondays through Fridays (Except Major Holidays)

NJ Transit Northeast Corridor

Stations	Train Number	–	–	3809	3813	–	3815	3817	3821	3825	3829	3833	3837	3841	3847	3849	3937	3855	3943	3953	3957	3873	3879	3883	3887	3979
		–	–	AM	AM	–	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
New York Penn Station ♿		–	–	4:41	5:14	–	6:06	6:38	7:14	8:12	9:19	10:01	11:09	12:01	1:32	2:07	3:01	3:30	4:13	5:38	6:03	6:17	7:20	8:07	9:06	10:11
Newark, NJ Penn Station ♿		–	–	4:58	5:31	–	6:23	6:56	7:31	8:30	9:37	10:20	11:27	12:19	1:50	2:25	3:16	3:49	4:33	5:58	6:20	6:37	7:38	8:26	9:24	10:30
Metropark ♿		–	–	5:24	6:00	–	6:48	7:24	8:00	8:59	10:02	10:45	11:54	12:46	2:17	2:51	–	4:06	–	–	–	**D7:00**	7:55	8:54	9:47	–
New Brunswick ♿		–	–	5:37	6:13	–	7:02	7:39	8:23	9:12	10:16	10:58	12:07	1:00	2:30	3:05	**D3:43**	4:20	**–**	**–**	–	**D7:15**	**D8:10**	9:08	10:00	–
Princeton Junction ♿		–	–	**5:52**	6:28	**–**	7:17	**D7:54**	**8:28**	**D9:28**	**D10:31**	**D11:13**	**D12:30**	**D1:17**	**D2:46**	**D3:22**	**D3:59**	**D4:37**	**D5:07**	**D6:31**	**D6:53**	**D7:32**	**D8:31**	**D9:26**	**D10:29**	**D11:06**
Trenton Transit Center ♿		–	–	6:11	6:46	–	7:35	8:13	8:46	9:46	10:49	11:26	12:44	1:35	3:09	3:43	4:19	4:54	5:26	6:49	7:14	7:51	8:46	9:44	10:46	11:25
		–	–	AM	AM	–	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM

TO CENTER CITY

Fare Zone	Stations	Train Number	700	702	7204	7206	9744	746	7504	706	708	710	712	714	716	718	720	9752	722	7572	726	9756	728	730	732	734	9736
			AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	AM
NJ	Trenton Transit Center ♿		5:00	5:46	6:25	7:01	7:26	7:46	8:21	8:59	9:59	10:59	11:51	12:59	1:51	3:14	4:05	4:46	5:05	5:56	6:59	7:30	8:00	9:03	10:05	10:59	12:02
4	Levittown ♿		5:08	5:54	6:33	7:09	7:34	7:54	8:29	9:07	10:07	11:07	11:59	1:07	1:59	3:22	4:13	4:53	5:13	6:04	7:07	7:40	8:08	9:11	10:13	11:07	12:10
4	Bristol		5:11	5:58	6:37	7:13	7:37	7:57	8:33	9:10	10:10	11:10	12:02	1:10	2:02	3:25	4:16	4:57	5:16	6:08	7:10	7:44	8:11	9:14	10:16	11:10	12:13
3	Croydon ♿		5:15	6:02	6:41	7:17	7:41	8:01	8:37	9:14	10:14	11:14	12:06	1:14	2:06	3:29	4:20	5:01	5:20	6:12	7:14	7:47	8:15	9:18	10:20	11:14	12:17
3	Eddington		**F5:17**	–	**F6:43**	–	–	**F8:03**	–	**F9:16**	–	**F11:16**	–	**F1:16**	–	**F3:31**	–	–	**F5:22**	**F6:14**	**F7:16**	–	–	**F9:20**	**F10:22**	**F11:16**	**F12:19**
3	Cornwells Heights ♿		5:19	6:06	6:45	7:21	7:45	8:05	8:41	9:18	10:18	11:18	12:10	1:18	2:10	3:33	4:24	5:05	5:24	6:16	7:18	7:51	8:19	9:22	10:24	11:18	12:21
3	Torresdale		5:22	6:10	6:48	7:25	7:49	8:09	8:45	9:21	10:21	11:21	12:13	1:21	2:13	3:36	4:27	5:08	5:27	6:19	7:21	7:55	8:22	9:25	10:27	11:21	12:24
2	Holmesburg Junction		5:26	6:14	6:52	7:30	7:53	8:13	8:49	9:25	10:25	11:25	12:17	1:25	2:17	3:40	4:31	5:12	5:31	6:23	7:25	7:58	8:26	9:29	10:31	11:25	12:28
2	Tacony		5:28	6:17	6:54	7:33	7:55	8:15	8:52	9:27	10:27	11:27	12:19	1:27	2:19	3:42	4:33	5:14	5:33	6:25	7:27	8:00	8:28	9:31	10:33	11:27	12:30
2	Bridesburg		5:31	6:20	6:57	7:36	7:58	8:18	8:55	9:30	10:30	11:30	12:22	1:30	2:22	3:45	4:36	5:16	5:36	6:28	7:30	8:03	8:31	9:34	10:36	11:30	12:33
1	North Philadelphia		**D5:38**	**D6:27**	**D7:04**	**D7:43**	**D8:05**	**D8:25**	**D9:02**	**D9:37**	**D10:37**	**D11:37**	**D12:29**	**D1:37**	**D2:29**	**D3:52**	**D4:43**	**D5:23**	**D5:43**	**D6:35**	**D7:37**	**D8:10**	**D8:38**	**D9:41**	**D10:43**	**D11:37**	**D12:40**
C	Gray 30th St Station ♿		5:48	6:39	7:17	7:54	**D8:20**	8:40	9:12	9:47	10:47	11:47	12:39	1:47	2:39	4:02	4:53	**D5:33**	5:53	6:45	7:47	**D8:20**	8:48	9:51	10:53	11:47	**D12:50**
C	Suburban Station ♿		5:53	6:44	7:22	7:59	**D8:25**	8:45	9:17	9:52	10:52	11:52	12:44	1:52	2:44	4:07	4:58	**D5:38**	5:58	6:50	7:52	**D8:25**	8:53	9:56	10:58	11:52	**D12:55**
C	Jefferson Station ♿		5:58	6:49	7:27	8:04	**D8:30**	8:50	9:22	9:57	10:57	11:57	12:49	1:57	2:49	4:12	5:03	**D5:43**	6:03	6:55	7:57	**D8:30**	8:58	10:01	11:03	11:57	**D1:00**
C	Temple University ♿		6:03	6:54	7:32	8:09	8:35	8:55	9:27	10:02	11:02	12:02	12:54	2:02	2:54	4:17	5:08	5:48	6:08	7:00	8:02	8:35	9:03	10:06	11:08	12:02	1:05
	(See Destination Codes)		AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	AM	AM
	Train continues to		**CHE**	**CHE**	**NTC**	**MIQ**	–	**CHE**	**DOY**	**CHE**	**CHE**	**CHE**	**CHE**	**CHE**	**CHE**	**CHE**	**CHE**	–	**CHE**	**LAN**	**CHE**	–	**CHE**	**CHE**	**CHE**	**CHE**	–

TO TRENTON

Fare Zone	Stations	Train Number	9701	9703	1701	9705	703	705	707	709	711	713	715	717	719	4753	9755	9757	9759	9761	725	727	729	731	733	735	737
			AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
C	Temple University ♿		3:50	4:30	–	5:49	6:29	7:29	8:29	9:29	10:24	11:29	12:24	1:29	2:29	3:09	3:34	4:04	4:33	5:04	5:35	6:29	7:29	8:29	9:29	10:29	11:29
C	Jefferson Station ♿		3:55	4:35	–	5:55	6:35	7:35	8:35	9:35	10:30	11:35	12:30	1:35	2:35	3:14	3:40	4:10	4:39	5:10	5:41	6:35	7:35	8:35	9:35	10:35	11:35
C	Suburban Station ♿		4:00	4:40	5:35	6:00	6:40	7:40	8:40	9:40	10:35	11:40	12:35	1:40	2:40	3:19	3:45	4:15	4:44	5:15	5:46	6:40	7:40	8:40	9:40	10:40	11:40
C	Gray 30th St Station ♿		4:05	4:45	5:40	6:05	6:45	7:45	8:45	9:45	10:40	11:45	12:40	1:45	2:45	3:24	3:50	4:20	4:49	5:20	5:51	6:45	7:45	8:45	9:45	10:45	11:45
1	North Philadelphia		4:14	4:54	5:50	6:15	6:55	7:55	8:55	9:55	10:50	11:55	12:50	1:55	2:55	3:34	4:00	4:30	–	5:29	6:01	6:55	7:55	8:55	9:55	10:55	11:55
2	Bridesburg		4:21	5:01	5:56	–	7:01	8:01	9:01	10:01	10:56	12:01	12:56	2:01	3:01	3:40	4:06	4:36	–	5:36	6:07	7:01	8:02	9:01	10:01	11:01	12:01
2	Tacony		4:24	5:04	5:59	–	7:04	8:04	9:04	10:04	10:59	12:04	12:59	2:04	3:04	3:43	4:09	4:39	–	5:39	6:10	7:04	8:05	9:04	10:04	11:04	12:04
2	Holmesburg Junction		4:26	5:06	6:01	–	7:06	8:06	9:06	10:06	11:01	12:06	1:01	2:06	3:06	3:45	4:11	4:42	**D5:06**	5:42	6:13	7:06	8:08	9:06	10:06	11:06	12:06
3	Torresdale		4:29	5:09	6:04	**D6:26**	7:10	8:10	9:10	10:10	11:05	12:10	1:05	2:10	3:10	3:49	4:14	4:46	**D5:10**	5:46	6:17	7:10	8:12	9:10	10:10	11:10	12:10
3	Cornwells Heights ♿		4:32	5:12	6:07	**D6:29**	7:12	8:12	9:12	10:12	11:07	12:12	1:07	2:12	3:12	3:51	4:16	4:49	**D5:13**	5:49	6:20	7:12	8:15	9:12	10:12	11:12	12:12
3	Eddington		–	**F5:14**	–	–	**F7:14**	**F8:14**	–	**F10:14**	–	**F12:14**	–	**F2:14**	–	**F3:53**	–	**F4:51**	–	–	**F6:22**	–	**F8:17**	**F9:14**	**F10:14**	**F11:14**	**F12:14**
3	Croydon ♿		**D4:36**	**D5:17**	**D6:12**	–	**D7:17**	**D8:17**	**D9:17**	**D10:17**	**D11:11**	**D12:17**	**D1:11**	**D2:17**	**D3:17**	**D3:56**	**D4:21**	**D4:54**	**D5:19**	**D5:55**	**D6:25**	**D7:17**	**D8:20**	**D9:17**	**D10:17**	**D11:17**	**D12:17**
3	Bristol		**D4:40**	**D5:21**	**D6:15**	–	**D7:21**	**D8:21**	**D9:21**	**D10:21**	**D11:16**	**D12:21**	**D1:16**	**D2:21**	**D3:21**	**D3:59**	**D4:25**	**D4:58**	**D5:22**	**D5:58**	**D6:29**	**D7:21**	**D8:24**	**D9:21**	**D10:21**	**D11:21**	**D12:21**
4	Levittown ♿		**D4:45**	**D5:26**	**D6:20**	**D6:40**	**D7:26**	**D8:26**	**D9:26**	**D10:26**	**D11:20**	**D12:26**	**D1:20**	**D2:26**	**D3:26**	**D4:04**	**D4:29**	**D5:02**	**D5:26**	**D6:02**	**D6:34**	**D7:26**	**D8:29**	**D9:26**	**D10:26**	**D11:26**	**D12:26**
4	Trenton Transit Center ♿		4:59	5:41	6:32	6:50	7:45	8:39	9:39	10:37	11:31	12:37	1:31	2:37	3:37	4:19	4:44	5:19	5:38	6:15	6:49	7:37	8:40	9:37	10:37	11:37	12:37
			AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	AM

NJ Transit Northeast Corridor

Stations	Train Number	3910	3914	*3920	3924	3930	3934	3834	3838	3842	3846	3850	3954	3860	3862	3864	3866	3868	3870	3874	3876	3882	3886	3888	3892	3800
		AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	AM	AM
Trenton Transit Center ♿		5:06	6:05	6:37	7:11	8:06	8:54	9:48	10:41	11:52	12:50	1:44	2:59	4:03	4:41	5:02	5:25	6:08	6:31	7:15	7:56	9:10	10:04	11:23	12:02	12:42
Princeton Junction ♿		5:20	6:19	6:51	7:26	8:20	9:08	10:01	10:54	12:05	1:03	1:57	3:12	4:16	4:54	5:15	5:38	6:21	6:44	7:28	8:09	9:23	10:17	11:36	12:15	12:55
New Brunswick ♿		–	–	–	–	–	9:22	10:15	11:09	12:19	1:18	2:11	3:26	4:31	5:10	5:29	5:52	6:35	6:59	7:48	8:24	9:37	10:31	11:51	12:29	1:09
Metropark ♿		–	–	–	–	–	–	10:29	11:24	12:33	1:32	2:25	–	4:45	5:25	5:44	6:06	6:49	–	8:03	8:38	9:51	10:45	12:05	12:43	1:22
Newark, NJ Penn Station ♿		5:54	6:52	7:26	8:02	8:56	9:53	10:53	11:55	1:01	1:59	2:54	3:55	5:14	5:49	6:14	6:36	7:17	7:27	8:31	9:08	10:21	11:15	12:35	1:11	1:49
New York Penn Station ♿		6:12	7:12	7:46	8:23	9:16	10:13	11:16	12:17	1:23	2:22	3:15	4:16	5:35	6:09	6:34	6:56	7:37	7:45	8:51	9:28	10:42	11:35	12:55	1:36	2:09
		AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	AM	AM	AM

♿ – **Accessible station**
D – Train stops to discharge or pick up passengers, but may depart ahead of schedule.
F – Train stops to discharge passengers on notice to conductor and pick up passengers standing on the platform in position visible to engineer.
NJ Transit Northeast Corridor times effective August 24, 2025. Information is subject to change.
* Train 3920 will not operate 12/26/25–1/2/26

Saturdays, Sundays and Major Holidays

NJ Transit Northeast Corridor

Stations	Train Number	–	7813	7817	7821	7825	7829	7833	7837	7841	7845	7849	7853	7857	7861	7865	7869	7873	7877	7883
		–	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
New York Penn Station ♿		–	5:10	6:13	7:14	8:14	9:14	10:16	11:14	12:14	1:14	2:14	3:15	4:14	5:14	6:16	7:14	8:14	9:14	10:57
Newark, NJ Penn Station ♿		–	5:28	6:31	7:32	8:32	9:32	10:34	11:32	12:32	1:32	2:32	3:33	4:32	5:32	6:34	7:32	8:32	9:32	11:12
Metropark ♿		–	5:55	6:57	7:58	8:58	9:59	11:01	11:59	1:03	2:02	2:59	4:01	4:59	5:59	7:00	7:59	8:59	10:02	11:32
New Brunswick ♿		–	6:09	7:11	8:12	9:12	10:12	11:15	12:13	1:16	2:15	3:13	4:15	5:13	6:13	7:14	8:13	9:13	10:16	11:46
Princeton Junction ♿		–	**D6:24**	**D7:26**	**D8:27**	**D9:27**	**D10:27**	**D11:30**	**D12:28**	**D1:31**	**D2:30**	**D3:28**	**D4:30**	**D5:28**	**D6:28**	**D7:29**	**D8:28**	**D9:28**	**D10:30**	**D12:02**
Trenton Transit Center ♿		–	6:41	7:45	8:42	9:47	10:44	11:49	12:48	1:46	2:47	3:46	4:48	5:46	6:46	7:47	8:46	9:46	10:48	12:18
		–	AM	AM	AM	AM	AM	AM	PM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	AM

TO CENTER CITY

Stations	Fare Zone	Train Number	9782	1706	1708	1710	1712	1714	1716	1718	1720	1722	1724	1726	1728	1730	1732	1734	9790	9792	9794
			AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	AM
Trenton Transit Center ♿	NJ		6:04	7:04	8:04	9:04	10:04	11:04	12:04	1:04	2:04	3:04	4:04	5:04	6:04	7:04	8:04	9:04	10:04	11:04	12:25
Levittown ♿	4		6:11	7:11	8:11	9:11	10:11	11:11	12:11	1:11	2:11	3:11	4:11	5:11	6:11	7:11	8:11	9:11	10:11	11:11	12:32
Bristol	4		6:15	7:15	8:15	9:15	10:15	11:15	12:15	1:15	2:15	3:15	4:15	5:15	6:15	7:15	8:15	9:15	10:15	11:15	12:36
Croydon ♿	3		6:18	7:18	8:18	9:18	10:18	11:18	12:18	1:18	2:18	3:18	4:18	5:18	6:18	7:18	8:18	9:18	10:18	11:18	12:39
Eddington	3		**F6:21**	**F7:21**	**F8:21**	**F9:21**	**F10:21**	**F11:21**	**F12:21**	**F1:21**	**F2:21**	**F3:21**	**F4:21**	**F5:21**	**F6:21**	**F7:21**	**F8:21**	**F9:21**	**F10:21**	**F11:21**	**F12:42**
Cornwells Heights ♿	3		6:23	7:23	8:23	9:23	10:23	11:23	12:23	1:23	2:23	3:23	4:23	5:23	6:23	7:23	8:23	9:23	10:23	11:23	12:44
Torresdale	3		6:26	7:26	8:26	9:26	10:26	11:26	12:26	1:26	2:26	3:26	4:26	5:26	6:26	7:26	8:26	9:26	10:26	11:26	12:47
Holmesburg Junction	2		6:30	7:30	8:30	9:30	10:30	11:30	12:30	1:30	2:30	3:30	4:30	5:30	6:30	7:30	8:30	9:30	10:30	11:30	12:51
Tacony	2		6:32	7:32	8:32	9:32	10:32	11:32	12:32	1:32	2:32	3:32	4:32	5:32	6:32	7:32	8:32	9:32	10:32	11:32	12:53
Bridesburg	2		6:35	7:35	8:35	9:35	10:35	11:35	12:35	1:35	2:35	3:35	4:35	5:35	6:35	7:35	8:35	9:35	10:35	11:35	12:56
North Philadelphia	1		**D6:42**	**D7:42**	**D8:42**	**D9:42**	**D10:42**	**D11:42**	**D12:42**	**D1:42**	**D2:42**	**D3:42**	**D4:42**	**D5:42**	**D6:42**	**D7:42**	**D8:42**	**D9:42**	**D10:42**	**D11:42**	**D1:03**
Gray 30th St Station ♿	C		**D6:52**	**D7:52**	**D8:52**	**D9:52**	**D10:52**	**D11:52**	**D12:52**	**D1:52**	**D2:52**	**D3:52**	**D4:52**	**D5:52**	**D6:52**	**D7:52**	**D8:52**	**D9:52**	**D10:52**	**D11:52**	**D1:13**
Suburban Station ♿	C		**D6:57**	**D7:57**	**D8:57**	**D9:57**	**D10:57**	**D11:57**	**D12:57**	**D1:57**	**D2:57**	**D3:57**	**D4:57**	**D5:57**	**D6:57**	**D7:57**	**D8:57**	**D9:57**	**D10:57**	**D11:57**	**D1:18**
Jefferson Station ♿	C		**D7:02**	8:02	9:02	10:02	11:02	12:02	1:02	2:02	3:02	4:02	5:02	6:02	7:02	8:02	9:02	10:02	**D11:02**	**D12:02**	**D1:23**
Temple University ♿	C		7:07	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	11:07	12:07	1:28
			AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	AM	AM

TO TRENTON

Stations	Fare Zone	Train Number	9781	9783	9785	1707	1709	1711	1713	1715	1717	1719	1721	1723	1725	1727	1729	1731	1733	1735	9797
			AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
Temple University ♿	C		5:24	6:24	7:24	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	11:24
Jefferson Station ♿	C		5:30	6:30	7:30	8:30	9:30	10:30	11:30	12:30	1:30	2:30	3:30	4:30	5:30	6:30	7:30	8:30	9:30	10:30	11:30
Suburban Station ♿	C		5:35	6:35	7:35	8:35	9:35	10:35	11:35	12:35	1:35	2:35	3:35	4:35	5:35	6:35	7:35	8:35	9:35	10:35	11:35
Gray 30th St Station ♿	C		5:40	6:40	7:40	8:40	9:40	10:40	11:40	12:40	1:40	2:40	3:40	4:40	5:40	6:40	7:40	8:40	9:40	10:40	11:40
North Philadelphia	1		5:49	6:49	7:49	8:49	9:49	10:49	11:49	12:49	1:49	2:49	3:49	4:49	5:49	6:49	7:49	8:49	9:49	10:49	11:49
Bridesburg	2		5:55	6:55	7:55	8:55	9:55	10:55	11:55	12:55	1:55	2:55	3:55	4:55	5:55	6:55	7:55	8:55	9:55	10:55	11:55
Tacony	2		5:58	6:58	7:58	8:58	9:58	10:58	11:58	12:58	1:58	2:58	3:58	4:58	5:58	6:58	7:58	8:58	9:58	10:58	11:58
Holmesburg Junction	2		6:00	7:00	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00
Torresdale	3		6:03	7:03	8:03	9:03	10:03	11:03	12:03	1:03	2:03	3:03	4:03	5:03	6:03	7:03	8:03	9:03	10:03	11:03	12:03
Cornwells Heights ♿	3		6:06	7:06	8:06	9:06	10:06	11:06	12:06	1:06	2:06	3:06	4:06	5:06	6:06	7:06	8:06	9:06	10:06	11:06	12:06
Eddington	3		**F6:08**	**F7:08**	**F8:08**	**F9:08**	**F10:08**	**F11:08**	**F12:08**	**F1:08**	**F2:08**	**F3:08**	**F4:08**	**F5:08**	**F6:08**	**F7:08**	**F8:08**	**F9:08**	**F10:08**	**F11:08**	**F12:08**
Croydon ♿	3		**D6:10**	**D7:10**	**D8:10**	**D9:10**	**D10:10**	**D11:10**	**D12:10**	**D1:10**	**D2:10**	**D3:10**	**D4:10**	**D5:10**	**D6:10**	**D7:10**	**D8:10**	**D9:10**	**D10:10**	**D11:10**	**D12:10**
Bristol	3		**D6:13**	**D7:13**	**D8:13**	**D9:13**	**D10:13**	**D11:13**	**D12:13**	**D1:13**	**D2:13**	**D3:13**	**D4:13**	**D5:13**	**D6:13**	**D7:13**	**D8:13**	**D9:13**	**D10:13**	**D11:13**	**D12:13**
Levittown ♿	4		**D6:18**	**D7:18**	**D8:18**	**D9:18**	**D10:18**	**D11:18**	**D12:18**	**D1:18**	**D2:18**	**D3:18**	**D4:18**	**D5:18**	**D6:18**	**D7:18**	**D8:18**	**D9:18**	**D10:18**	**D11:18**	**D12:18**
Trenton Transit Center ♿	4		6:32	7:32	8:32	9:32	10:32	11:32	12:32	1:32	2:32	3:32	4:32	5:32	6:32	7:32	8:32	9:32	10:32	11:32	12:32
			AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	AM

NJ Transit Northeast Corridor

Stations	Train Number	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	AM	AM
		6:58	7:58	9:02	10:00	10:58	12:02	12:57	1:58	2:58	4:02	5:00	6:00	7:09	8:01	9:09	9:58	10:57	12:02	12:42
Trenton Transit Center ♿		7:11	8:11	9:15	10:13	11:11	12:15	1:10	2:11	3:11	4:15	5:13	6:13	7:22	8:14	9:22	10:11	11:11	12:15	12:55
Princeton Junction ♿		7:27	8:27	9:31	10:29	11:27	12:31	1:26	2:27	3:27	4:31	5:29	6:29	7:39	8:30	9:39	10:27	11:27	12:29	1:09
New Brunswick ♿		7:41	8:41	9:45	10:43	11:41	12:45	1:40	2:41	3:41	4:45	5:43	6:43	7:54	8:44	9:54	10:41	11:41	12:43	1:22
Metropark ♿		8:10	9:10	10:14	11:12	12:12	1:14	2:10	3:12	4:10	5:15	6:12	7:12	8:22	9:15	10:22	10:22	12:12	1:11	1:49
Newark, NJ Penn Station ♿		8:32	9:32	10:36	11:34	12:36	1:36	2:33	3:34	4:33	5:36	6:33	7:33	8:42	9:38	10:42	10:42	12:32	1:36	2:09
New York Penn Station ♿		AM	AM	AM	AM	PM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	AM	AM	AM
		AM	AM	AM	AM	PM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	AM	AM	AM

♿ – **Accessible station**
D – Train stops to discharge or pick up passengers, but may depart ahead of schedule.
F – Train stops to discharge passengers on notice to conductor and pick up passengers standing on the platform in position visible to engineer.
NJ Transit Northeast Corridor times effective August 24, 2025. Information is subject to change.

Travel Tips

Schedule Times: Indicate when trains depart the station.

Fare Payment Options: Contactless, SEPTA Key, Quick Trip Ticket, or cash. Visit **www.septa.org/fares** for more information.

QuietRide Car: Available on all weekday trains (Monday–Friday 4:00 AM to 7:00 PM) with 3 or more cars open for passenger service. The first car will be designated as your QuietRide Car.

Regional Rail Major Holidays: New Year's Day, Martin Luther King Jr. Day, Memorial Day, July 4th, Labor Day, Thanksgiving Day, Christmas Day (Special Schedule). *Please note: Holidays may be observed on another day.*

Disclaimer: SEPTA does not assume responsibility for inconvenience, experience or damage resulting from errors in timetables, delayed trains, failure to make connections or for shortage of equipment. Information is subject to change.

Severe Weather Schedule: During extreme weather conditions, trains may operate on a special schedule. Visit **www.septa.org/alerts** for more information.

Destination Codes

CHE	Chestnut Hill East	**LAN**	Lansdale
DOY	Doylestown	**MIQ**	Miquon
ELM	Elm Street	**NTC**	Norristown Transit Center
FOX	Fox Chase	**NSH**	Neshaminy Falls
GLN	Glenside	**WAR**	Warminster
JNK	Jenkintown-Wyncote	**WTR**	West Trenton

Safety Tips

- **Never** pass between cars when a train is moving
- **Never** attempt to board a moving train
- **Always** wait for the train to come to a complete stop **before** exiting
- **Never** ride in the vestibule or on the steps of a moving train
- **Never** lean against the train doors

For more information, visit **www.septa.org/safety**.

TRANSIT

For complete train and bus service details at Trenton Transit Center, consult the NJ Transit timetables or **www.njtransit.com**. Information is subject to change.

Warminster Line

To/From Center City Philadelphia

Effective September 2, 2025

SEPTA REGIONAL RAIL

- Warminster
- Hatboro
- Willow Grove
- Crestmont
- Roslyn
- Ardsley
- Glenside
- Jenkintown-Wyncote
- Elkins Park
- Melrose Park
- Fern Rock Transit Center
- Wayne Junction
- Temple University
- Jefferson Station
- Suburban Station
- William H. Gray III 30th St Station
- Penn Medicine Station

Customer Service: **215-580-7800**
TDD/TTY: **215-580-7853**
www.septa.org

Penn Medicine
800.789.PENN PennMedicine.org

Station Locations & Connecting Services

Warminster 100 Station Dr • 215-580-6839	$ P 22
Hatboro 40 S. Penn St	P
Willow Grove 215 Davisville Rd	P 22, 55
Crestmont 2198 Rubicam Av	P
Roslyn 1095 Easton Rd	P 22
Ardsley 2620 Jenkintown Rd	P
Glenside 49 W. Glenside Av	P 22, 77
Jenkintown-Wyncote 2 Greenwood Av • 215-580-6838	$ P 77
Elkins Park 7876 Spring Av	P 28
Melrose Park 900 Valley Rd	P
Fern Rock Transit Center 900 Nedro Av	P B 4, 28, 57, 70
Wayne Junction 2129 Windrim Av • 215-580-6892	$ 2, 23, 53, 75
Temple University 927 W. Berks St • 215-580-5440	$
Jefferson Station Market St between 10th St & 12th St	$ L B3 17, 23, 33, 38, 44, 45, 47, 47M, 48, 61, 62, 78, NJ Transit Buses
Suburban Station 16th St & JFK Blvd	$ L B T 2, 4, 16, 17, 27, 31, 32, 33, 38, 44, 48, 62, 78, 124, 125
William H. Gray III 30th St Station 30th St & Market St	$ L T 9, 30, 31, 44, 49, 62, 78, 124, 125, LUCY Amtrak, NJ Transit Atlantic City Line
Penn Medicine Station 3149 Convention Blvd • 215-580-6565	$ 40, LUCY

P – **Parking available**

$ – **Sales Office** (hours vary, visit **www.septa.org/stations** for details)

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Mondays through Fridays (Except Major Holidays)

TO CENTER CITY

Fare Zone	Train Number	401	403	405	407	409	4511	413	6495	417	4307	421	6477	425	429	433	437	441	4753	445	449	4539	453	4571	457	461	465	469	473	477
	Stations	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
3	**Warminster** ♿	–	–	–	4:56	5:26	5:51	6:26	7:01	7:26	8:01	8:26	–	9:26	10:26	11:26	12:26	1:26	–	2:26	3:26	–	4:26	5:21	–	6:26	7:26	8:26	9:26	10:26
3	**Hatboro**	–	–	–	5:01	5:31	5:56	6:31	7:08	7:31	8:07	8:31	–	9:31	10:31	11:31	12:31	1:31	–	2:31	3:31	–	4:31	5:26	–	6:31	7:31	8:31	9:31	10:31
3	**Willow Grove**	–	–	–	5:06	5:36	6:01	6:36	7:13	7:36	8:12	8:36	–	9:36	10:36	11:36	12:36	1:36	–	2:36	3:36	–	4:36	5:31	–	6:36	7:36	8:36	9:36	10:36
3	**Crestmont** ♿	–	–	–	5:09	5:39	6:04	6:39	7:17	7:39	8:15	8:39	–	9:39	10:39	11:39	12:39	1:39	–	2:39	3:39	–	4:39	5:34	–	6:39	7:39	8:39	9:39	10:39
3	**Roslyn** ♿	–	–	–	5:12	5:42	6:07	6:42	7:20	7:42	8:17	8:42	–	9:42	10:42	11:42	12:42	1:42	–	2:42	3:42	–	4:42	5:37	–	6:42	7:42	8:42	9:42	10:42
3	**Ardsley** ♿	–	–	–	5:17	5:47	6:12	6:47	7:22	7:47	8:19	8:47	–	9:47	10:47	11:47	12:47	1:47	–	2:47	3:47	–	4:47	5:42	–	6:47	7:47	8:47	9:47	10:47
3	**Glenside**	–	4:22	4:52	5:22	5:52	6:17	6:52	7:25	7:52	8:25	8:52	9:30	9:52	10:52	11:52	12:52	1:52	2:48	2:52	3:52	4:39	4:52	5:47	5:52	6:52	7:52	8:52	9:52	10:52
3	**Jenkintown-Wyncote**	–	4:25	4:55	5:25	5:55	6:20	6:55	7:29	7:55	8:29	8:55	9:33	9:55	10:55	11:55	12:55	1:55	2:51	2:55	3:55	4:42	4:55	5:50	5:55	6:55	7:55	8:55	9:55	10:55
2	**Elkins Park**	–	4:27	4:57	5:27	5:57	6:22	6:57	7:32	7:57	8:32	8:57	9:35	9:57	10:57	11:57	12:57	1:57	2:53	2:57	3:57	4:45	4:57	–	5:57	6:57	7:57	8:57	9:57	10:57
2	**Melrose Park** ♿	–	4:29	4:59	5:29	5:59	6:24	6:59	7:34	7:59	8:34	8:59	9:37	9:59	10:59	11:59	12:59	1:59	2:55	2:59	3:59	4:47	4:59	–	5:59	6:59	7:59	8:59	9:59	10:59
1	**Fern Rock Transit Center** ♿	4:03	4:33	5:03	5:33	6:03	6:28	7:03	7:38	8:03	8:37	9:03	9:41	10:03	11:03	12:03	1:03	2:03	2:59	3:03	4:03	4:50	5:03	–	6:03	7:03	8:03	9:03	10:03	11:03
1	**Wayne Junction** ♿	4:07	4:37	5:07	5:37	6:07	6:32	7:07	7:42	8:07	8:41	9:07	9:45	10:07	11:07	12:07	1:07	2:07	–	3:07	4:07	–	5:07	–	6:07	7:07	8:07	9:07	10:07	11:07
C	**Temple University** ♿	4:13	4:43	5:13	5:43	6:13	**D6:38**	7:13	**D7:49**	8:13	8:48	9:13	**D9:51**	10:13	11:13	12:13	1:13	2:13	3:09	3:13	4:13	5:00	5:13	6:09	6:13	7:13	8:13	9:13	10:13	11:13
C	**Jefferson Station** ♿	4:20	4:50	5:20	5:50	6:20	**D6:45**	7:20	**D7:56**	8:20	8:54	9:20	**D9:58**	10:20	11:20	12:20	1:20	2:20	3:14	3:20	4:20	5:06	5:20	6:15	6:20	7:20	8:20	9:20	10:20	11:20
C	**Suburban Station** ♿	4:25	4:55	5:25	5:55	6:25	**D6:50**	7:25	**D8:01**	8:25	8:59	9:25	**D10:03**	10:25	11:25	12:25	1:25	2:25	3:19	3:25	4:25	5:11	5:25	6:20	6:25	7:25	8:25	9:25	10:25	11:25
C	**Gray 30th St Station** ♿	4:29	4:59	5:29	5:59	6:29	6:55	7:29	8:05	8:29	9:03	9:29	10:07	10:29	11:29	12:29	1:29	2:29	3:24	3:29	4:29	5:16	5:29	6:25	6:29	7:29	8:29	9:29	10:29	11:29
C	**Penn Medicine Station** ♿	4:32	5:02	5:32	6:02	6:32	–	7:32	–	8:32	9:06	9:32	–	10:32	11:32	12:32	1:32	2:32	–	3:32	4:32	–	5:32	–	6:32	7:32	8:32	9:32	10:32	11:32
	(See Destination Codes)	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
	Train continues to	**AIR**	**AIR**	**AIR**	**AIR**	**AIR**	–	**AIR**	–	**AIR**	**WAW**	**AIR**	–	**AIR**	**AIR**	**AIR**	**AIR**	**AIR**	**TRE**	**AIR**	**AIR**	**WAY**	**AIR**	**THO**	**AIR**	**AIR**	**AIR**	**AIR**	**AIR**	**AIR**

TO GLENSIDE & WARMINSTER

Fare Zone	Train Number	404	408	412	3476	416	420	424	428	432	6478	436	440	6432	444	6480	5438	448	5440	452	456	460	464	468	472
	Stations	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
C	**Penn Medicine Station** ♿	5:57	6:57	7:57	8:32	8:57	9:57	10:57	11:57	12:57	–	1:57	2:57	–	3:57	–	–	4:57	–	5:57	6:57	7:57	8:57	9:57	10:57
C	**Gray 30th St Station** ♿	6:00	7:00	8:00	8:35	9:00	10:00	11:00	12:00	1:00	1:39	2:00	3:00	3:37	4:00	4:21	4:48	5:00	5:26	6:00	7:00	8:00	9:00	10:00	11:00
C	**Suburban Station** ♿	6:05	7:05	8:05	8:40	9:05	10:05	11:05	12:05	1:05	1:44	2:05	3:05	3:42	4:05	4:26	4:53	5:05	5:31	6:05	7:05	8:05	9:05	10:05	11:05
C	**Jefferson Station** ♿	6:10	7:10	8:10	8:45	9:10	10:10	11:10	12:10	1:10	1:49	2:10	3:10	3:47	4:10	4:31	4:58	5:10	5:36	6:10	7:10	8:10	9:10	10:10	11:10
C	**Temple University** ♿	6:15	7:15	8:15	8:49	9:15	10:15	11:15	12:15	1:15	1:53	2:15	3:15	3:51	4:15	4:36	5:02	5:15	5:40	6:15	7:15	8:15	9:15	10:15	11:15
1	**Wayne Junction** ♿	6:21	7:21	8:21	8:55	9:21	10:21	11:21	12:21	1:21	1:59	2:21	3:21	3:57	4:21	–	5:08	5:21	5:45	6:21	7:21	8:21	9:21	10:21	11:21
1	**Fern Rock Transit Center** ♿	6:25	7:25	8:25	8:58	9:25	10:25	11:25	12:25	1:25	2:03	2:25	3:25	4:01	4:25	**D4:45**	5:12	5:25	5:50	6:25	7:25	8:25	9:25	10:25	11:25
2	**Melrose Park** ♿	6:27	7:27	8:27	9:00	9:27	10:27	11:27	12:27	1:27	2:05	2:27	3:27	4:03	4:27	–	5:14	5:27	5:52	6:27	7:27	8:27	9:27	10:27	11:27
2	**Elkins Park**	6:29	7:29	8:29	9:02	9:29	10:29	11:29	12:29	1:29	2:07	2:29	3:29	4:05	4:29	–	5:16	5:29	5:54	6:29	7:29	8:29	9:29	10:29	11:29
3	**Jenkintown-Wyncote**	6:34	7:34	8:34	9:06	9:34	10:34	11:34	12:34	1:34	2:12	2:34	3:34	4:09	4:34	**D4:54**	5:20	5:34	5:59	6:34	7:34	8:34	9:34	10:34	11:34
3	**Glenside**	**D6:38**	**D7:38**	**D8:38**	9:11	**D9:38**	**D10:38**	**D11:38**	**D12:38**	**D1:38**	2:16	**D2:38**	**D3:38**	4:13	**D4:38**	**D4:58**	5:23	**D5:38**	**D6:03**	**D6:38**	**D7:38**	**D8:38**	**D9:38**	**D10:38**	**D11:38**
3	**Ardsley** ♿	**D6:42**	**D7:42**	**D8:42**	–	**D9:42**	**D10:42**	**D11:42**	**D12:42**	**D1:42**	–	**D2:42**	**D3:42**	–	**D4:42**	**D5:02**	–	**D5:42**	**D6:07**	**D6:42**	**D7:42**	**D8:42**	**D9:42**	**D10:42**	**D11:42**
3	**Roslyn** ♿	**D6:48**	**D7:46**	**D8:46**	–	**D9:46**	**D10:46**	**D11:46**	**D12:46**	**D1:46**	–	**D2:46**	**D3:46**	–	**D4:46**	**D5:06**	–	**D5:46**	**D6:11**	**D6:46**	**D7:46**	**D8:46**	**D9:46**	**D10:46**	**D11:46**
3	**Crestmont** ♿	**D6:51**	**D7:49**	**D8:49**	–	**D9:49**	**D10:49**	**D11:49**	**D12:49**	**D1:49**	–	**D2:49**	**D3:49**	–	**D4:49**	**D5:09**	–	**D5:49**	**D6:14**	**D6:49**	**D7:49**	**D8:49**	**D9:49**	**D10:49**	**D11:49**
3	**Willow Grove**	**D6:54**	**D7:52**	**D8:52**	–	**D9:52**	**D10:52**	**D11:52**	**D12:52**	**D1:52**	–	**D2:52**	**D3:52**	–	**D4:52**	**D5:12**	–	**D5:52**	**D6:17**	**D6:52**	**D7:52**	**D8:52**	**D9:52**	**D10:52**	**D11:52**
3	**Hatboro**	**D6:58**	**D7:56**	**D8:56**	–	**D9:56**	**D10:56**	**D11:56**	**D12:56**	**D1:56**	–	**D2:56**	**D3:56**	–	**D4:56**	**D5:16**	–	**D6:00**	**D6:21**	**D6:56**	**D7:56**	**D8:56**	**D9:56**	**D10:56**	**D11:56**
3	**Warminster** ♿	7:03	8:03	9:03	–	10:03	11:03	12:03	1:03	2:03	–	3:03	4:03	–	5:03	5:23	–	6:08	6:27	7:03	8:03	9:03	10:03	11:03	12:03
		AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	AM

♿ – **Accessible station**

D – Train stops to discharge or pick up passengers, but may depart ahead of schedule.

Saturdays, Sundays and Major Holidays

TO CENTER CITY

Fare Zone	Stations / Train Number	4401	4403	4405	4407	4411	4415	4419	4423	4427	4431	4435	4439	4443	4447	4451	4455	4459	4463	4467	4471	4475	4479
		AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
3	Warminster ♿	–	–	–	4:56	–	6:56	7:56	8:56	9:56	10:56	11:56	12:56	1:56	2:56	3:56	4:56	5:56	6:56	7:56	8:56	9:56	10:56
3	Hatboro	–	–	–	5:01	–	7:01	8:01	9:01	10:01	11:01	12:01	1:01	2:01	3:01	4:01	5:01	6:01	7:01	8:01	9:01	10:01	11:01
3	Willow Grove	–	–	–	5:06	–	7:06	8:06	9:06	10:06	11:06	12:06	1:06	2:06	3:06	4:06	5:06	6:06	7:06	8:06	9:06	10:06	11:06
3	Crestmont ♿	–	–	–	5:09	–	7:09	8:09	9:09	10:09	11:09	12:09	1:09	2:09	3:09	4:09	5:09	6:09	7:09	8:09	9:09	10:09	11:09
3	Roslyn ♿	–	–	–	5:12	–	7:12	8:12	9:12	10:12	11:12	12:12	1:12	2:12	3:12	4:12	5:12	6:12	7:12	8:12	9:12	10:12	11:12
3	Ardsley ♿	–	–	–	5:15	–	7:15	8:15	9:15	10:15	11:15	12:15	1:15	2:15	3:15	4:15	5:15	6:15	7:15	8:15	9:15	10:15	11:15
3	Glenside	–	4:22	4:52	5:22	6:22	7:22	8:22	9:22	10:22	11:22	12:22	1:22	2:22	3:22	4:22	5:22	6:22	7:22	8:22	9:22	10:22	11:22
3	Jenkintown-Wyncote	–	4:25	4:55	5:25	6:25	7:25	8:25	9:25	10:25	11:25	12:25	1:25	2:25	3:25	4:25	5:25	6:25	7:25	8:25	9:25	10:25	11:25
2	Elkins Park	–	4:27	4:57	5:27	6:27	7:27	8:27	9:27	10:27	11:27	12:27	1:27	2:27	3:27	4:27	5:27	6:27	7:27	8:27	9:27	10:27	11:27
2	Melrose Park ♿	–	4:29	4:59	5:29	6:29	7:29	8:29	9:29	10:29	11:29	12:29	1:29	2:29	3:29	4:29	5:29	6:29	7:29	8:29	9:29	10:29	11:29
1	Fern Rock Transit Center ♿	4:03	4:33	5:03	5:33	6:33	7:33	8:33	9:33	10:33	11:33	12:33	1:33	2:33	3:33	4:33	5:33	6:33	7:33	8:33	9:33	10:33	11:33
1	Wayne Junction ♿	4:07	4:37	5:07	5:37	6:37	7:37	8:37	9:37	10:37	11:37	12:37	1:37	2:37	3:37	4:37	5:37	6:37	7:37	8:37	9:37	10:37	11:37
C	Temple University ♿	4:14	4:44	5:14	5:44	6:44	7:44	8:44	9:44	10:44	11:44	12:44	1:44	2:44	3:44	4:44	5:44	6:44	7:44	8:44	9:44	10:44	11:44
C	Jefferson Station ♿	4:20	4:50	5:20	5:50	6:50	7:50	8:50	9:50	10:50	11:50	12:50	1:50	2:50	3:50	4:50	5:50	6:50	7:50	8:50	9:50	10:50	**D11:50**
C	Suburban Station ♿	4:25	4:55	5:25	5:55	6:55	7:55	8:55	9:55	10:55	11:55	12:55	1:55	2:55	3:55	4:55	5:55	6:55	7:55	8:55	9:55	10:55	**D11:55**
C	Gray 30th St Station ♿	4:30	5:00	5:30	6:00	7:00	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00
C	Penn Medicine Station ♿	4:33	5:03	5:33	6:03	7:03	8:03	9:03	10:03	11:03	12:03	1:03	2:03	3:03	4:03	5:03	6:03	7:03	8:03	9:03	10:03	11:03	–
	(See Destination Codes)	AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	AM
	Train continues to	**AIR**	**AIR**	**AIR**	**AIR**	**AIR**	**AIR**	**AIR**	**AIR**	**AIR**	**AIR**	**AIR**	**AIR**	**AIR**	**AIR**	**AIR**	**AIR**	**AIR**	**AIR**	**AIR**	**AIR**	**AIR**	–

TO GLENSIDE & WARMINSTER

Fare Zone	Stations / Train Number	4402	4406	4410	4414	4418	4422	4426	4430	4434	4438	4442	4446	4450	4454	4458	4462	4466	4470	4474	4478
		AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	AM
C	Penn Medicine Station ♿	5:27	6:27	7:27	8:27	9:27	10:27	11:27	12:27	1:27	2:27	3:27	4:27	5:27	6:27	7:27	8:27	9:27	10:27	11:27	12:27
C	Gray 30th St Station ♿	5:30	6:30	7:30	8:30	9:30	10:30	11:30	12:30	1:30	2:30	3:30	4:30	5:30	6:30	7:30	8:30	9:30	10:30	11:30	12:30
C	Suburban Station ♿	5:35	6:35	7:35	8:35	9:35	10:35	11:35	12:35	1:35	2:35	3:35	4:35	5:35	6:35	7:35	8:35	9:35	10:35	11:35	12:35
C	Jefferson Station ♿	5:40	6:40	7:40	8:40	9:40	10:40	11:40	12:40	1:40	2:40	3:40	4:40	5:40	6:40	7:40	8:40	9:40	10:40	11:40	12:40
C	Temple University ♿	5:45	6:45	7:45	8:45	9:45	10:45	11:45	12:45	1:45	2:45	3:45	4:45	5:45	6:45	7:45	8:45	9:45	10:45	11:45	12:45
1	Wayne Junction ♿	5:51	6:51	7:51	8:51	9:51	10:51	11:51	12:51	1:51	2:51	3:51	4:51	5:51	6:51	7:51	8:51	9:51	10:51	11:51	12:51
1	Fern Rock Transit Center ♿	5:55	6:55	7:55	8:55	9:55	10:55	11:55	12:55	1:55	2:55	3:55	4:55	5:55	6:55	7:55	8:55	9:55	10:55	11:55	12:55
2	Melrose Park ♿	5:57	6:57	7:57	8:57	9:57	10:57	11:57	12:57	1:57	2:57	3:57	4:57	5:57	6:57	7:57	8:57	9:57	10:57	11:57	12:57
2	Elkins Park	5:59	6:59	7:59	8:59	9:59	10:59	11:59	12:59	1:59	2:59	3:59	4:59	5:59	6:59	7:59	8:59	9:59	10:59	11:59	12:59
3	Jenkintown-Wyncote	6:04	7:04	8:04	9:04	10:04	11:04	12:04	1:04	2:04	3:04	4:04	5:04	6:04	7:04	8:04	9:04	10:04	11:04	12:04	1:04
3	Glenside	**D6:08**	**D7:08**	**D8:08**	**D9:08**	**D10:08**	**D11:08**	**D12:08**	**D1:08**	**D2:08**	**D3:08**	**D4:08**	**D5:08**	**D6:08**	**D7:08**	**D8:08**	**D9:08**	**D10:08**	11:08	**D12:08**	1:08
3	Ardsley ♿	**D6:12**	**D7:12**	**D8:12**	**D9:12**	**D10:12**	**D11:12**	**D12:12**	**D1:12**	**D2:12**	**D3:12**	**D4:12**	**D5:12**	**D6:12**	**D7:12**	**D8:12**	**D9:12**	**D10:12**	–	**D12:12**	–
3	Roslyn ♿	**D6:16**	**D7:16**	**D8:16**	**D9:16**	**D10:16**	**D11:16**	**D12:16**	**D1:16**	**D2:16**	**D3:16**	**D4:16**	**D5:16**	**D6:16**	**D7:16**	**D8:16**	**D9:16**	**D10:16**	–	**D12:16**	–
3	Crestmont ♿	**D6:19**	**D7:19**	**D8:19**	**D9:19**	**D10:19**	**D11:19**	**D12:19**	**D1:19**	**D2:19**	**D3:19**	**D4:19**	**D5:19**	**D6:19**	**D7:19**	**D8:19**	**D9:19**	**D10:19**	–	**D12:19**	–
3	Willow Grove	**D6:22**	**D7:22**	**D8:22**	**D9:22**	**D10:22**	**D11:22**	**D12:22**	**D1:22**	**D2:22**	**D3:22**	**D4:22**	**D5:22**	**D6:22**	**D7:22**	**D8:22**	**D9:22**	**D10:22**	–	**D12:22**	–
3	Hatboro	**D6:26**	**D7:26**	**D8:26**	**D9:26**	**D10:26**	**D11:26**	**D12:26**	**D1:26**	**D2:26**	**D3:26**	**D4:26**	**D5:26**	**D6:26**	**D7:26**	**D8:26**	**D9:26**	**D10:26**	–	**D12:26**	–
3	Warminster ♿	6:30	7:30	8:30	9:30	10:30	11:30	12:30	1:30	2:30	3:30	4:30	5:30	6:30	7:30	8:30	9:30	10:30	–	12:30	–
		AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	AM	AM

♿ – **Accessible station**
D – Train stops to discharge or pick up passengers, but may depart ahead of schedule.

Travel Tips

Schedule Times: Indicate when trains depart the station.

Fare Payment Options: Contactless, SEPTA Key, Quick Trip Ticket, or cash. Visit **www.septa.org/fares** for more information.

QuietRide Car: Available on all weekday trains (Monday–Friday 4:00 AM to 7:00 PM) with 3 or more cars open for passenger service. The first car will be designated as your QuietRide Car.

Regional Rail Major Holidays: New Year's Day, Martin Luther King Jr. Day, Memorial Day, July 4th, Labor Day, Thanksgiving Day, Christmas Day (Special Schedule). *Please note: Holidays may be observed on another day.*

Disclaimer: SEPTA does not assume responsibility for inconvenience, experience or damage resulting from errors in timetables, delayed trains, failure to make connections or for shortage of equipment. Information is subject to change.

Severe Weather Schedule: During extreme weather conditions, trains may operate on a special schedule. Visit **www.septa.org/alerts** for more information.

Destination Codes

AIR	Airport	**MHK**	Marcus Hook
BMR	Bryn Mawr	**NWK**	Newark, DE
CHW	Chestnut Hill West	**THO**	Thorndale
CYN	Cynwyd	**TRE**	Trenton Transit Center
ELW	Elwyn	**WAW**	Wawa
MAL	Malvern	**WAY**	Wayne
MED	Media	**WIL**	Wilmington

Safety Tips

- **Never** pass between cars when a train is moving
- **Never** attempt to board a moving train
- **Always** wait for the train to come to a complete stop **before** exiting
- **Never** ride in the vestibule or on the steps of a moving train
- **Never** lean against the train doors

For more information, visit **www.septa.org/safety**.

Revised August 11, 2025

Wilmington/ Newark Line

To/From Center City Philadelphia

Effective September 2, 2025

SEPTA REGIONAL RAIL

- Newark
- Churchman's Crossing
- Wilmington
- Claymont
- Marcus Hook
- Highland Av
- Chester Transit Center
- Eddystone
- Crum Lynne
- Ridley Park
- Prospect Park
- Norwood
- Glenolden
- Folcroft
- Sharon Hill
- Curtis Park
- Darby
- Penn Medicine Station
- William H. Gray III 30th St Station
- Suburban Station
- Jefferson Station
- Temple University

Customer Service: **215-580-7800**
TDD/TTY: **215-580-7853**
www.septa.org

Penn Medicine
800.789.PENN PennMedicine.org

Station Locations & Connecting Services

Newark 100 Station Way • 1-800-652-DART	DART First State Rts. 10, 33, 46 Cecil Transit Rt. 4 DART Connect-Newark
Churchman's Crossing 1 Fairplay Blvd • 1-800-652-DART	DART First State Rts. 54, 64
Wilmington 100 S. French St • 1-800-652-DART	DART First State Rts. 2, 5, 6, 10, 11, 13, 14, 18, 20, 28, 33, 35, 40, 301 Amtrak
Claymont 191 Transit Center Dr • 1-800-652-DART	113 DART First State Rts. 13, 61
Marcus Hook 20 W. 12th St • 610-485-3294	119
Highland Av 450 Highland Av	113
Chester Transit Center 595 Avenue of the States • 610-876-4144	37, 109, 113, 114, 117, 118, 119
Eddystone 650 Saville Av	37
Crum Lynne 350 W. Ridley Av	114
Ridley Park 201 E. Hinckley Av • 610-521-1242	
Prospect Park 749 Maryland Av • 610-532-0540	
Norwood 498 Welcome Av • 610-532-1414	
Glenolden 85 E. Glenolden Av • 610-583-5794	
Folcroft 1555 Baltimore Av • 610-583-5750	115
Sharon Hill 414 Sharon Av	115
Curtis Park 400 Oak Av	115
Darby 399 S. 4th St	
Penn Medicine Station 3149 Convention Blvd • 215-580-6565	40, LUCY
William H. Gray III 30th St Station 30th St & Market St	L T 9, 30, 31, 44, 49, 62, 78, 124, 125, LUCY Amtrak, NJ Transit Atlantic City Line
Suburban Station 16th St & JFK Blvd	L B T 2, 4, 16, 17, 27, 31, 32, 33, 38, 44, 48, 62, 78, 124, 125
Jefferson Station Market St between 10th St & 12th St	L B3 17, 23, 33, 38, 44, 45, 47, 47M, 48, 61, 62, 78, NJ Transit Buses
Temple University 927 W. Berks St • 215-580-5440	

P – **Parking available**

$ – **Sales Office** (hours vary, visit **www.septa.org/stations** for details)

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Mondays through Fridays (Except Major Holidays)

TO CENTER CITY

Fare Zone	Train Number / Stations	206	2500	9204	9202	9206	9208	9212	9214	2514	9216	2518	220	2522	2336	2524	1226	2528	9250	2530	9230	9232
		AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
4	Newark ♿	–	5:52	6:42	–	7:56	9:12	–	–	–	–	–	–	3:59	–	5:05	6:18	–	7:40	8:05	–	–
4	Churchman's Crossing ♿	–	5:58	6:48	–	8:02	9:19	–	–	–	–	–	–	4:05	–	5:11	6:24	–	7:46	8:11	–	–
4	Wilmington ♿	5:21	6:08	6:58	–	8:12	9:29	10:04	–	12:12	–	2:20	3:25	4:12	–	5:19	6:32	7:20	7:54	8:18	9:23	–
4	Claymont ♿	5:30	6:18	7:09	–	8:22	9:38	10:13	–	12:21	–	2:29	3:34	4:22	–	5:28	6:41	7:29	8:05	8:27	9:32	–
3	Marcus Hook	5:34	6:23	7:14	7:39	8:27	9:43	10:17	11:18	12:25	1:24	2:33	3:38	4:26	5:05	5:32	6:45	7:33	8:08	8:29	9:36	10:25
3	Highland Av	5:38	6:27	7:17	7:42	8:31	9:50	10:21	11:22	12:29	1:28	2:37	3:43	4:31	5:10	5:36	6:49	7:37	8:10	8:33	9:40	10:29
3	Chester Transit Center ♿	5:41	6:30	7:21	7:44	8:34	9:53	10:24	11:25	12:32	1:31	2:40	3:46	4:35	5:13	5:39	6:52	7:40	–	8:36	9:43	10:32
3	Eddystone	5:43	6:32	–	7:47	–	9:55	–	11:27	12:34	1:33	–	3:48	–	–	5:41	–	7:42	–	–	9:45	10:34
3	Crum Lynne	5:45	6:34	–	7:49	8:37	9:57	10:27	11:29	12:36	1:35	2:43	3:50	4:40	5:16	5:43	6:55	7:44	–	8:39	9:47	10:36
3	Ridley Park	5:46	6:36	7:26	7:51	8:39	9:58	10:29	11:31	12:37	1:37	2:45	3:52	4:43	5:20	5:44	6:57	7:45	8:17	8:41	9:48	10:37
2	Prospect Park	5:48	6:38	7:29	7:53	8:41	10:00	10:31	11:33	12:39	1:39	2:47	3:54	4:45	5:22	5:46	6:59	7:47	8:18	8:43	9:50	10:39
2	Norwood	5:50	6:40	7:32	7:55	8:43	10:02	10:33	11:35	12:41	1:41	2:49	3:56	4:47	5:24	5:48	7:01	7:49	8:20	8:44	9:52	10:41
2	Glenolden	5:52	6:42	–	7:57	8:45	10:04	10:35	11:37	12:43	1:43	2:51	3:58	4:49	5:26	5:50	7:03	7:51	–	8:46	9:54	10:43
2	Folcroft	5:54	6:44	–	7:59	8:47	10:06	10:37	11:39	12:45	1:45	2:53	4:00	4:51	5:28	5:52	7:05	7:53	–	8:47	9:56	10:45
2	Sharon Hill	5:56	6:46	–	8:01	8:49	10:08	10:39	11:41	12:47	1:47	2:55	4:02	4:53	5:30	5:54	7:07	7:55	–	8:49	9:58	10:47
2	Curtis Park	5:58	6:48	–	8:03	8:51	10:10	10:41	11:43	12:49	1:49	2:57	4:04	4:55	5:32	5:56	7:09	7:57	–	8:50	10:00	10:49
2	Darby	5:59	6:50	–	8:05	8:53	10:12	10:43	11:45	12:51	1:51	2:59	4:06	4:57	5:34	5:58	7:11	7:59	–	8:52	10:02	10:51
C	Penn Medicine Station ♿	6:09	7:01	**D7:45**	**D8:14**	**D9:04**	**D10:22**	**D10:53**	**D11:54**	1:01	**D2:00**	3:09	4:17	5:09	5:44	6:08	**D7:22**	8:09	**D8:40**	9:01	**D10:12**	**D11:02**
C	Gray 30th St Station ♿	6:12	7:04	**D7:48**	**D8:17**	**D9:07**	**D10:25**	**D10:56**	**D11:57**	1:04	**D2:03**	3:12	4:20	5:12	5:47	6:11	**D7:25**	8:12	**D8:45**	9:04	**D10:15**	**D11:05**
C	Suburban Station ♿	6:17	7:09	**D7:53**	**D8:22**	**D9:12**	**D10:30**	**D11:01**	**D12:02**	1:09	**D2:08**	3:16	4:24	5:16	5:52	6:16	7:30	8:16	**D8:50**	9:09	**D10:20**	**D11:09**
C	Jefferson Station ♿	6:22	7:14	**D7:58**	**D8:27**	**D9:17**	**D10:35**	**D11:06**	**D12:07**	1:14	**D2:13**	3:20	4:29	5:20	5:57	6:21	–	8:20	**D8:55**	9:14	**D10:25**	**D11:14**
C	Temple University ♿	6:26	7:18	8:03	8:32	9:22	10:40	11:11	12:12	1:18	2:18	3:24	4:33	5:24	6:02	6:26	–	8:24	9:00	9:18	10:29	11:18
	(See Destination Codes)	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
	Train continues to	**ELM**	**DOY**	–	–	–	–	–	–	**DOY**	–	**DOY**	**ELM**	**DOY**	**WTR**	**DOY**	–	**DOY**	–	**DOY**	–	–

TO WILMINGTON/NEWARK

Fare Zone	Train Number / Stations	9211	9213	9215	203	5205	207	5211	3209	9219	5215	5217	3219	9221	9229	3231	9233	7241	9225	5227	5229	5231	5239
		AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
C	Temple University ♿	4:00	4:53	5:46	6:24	7:24	8:26	9:26	10:17	11:18	12:24	1:24	2:17	3:05	3:40	4:19	4:29	5:09	5:52	6:19	7:24	8:24	10:24
C	Jefferson Station ♿	4:06	4:59	5:52	6:31	7:30	8:32	9:32	10:23	11:24	12:30	1:30	2:23	3:11	3:46	4:25	4:35	5:15	5:58	6:25	7:30	8:30	10:30
C	Suburban Station ♿	4:11	5:04	5:57	6:36	7:35	8:37	9:37	10:28	11:29	12:35	1:35	2:28	3:16	3:51	4:30	4:40	5:20	6:03	6:30	7:35	8:35	10:35
C	Gray 30th St Station ♿	4:15	5:09	6:02	6:41	7:40	8:42	9:42	10:32	11:34	12:39	1:39	2:32	3:21	3:56	4:35	4:45	5:25	6:08	6:35	7:39	8:39	10:39
C	Penn Medicine Station ♿	4:18	5:12	6:05	6:44	7:43	8:45	9:45	10:35	11:37	12:42	1:42	2:35	3:24	3:59	4:38	4:48	5:28	6:11	6:38	7:42	8:42	10:42
2	Darby	4:24	5:20	6:15	6:53	7:54	8:54	9:54	10:43	11:46	12:50	1:50	2:41	3:34	4:08	–	4:57	5:38	6:20	6:46	7:50	8:50	10:50
2	Curtis Park	4:26	5:22	6:16	6:55	7:56	8:56	9:56	10:45	11:48	12:52	1:52	2:43	3:36	4:10	–	4:59	5:40	6:22	6:48	7:52	8:52	10:52
2	Sharon Hill	4:27	5:23	6:18	6:57	7:57	8:58	9:58	10:46	11:49	12:53	1:53	2:44	3:38	4:12	–	5:01	5:42	6:23	6:50	7:53	8:53	10:53
2	Folcroft	4:29	5:25	–	6:59	7:59	9:00	10:00	10:48	11:51	12:55	1:55	2:46	3:40	4:14	–	5:03	5:44	–	6:52	7:55	8:55	10:55
2	Glenolden	4:30	5:26	–	7:00	8:00	9:01	10:01	10:49	11:52	12:56	1:56	2:48	3:42	4:16	–	5:05	5:46	–	6:54	7:56	8:56	10:56
2	Norwood	4:32	5:28	–	7:02	8:02	9:03	10:03	10:51	11:54	12:58	1:58	2:50	3:44	4:18	4:54	5:07	5:48	6:27	6:56	7:58	8:58	10:58
2	Prospect Park	4:33	5:30	6:21	7:04	8:04	9:05	10:05	10:53	11:56	1:00	2:00	2:52	3:46	4:20	4:56	5:09	5:50	6:29	6:58	8:00	9:00	11:00
3	Ridley Park	4:34	5:32	6:23	7:06	8:06	9:07	10:07	10:55	11:58	1:02	2:02	2:54	3:48	4:22	4:58	5:11	5:52	6:31	7:00	8:02	9:02	11:02
3	Crum Lynne	**D4:37**	**D5:34**	–	**D7:08**	**D8:08**	**D9:12**	**D10:09**	**D10:57**	**D12:00**	**D1:04**	**D2:04**	**D2:56**	**D3:50**	**D4:25**	–	**D5:14**	**D5:55**	–	**D7:02**	**D8:05**	**D9:05**	**D11:05**
3	Eddystone	–	**D5:37**	–	**D7:10**	–	**D9:14**	**D10:11**	**D11:00**	**D12:02**	**D1:07**	**D2:06**	**D2:58**	–	–	–	**D5:17**	**D5:57**	–	**D7:04**	–	–	**D11:07**
3	Chester Transit Center ♿	**D4:40**	**D5:39**	**D6:28**	**D7:12**	**D8:11**	**D9:16**	**D10:13**	**D11:02**	**D12:04**	**D1:09**	**D2:08**	**D3:00**	**D3:53**	**D4:31**	**D5:03**	**D5:22**	**D5:59**	**D6:36**	**D7:07**	**D8:09**	**D9:08**	**D11:09**
3	Highland Av	**D4:42**	**D5:42**	**D6:31**	**D7:15**	**D8:14**	**D9:19**	**D10:16**	**D11:05**	**D12:07**	**D1:12**	**D2:11**	**D3:02**	**D3:57**	**D4:35**	**D5:08**	**D5:26**	**D6:02**	**D6:38**	**D7:10**	**D8:12**	**D9:11**	**D11:12**
3	Marcus Hook	**D4:45**	**D5:44**	**D6:33**	7:18	**D8:17**	**D9:22**	10:23	**D11:08**	12:14	**D1:15**	**D2:14**	**D3:05**	**D4:00**	4:45	**D5:12**	5:32	**D6:05**	**D6:41**	**D7:13**	**D8:15**	9:16	11:15
4	Claymont ♿	**D4:49**	**D5:48**	**D6:36**	–	**D8:21**	**D9:26**	–	**D11:12**	–	**D1:19**	**D2:18**	**D3:09**	**D4:04**	–	**D5:16**	–	**D6:09**	**D6:55**	**D7:17**	**D8:19**	–	–
4	Wilmington ♿	5:01	**D6:00**	**D6:46**	–	**D8:33**	9:42	–	11:28	–	1:35	2:34	**D3:19**	**D4:16**	–	**D5:28**	–	6:23	**D7:05**	**D7:27**	8:35	–	–
4	Churchman's Crossing ♿	–	**D6:09**	**D6:56**	–	**D8:43**	–	–	–	–	–	–	**D3:29**	**D4:26**	–	**D5:38**	–	–	**D7:15**	**D7:37**	–	–	–
4	Newark ♿	–	6:15	7:06	–	8:52	–	–	–	–	–	–	3:39	4:36	–	5:49	–	–	7:25	7:45	–	–	–
		AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM

Saturdays, Sundays and Major Holidays

TO CENTER CITY

Fare Zone	Train Number	2708	2712	2716	2720	2724	2728	2732	2736	2740
	Stations	AM	AM	AM	PM	PM	PM	PM	PM	PM
4	**Wilmington** ♿	6:27	8:27	10:27	12:27	2:27	4:27	6:27	8:27	10:27
4	**Claymont** ♿	6:35	8:35	10:35	12:35	2:35	4:35	6:35	8:35	10:35
3	**Marcus Hook**	6:38	8:38	10:38	12:38	2:38	4:38	6:38	8:38	10:38
3	**Highland Av**	6:41	8:41	10:41	12:41	2:41	4:41	6:41	8:41	10:41
3	**Chester Transit Center** ♿	6:44	8:44	10:44	12:44	2:44	4:44	6:44	8:44	10:44
3	**Eddystone**	6:46	8:46	10:46	12:46	2:46	4:46	6:46	8:46	10:46
3	**Crum Lynne**	6:48	8:48	10:48	12:48	2:48	4:48	6:48	8:48	10:48
3	**Ridley Park**	6:50	8:50	10:50	12:50	2:50	4:50	6:50	8:50	10:50
2	**Prospect Park**	6:52	8:52	10:52	12:52	2:52	4:52	6:52	8:52	10:52
2	**Norwood**	6:53	8:53	10:53	12:53	2:53	4:53	6:53	8:53	10:53
2	**Glenolden**	6:55	8:55	10:55	12:55	2:55	4:55	6:55	8:55	10:55
2	**Folcroft**	6:57	8:57	10:57	12:57	2:57	4:57	6:57	8:57	10:57
2	**Sharon Hill**	6:59	8:59	10:59	12:59	2:59	4:59	6:59	8:59	10:59
2	**Curtis Park**	7:00	9:00	11:00	1:00	3:00	5:00	7:00	9:00	11:00
2	**Darby**	7:02	9:02	11:02	1:02	3:02	5:02	7:02	9:02	11:02
C	**Penn Medicine Station** ♿	7:12	9:12	11:12	1:12	3:12	5:12	7:12	9:12	11:12
C	**Gray 30th St Station** ♿	7:15	9:15	11:15	1:15	3:15	5:15	7:15	9:15	11:15
C	**Suburban Station** ♿	7:20	9:20	11:20	1:20	3:20	5:20	7:20	9:20	11:20
C	**Jefferson Station** ♿	7:25	9:25	11:25	1:25	3:25	5:25	7:25	9:25	11:25
C	**Temple University** ♿	7:30	9:30	11:30	1:30	3:30	5:30	7:30	9:30	11:30
	(See Destination Codes)	AM	AM	AM	PM	PM	PM	PM	PM	PM
	Train continues to	**CHE**	**CHE**	**CHE**	**CHE**	**CHE**	**CHE**	**CHE**	**CHE**	**CHE**

TO WILMINGTON

Fare Zone	Train Number	9201	7205	7209	7213	7217	7221	7225	7229	7233	7237
	Stations	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM
C	**Temple University** ♿	4:58	6:58	8:58	10:58	12:58	2:58	4:58	6:58	8:58	10:58
C	**Jefferson Station** ♿	5:04	7:04	9:04	11:04	1:04	3:04	5:04	7:04	9:04	11:04
C	**Suburban Station** ♿	5:09	7:09	9:09	11:09	1:09	3:09	5:09	7:09	9:09	11:09
C	**Gray 30th St Station** ♿	5:14	7:14	9:14	11:14	1:14	3:14	5:14	7:14	9:14	11:14
C	**Penn Medicine Station** ♿	5:17	7:17	9:17	11:17	1:17	3:17	5:17	7:17	9:17	11:17
2	**Darby**	5:25	7:25	9:25	11:25	1:25	3:25	5:25	7:25	9:25	11:25
2	**Curtis Park**	5:27	7:27	9:27	11:27	1:27	3:27	5:27	7:27	9:27	11:27
2	**Sharon Hill**	5:28	7:28	9:28	11:28	1:28	3:28	5:28	7:28	9:28	11:28
2	**Folcroft**	5:30	7:30	9:30	11:30	1:30	3:30	5:30	7:30	9:30	11:30
2	**Glenolden**	5:32	7:32	9:32	11:32	1:32	3:32	5:32	7:32	9:32	11:32
2	**Norwood**	5:34	7:34	9:34	11:34	1:34	3:34	5:34	7:34	9:34	11:34
2	**Prospect Park**	5:35	7:35	9:35	11:35	1:35	3:35	5:35	7:35	9:35	11:35
3	**Ridley Park**	5:37	7:37	9:37	11:37	1:37	3:37	5:37	7:37	9:37	11:37
3	**Crum Lynne**	**D5:39**	**D7:39**	**D9:39**	**D11:39**	**D1:39**	**D3:39**	**D5:39**	**D7:39**	**D9:39**	**D11:39**
3	**Eddystone**	**D5:41**	**D7:41**	**D9:41**	**D11:41**	**D1:41**	**D3:41**	**D5:41**	**D7:41**	**D9:41**	**D11:41**
3	**Chester Transit Center** ♿	**D5:43**	**D7:43**	**D9:43**	**D11:43**	**D1:43**	**D3:43**	**D5:43**	**D7:43**	**D9:43**	**D11:43**
3	**Highland Av**	**D5:46**	**D7:46**	**D9:46**	**D11:46**	**D1:46**	**D3:46**	**D5:46**	**D7:46**	**D9:46**	**D11:46**
3	**Marcus Hook**	5:48	**D7:48**	**D9:48**	**D11:48**	**D1:48**	**D3:48**	**D5:48**	**D7:48**	**D9:48**	11:48
4	**Claymont** ♿	—	**D7:51**	**D9:51**	**D11:51**	**D1:51**	**D3:51**	**D5:51**	**D7:51**	**D9:51**	—
4	**Wilmington** ♿	—	8:06	10:06	12:06	2:06	4:06	6:06	8:06	10:06	—
		AM	AM	AM	PM	PM	PM	PM	PM	PM	PM

Travel Tips

Schedule Times: Indicate when trains depart the station.

Fare Payment Options: Contactless, SEPTA Key, Quick Trip Ticket, or cash. Visit **www.septa.org/fares** for more information.

QuietRide Car: Available on all weekday trains (Monday–Friday 4:00 AM to 7:00 PM) with 3 or more cars open for passenger service. The first car will be designated as your QuietRide Car.

Regional Rail Major Holidays: New Year's Day, Martin Luther King Jr. Day, Memorial Day, July 4th, Labor Day, Thanksgiving Day, Christmas Day (Special Schedule). *Please note: Holidays may be observed on another day.*

Disclaimer: SEPTA does not assume responsibility for inconvenience, experience or damage resulting from errors in timetables, delayed trains, failure to make connections or for shortage of equipment. Information is subject to change.

Severe Weather Schedule: During extreme weather conditions, trains may operate on a special schedule. Visit **www.septa.org/alerts** for more information.

State of Delaware Service

SEPTA rail service in Delaware is sponsored by the Delaware Transit Corporation, an operating division of the Delaware Department of Transportation. For information about SEPTA-provided rail service within Delaware State, call **1-800-652-DART (3278)** or visit **www.DartFirstState.com**.

Destination Codes

CHE	Chestnut Hill East	**LAN**	Lansdale
DOY	Doylestown	**LNK**	Link Belt
ELM	Elm Street	**NTC**	Norristown Transit Center
FOX	Fox Chase	**NSH**	Neshaminy Falls
GLN	Glenside	**WAR**	Warminster
JNK	Jenkintown-Wyncote	**WTR**	West Trenton

Safety Tips

- **Never** pass between cars when a train is moving
- **Never** attempt to board a moving train
- **Always** wait for the train to come to a complete stop **before** exiting
- **Never** ride in the vestibule or on the steps of a moving train
- **Never** lean against the train doors

For more information, visit **www.septa.org/safety**.

♿ – **Accessible station**
D – Train stops to discharge or pick up passengers, but may depart ahead of schedule.

West Trenton Line

To/From Center City Philadelphia

Effective September 2, 2025

SEPTA REGIONAL RAIL

- West Trenton
- Yardley
- Woodbourne
- Langhorne
- Neshaminy Falls
- Trevose
- Somerton
- Forest Hills
- Philmont
- Bethayres
- Meadowbrook
- Rydal
- Noble
- Jenkintown-Wyncote
- Elkins Park
- Melrose Park
- Fern Rock Transit Center
- Temple University
- Jefferson Station
- Suburban Station
- William H. Gray III 30th St Station
- Penn Medicine Station

Customer Service: **215-580-7800**
TDD/TTY: **215-580-7853**
www.septa.org

Penn Medicine
800.789.PENN PennMedicine.org

Station Locations & Connecting Services

West Trenton 3 Railroad Av	(P) (bus) NJ Transit Rt. 608
Yardley 13 Reading Av	(P)
Woodbourne 903 Woodbourne Rd	(P)
Langhorne 137 Comly Av	(P) (bus) 14, 130
Neshaminy Falls 4255 E. Bristol Rd	(P) (bus) 58
Trevose 1100 Boundbrook Av	(P)
Somerton 13623 Philmont Av	(P) (bus) 58, 84
Forest Hills 299 Byberry Rd	(P) (bus) 84
Philmont 106 Tomlinson Rd	(P)
Bethayres 500 Station Av	(P) (bus) 24, 88
Meadowbrook 1430 Old Valley Rd	(P)
Rydal 1470 Susquehanna Rd	(P)
Noble 801 Old York Rd	(P) (bus) 55
Jenkintown-Wyncote 50 Greenwood Av • 215-580-6838	($) (P) (bus) 77
Elkins Park 7879 Spring Av	(P) (bus) 28
Melrose Park 880 Valley Rd	(P)
Fern Rock Transit Center 900 Nedro Av	(P) (trolley) B (bus) 4, 28, 57, 70
Temple University 927 W. Berks St • 215-580-5440	($)
Jefferson Station Market St between 10th St & 12th St	($) (trolley) L B3 (bus) 17, 23, 33, 38, 44, 45, 47, 47M, 48, 61, 62, 78, NJ Transit Buses
Suburban Station 16th St & JFK Blvd	($) (trolley) L B T (bus) 2, 4, 16, 17, 27, 31, 32, 33, 38, 44, 48, 62, 78, 124, 125
William H. Gray III 30th St Station 30th St & Market St	($) (trolley) L T (bus) 9, 30, 31, 44, 49, 62, 78, 124, 125, LUCY Amtrak, NJ Transit Atlantic City Line
Penn Medicine Station 3149 Convention Blvd • 215-580-6565	($) (bus) 40, LUCY

(P) – **Parking available**

($) – **Sales Office** (hours vary, visit **www.septa.org/stations** for details)

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Mondays through Fridays (Except Major Holidays)

TO CENTER CITY

Fare Zone	Train Number	3591	3501	303	6307	6367	6309	6311	3209	6313	6317	6321	3219	381	3231	6345	3541	6347	3549	3553	3557	3561
	Stations	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
NJ	**West Trenton, NJ**	5:09	5:57	6:28	6:54	7:18	7:38	8:24	9:20	10:20	11:20	12:20	1:20	2:22	3:18	4:00	5:00	5:55	7:05	8:00	9:00	10:00
4	**Yardley** ♿	5:13	6:01	6:32	6:58	7:22	7:41	8:27	9:23	10:23	11:23	12:23	1:23	2:25	3:21	4:03	5:03	5:58	7:08	8:03	9:03	10:03
4	**Woodbourne**	5:19	6:07	6:38	7:04	7:28	7:46	8:32	9:28	10:28	11:28	12:28	1:28	2:29	3:26	4:08	5:08	6:03	7:13	8:08	9:08	10:08
4	**Langhorne**	5:23	6:11	6:42	7:08	7:32	7:51	8:36	9:32	10:32	11:32	12:32	1:32	2:33	3:30	4:12	5:12	6:07	7:17	8:12	9:12	10:12
3	**Neshaminy Falls** ♿	5:27	6:15	6:47	7:12	7:35	7:56	8:40	9:36	10:36	11:36	12:36	1:36	2:38	3:36	4:16	5:15	6:10	7:21	8:15	9:15	10:15
3	**Trevose** ♿	5:29	6:17	6:50	7:15	7:37	7:59	8:43	9:39	10:39	11:39	12:39	1:39	2:41	3:39	4:18	5:17	6:12	7:24	8:17	9:17	10:17
3	**Somerton** ♿	5:32	6:19	6:53	7:18	7:40	8:03	8:46	9:42	10:42	11:42	12:42	1:42	2:44	3:42	4:21	5:20	6:15	7:27	8:20	9:20	10:20
3	**Forest Hills** ♿	5:35	6:22	6:55	7:20	7:42	8:05	8:49	9:45	10:45	11:45	12:45	1:45	2:46	3:44	4:23	5:22	6:17	7:29	8:22	9:22	10:22
3	**Philmont** ♿	5:38	6:24	6:57	7:22	7:44	8:08	8:51	9:47	10:47	11:47	12:47	1:47	2:48	3:46	4:25	5:24	6:18	7:31	8:24	9:24	10:24
3	**Bethayres** ♿	5:40	6:26	7:01	7:25	7:47	8:11	8:53	9:49	10:49	11:49	12:49	1:49	2:50	3:48	4:27	5:26	6:22	7:34	8:27	9:27	10:27
3	**Meadowbrook**	5:42	6:28	7:04	–	7:50	8:14	8:55	9:51	10:51	11:51	12:51	1:51	2:52	3:50	4:29	5:28	6:24	7:37	8:29	9:29	10:29
3	**Rydal**	5:45	6:30	7:07	–	7:53	8:16	8:57	9:53	10:53	11:53	12:53	1:53	2:54	3:52	4:31	5:30	6:26	7:39	8:31	9:31	10:31
3	**Noble**	5:47	6:32	7:09	–	7:55	8:18	9:00	9:56	10:56	11:56	12:56	1:56	2:58	3:55	4:33	5:32	6:27	7:41	8:33	9:33	10:33
3	**Jenkintown-Wyncote**	5:51	6:36	7:13	–	8:00	8:22	9:05	10:01	11:01	12:01	1:01	2:01	3:02	4:00	4:37	5:35	6:32	7:45	8:37	9:37	10:37
2	**Elkins Park**	–	6:38	–	–	–	–	9:07	10:03	11:03	12:03	1:03	2:03	3:04	4:02	–	5:37	6:34	7:47	8:39	9:39	10:39
2	**Melrose Park** ♿	–	6:40	–	–	–	–	9:09	10:05	11:05	12:05	1:05	2:05	3:06	4:04	–	5:39	6:36	7:49	8:41	9:41	10:41
1	**Fern Rock Transit Center** ♿	5:57	6:44	7:20	–	**D8:07**	**D8:29**	9:11	10:07	11:07	12:07	1:07	2:07	3:09	4:08	**D4:43**	5:41	6:38	7:51	8:43	9:43	10:43
C	**Temple University** ♿	6:05	6:52	7:28	**D7:50**	**D8:16**	**D8:40**	**D9:21**	10:17	**D11:17**	**D12:17**	**D1:17**	2:17	3:19	4:19	**D4:53**	5:50	**D6:50**	8:00	8:52	9:52	10:52
C	**Jefferson Station** ♿	6:12	6:59	7:34	**D7:56**	**D8:23**	**D8:46**	**D9:27**	10:23	**D11:23**	**D12:23**	**D1:23**	2:23	3:25	4:25	**D4:59**	5:56	**D6:56**	8:06	8:58	9:58	10:58
C	**Suburban Station** ♿	6:17	7:04	7:39	**D8:01**	**D8:28**	**D8:51**	**D9:32**	10:28	**D11:28**	**D12:28**	**D1:28**	2:28	3:30	4:30	**D5:04**	6:01	**D7:01**	8:11	9:03	10:03	11:03
C	**Gray 30th St Station** ♿	6:21	7:08	7:44	8:05	8:32	8:56	9:36	10:32	11:32	12:32	1:32	2:32	3:34	4:35	5:08	6:06	7:06	8:16	9:08	10:08	11:08
C	**Penn Medicine Station** ♿	–	–	7:49	–	–	–	–	10:35	–	–	–	2:35	3:37	4:38	–	–	–	–	–	–	–
	(See Destination Codes)	AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
	Train continues to	**THO**	**MAL**	**MED**	–	–	–	–	**WIL**	–	–	–	**NWK**	**MED**	**NWK**	–	**MAL**	–	**THO**	**MAL**	**THO**	**MAL**

TO WEST TRENTON

Fare Zone	Train Number	302	5300	5304	5318	5322	6316	6320	6324	6338	5330	6334	5336	306	334	2336	5344	5348	5352	5356	366
	Stations	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM
C	**Penn Medicine Station** ♿	5:51	–	–	–	–	–	–	–	–	–	–	–	4:32	5:13	5:44	–	–	–	–	11:49
C	**Gray 30th St Station** ♿	5:54	7:25	8:25	9:15	10:15	11:23	12:23	1:25	2:25	3:16	3:57	4:16	4:35	5:16	5:47	6:16	7:16	8:16	9:16	11:52
C	**Suburban Station** ♿	5:59	7:30	8:30	9:20	10:20	11:28	12:28	1:31	2:31	3:21	4:02	4:21	4:40	5:21	5:52	6:21	7:21	8:21	9:21	11:57
C	**Jefferson Station** ♿	6:04	7:35	8:35	9:25	10:25	11:33	12:33	1:36	2:36	3:26	4:07	4:26	4:45	5:26	5:57	6:26	7:26	8:26	9:26	12:02
C	**Temple University** ♿	6:09	7:39	8:40	9:30	10:30	11:37	12:37	1:40	2:40	3:30	4:12	4:30	4:49	5:31	6:02	6:30	7:30	8:30	9:30	12:06
1	**Fern Rock Transit Center** ♿	6:17	7:47	8:48	9:40	10:38	11:45	12:45	1:48	2:48	3:38	–	4:37	–	5:39	6:10	6:38	7:38	8:38	9:38	12:14
2	**Melrose Park** ♿	6:19	7:50	8:51	9:43	10:40	11:47	12:47	1:50	2:50	3:40	–	4:39	–	5:41	6:12	6:40	7:40	8:40	9:40	12:16
2	**Elkins Park**	6:21	7:52	8:53	9:45	10:42	11:49	12:49	1:52	2:52	3:42	–	4:41	–	5:43	6:14	6:42	7:42	8:42	9:42	12:18
3	**Jenkintown-Wyncote**	6:23	7:56	8:57	9:49	10:46	11:53	12:53	1:56	2:56	3:46	**D4:25**	4:46	**D5:03**	5:47	6:18	6:46	7:46	8:46	9:46	12:20
3	**Noble**	**D6:26**	**D7:59**	**D9:00**	**D9:52**	**D10:49**	**D11:56**	**D12:56**	**D1:59**	**D2:59**	**D3:49**	**D4:28**	**D4:49**	**D5:06**	**D5:50**	**D6:24**	**D6:49**	**D7:49**	**D8:49**	**D9:49**	**D12:23**
3	**Rydal**	**D6:28**	**D8:01**	**D9:02**	**D9:54**	**D10:51**	**D11:58**	**D12:58**	**D2:01**	**D3:01**	**D3:51**	**D4:30**	**D4:51**	**D5:08**	**D5:52**	**D6:26**	**D6:51**	**D7:51**	**D8:51**	**D9:51**	**D12:25**
3	**Meadowbrook**	**D6:30**	**D8:03**	**D9:04**	**D9:56**	**D10:53**	**D12:00**	**D1:00**	**D2:03**	**D3:03**	**D3:53**	**D4:32**	**D4:53**	**D5:11**	**D5:55**	**D6:29**	**D6:53**	**D7:53**	**D8:53**	**D9:53**	**D12:27**
3	**Bethayres** ♿	**D6:32**	**D8:05**	**D9:06**	**D9:58**	**D10:55**	**D12:02**	**D1:02**	**D2:05**	**D3:05**	**D3:55**	**D4:34**	**D4:56**	**D5:13**	**D5:58**	**D6:32**	**D6:55**	**D7:55**	**D8:55**	**D9:55**	**D12:29**
3	**Philmont** ♿	**D6:34**	**D8:07**	**D9:08**	**D10:00**	**D10:57**	**D12:04**	**D1:04**	**D2:07**	**D3:07**	**D3:57**	**D4:37**	**D4:59**	**D5:15**	**D6:01**	**D6:35**	**D6:57**	**D7:57**	**D8:57**	**D9:57**	**D12:31**
3	**Forest Hills** ♿	**D6:36**	**D8:09**	**D9:10**	**D10:02**	**D10:59**	**D12:06**	**D1:06**	**D2:09**	**D3:09**	**D3:59**	**D4:39**	**D5:02**	**D5:17**	**D6:04**	**D6:38**	**D6:59**	**D7:59**	**D8:59**	**D9:59**	**D12:33**
3	**Somerton** ♿	**D6:38**	**D8:11**	**D9:12**	**D10:04**	**D11:01**	**D12:08**	**D1:08**	**D2:11**	**D3:11**	**D4:01**	**D4:41**	**D5:04**	**D5:19**	**D6:07**	**D6:41**	**D7:01**	**D8:01**	**D9:01**	**D10:01**	**D12:35**
3	**Trevose** ♿	**D6:42**	**D8:15**	**D9:16**	**D10:07**	**D11:04**	**D12:11**	**D1:11**	**D2:14**	**D3:14**	**D4:04**	**D4:46**	**D5:07**	**D5:22**	**D6:10**	**D6:45**	**D7:04**	**D8:04**	**D9:04**	**D10:04**	**D12:39**
3	**Neshaminy Falls** ♿	**D6:45**	**D8:18**	**D9:19**	**D10:12**	**D11:09**	**D12:16**	**D1:16**	**D2:19**	**D3:19**	**D4:09**	**D4:48**	**D5:12**	**D5:25**	**D6:15**	**D6:51**	**D7:09**	**D8:09**	**D9:09**	**D10:09**	**D12:42**
4	**Langhorne**	**D6:49**	**D8:22**	**D9:24**	**D10:16**	**D11:13**	**D12:20**	**D1:20**	**D2:23**	**D3:23**	**D4:13**	**D4:52**	**D5:16**	**D5:29**	**D6:19**	**D6:56**	**D7:13**	**D8:13**	**D9:13**	**D10:13**	**D12:46**
4	**Woodbourne**	**D6:53**	**D8:28**	**D9:29**	**D10:22**	**D11:19**	**D12:26**	**D1:26**	**D2:29**	**D3:28**	**D4:17**	**D4:57**	**D5:20**	**D5:33**	**D6:23**	**D7:01**	**D7:17**	**D8:17**	**D9:17**	**D10:17**	**D12:50**
4	**Yardley** ♿	**D7:02**	**D8:35**	**D9:36**	**D10:30**	**D11:27**	**D12:34**	**D1:34**	**D2:36**	**D3:33**	**D4:22**	**D5:05**	**D5:25**	**D5:39**	**D6:28**	**D7:08**	**D7:22**	**D8:22**	**D9:22**	**D10:22**	**D12:56**
NJ	**West Trenton, NJ**	7:09	8:43	9:42	10:41	11:34	12:41	1:41	2:42	3:39	4:28	5:11	5:31	5:43	6:34	7:14	7:28	8:28	9:26	10:26	12:59
		AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	AM

Saturdays, Sundays and Major Holidays

TO CENTER CITY

Fare Zone	Train Number	3807	3811	3815	3819	3823	3827	3831	3835	3839	6343
	Stations	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM
NJ	**West Trenton, NJ**	5:17	7:17	9:17	11:17	1:17	3:17	5:17	7:17	9:17	11:17
4	**Yardley** ♿	5:20	7:20	9:20	11:20	1:20	3:20	5:20	7:20	9:20	11:20
4	**Woodbourne**	5:26	7:26	9:26	11:26	1:26	3:26	5:26	7:26	9:26	11:26
4	**Langhorne**	5:29	7:29	9:29	11:29	1:29	3:29	5:29	7:29	9:29	11:29
3	**Neshaminy Falls** ♿	5:33	7:33	9:33	11:33	1:33	3:33	5:33	7:33	9:33	11:33
3	**Trevose** ♿	5:35	7:35	9:35	11:35	1:35	3:35	5:35	7:35	9:35	11:35
3	**Somerton** ♿	5:38	7:38	9:38	11:38	1:38	3:38	5:38	7:38	9:38	11:38
3	**Forest Hills** ♿	5:40	7:40	9:40	11:40	1:40	3:40	5:40	7:40	9:40	11:40
3	**Philmont** ♿	5:42	7:42	9:42	11:42	1:42	3:42	5:42	7:42	9:42	11:42
3	**Bethayres** ♿	5:44	7:44	9:44	11:44	1:44	3:44	5:44	7:44	9:44	11:44
3	**Meadowbrook**	5:47	7:47	9:47	11:47	1:47	3:47	5:47	7:47	9:47	11:47
3	**Rydal**	5:49	7:49	9:49	11:49	1:49	3:49	5:49	7:49	9:49	11:49
3	**Noble**	5:51	7:51	9:51	11:51	1:51	3:51	5:51	7:51	9:51	11:51
3	**Jenkintown-Wyncote**	5:55	7:55	9:55	11:55	1:55	3:55	5:55	7:55	9:55	11:55
1	**Fern Rock Transit Center** ♿	6:01	8:01	10:01	12:01	2:01	4:01	6:01	8:01	10:01	12:01
C	**Temple University** ♿	6:09	8:09	10:09	12:09	2:09	4:09	6:09	8:09	10:09	12:09
C	**Jefferson Station** ♿	6:15	8:15	10:15	12:15	2:15	4:15	6:15	8:15	10:15	12:15
C	**Suburban Station** ♿	6:20	8:20	10:20	12:20	2:20	4:20	6:20	8:20	10:20	12:20
C	**Gray 30th St Station** ♿	6:24	8:24	10:24	12:24	2:24	4:24	6:24	8:24	10:24	12:24
	(See Destination Codes)	AM	AM	AM	PM	PM	PM	PM	PM	PM	AM
	Train continues to	**CHW**	**CHW**	**CHW**	**CHW**	**CHW**	**CHW**	**CHW**	**CHW**	**CHW**	–

TO WEST TRENTON

Fare Zone	Train Number	6304	8312	8320	8328	8336	8344	8352	8360	8368	8376
	Stations	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM
C	**Gray 30th St Station** ♿	5:45	7:45	9:45	11:45	1:45	3:45	5:45	7:45	9:45	11:45
C	**Suburban Station** ♿	5:50	7:50	9:50	11:50	1:50	3:50	5:50	7:50	9:50	11:50
C	**Jefferson Station** ♿	5:55	7:55	9:55	11:55	1:55	3:55	5:55	7:55	9:55	11:55
C	**Temple University** ♿	6:00	8:00	10:00	12:00	2:00	4:00	6:00	8:00	10:00	12:00
1	**Fern Rock Transit Center** ♿	6:08	8:08	10:08	12:08	2:08	4:08	6:08	8:08	10:08	12:08
3	**Jenkintown-Wyncote**	6:14	8:14	10:14	12:14	2:14	4:14	6:14	8:14	10:14	12:14
3	**Noble**	**D6:17**	**D8:17**	**D10:17**	**D12:17**	**D2:17**	**D4:17**	**D6:17**	**D8:17**	**D10:17**	**D12:17**
3	**Rydal**	**D6:19**	**D8:19**	**D10:19**	**D12:19**	**D2:19**	**D4:19**	**D6:19**	**D8:19**	**D10:19**	**D12:19**
3	**Meadowbrook**	**D6:21**	**D8:21**	**D10:21**	**D12:21**	**D2:21**	**D4:21**	**D6:21**	**D8:21**	**D10:21**	**D12:21**
3	**Bethayres** ♿	**D6:23**	**D8:23**	**D10:23**	**D12:23**	**D2:23**	**D4:23**	**D6:23**	**D8:23**	**D10:23**	**D12:23**
3	**Philmont** ♿	**D6:25**	**D8:25**	**D10:25**	**D12:25**	**D2:25**	**D4:25**	**D6:25**	**D8:25**	**D10:25**	**D12:25**
3	**Forest Hills** ♿	**D6:27**	**D8:27**	**D10:27**	**D12:27**	**D2:27**	**D4:27**	**D6:27**	**D8:27**	**D10:27**	**D12:27**
3	**Somerton** ♿	**D6:29**	**D8:29**	**D10:29**	**D12:29**	**D2:29**	**D4:29**	**D6:29**	**D8:29**	**D10:29**	**D12:29**
3	**Trevose** ♿	**D6:32**	**D8:32**	**D10:32**	**D12:32**	**D2:32**	**D4:32**	**D6:32**	**D8:32**	**D10:32**	**D12:32**
3	**Neshaminy Falls** ♿	**D6:34**	**D8:34**	**D10:34**	**D12:34**	**D2:34**	**D4:34**	**D6:34**	**D8:34**	**D10:34**	**D12:34**
4	**Langhorne**	**D6:38**	**D8:38**	**D10:38**	**D12:38**	**D2:38**	**D4:38**	**D6:38**	**D8:38**	**D10:38**	**D12:38**
4	**Woodbourne**	**D6:42**	**D8:42**	**D10:42**	**D12:42**	**D2:42**	**D4:42**	**D6:42**	**D8:42**	**D10:42**	**D12:42**
4	**Yardley** ♿	**D6:47**	**D8:47**	**D10:47**	**D12:47**	**D2:47**	**D4:47**	**D6:47**	**D8:47**	**D10:47**	**D12:47**
NJ	**West Trenton, NJ**	6:54	8:54	10:54	12:54	2:54	4:54	6:54	8:54	10:54	12:54
		AM	AM	AM	PM	PM	PM	PM	PM	PM	AM

Travel Tips

Schedule Times: Indicate when trains depart the station.

Fare Payment Options: Contactless, SEPTA Key, Quick Trip Ticket, or cash. Visit **www.septa.org/fares** for more information.

QuietRide Car: Available on all weekday trains (Monday–Friday 4:00 AM to 7:00 PM) with 3 or more cars open for passenger service. The first car will be designated as your QuietRide Car.

Regional Rail Major Holidays: New Year's Day, Martin Luther King Jr. Day, Memorial Day, July 4th, Labor Day, Thanksgiving Day, Christmas Day (Special Schedule). *Please note: Holidays may be observed on another day.*

Disclaimer: SEPTA does not assume responsibility for inconvenience, experience or damage resulting from errors in timetables, delayed trains, failure to make connections or for shortage of equipment. Information is subject to change.

Severe Weather Schedule: During extreme weather conditions, trains may operate on a special schedule. Visit **www.septa.org/alerts** for more information.

Destination Codes

AIR	Airport
BMR	Bryn Mawr
CHW	Chestnut Hill West
CYN	Cynwyd
ELW	Elwyn
MAL	Malvern
MED	Media
MHK	Marcus Hook
NWK	Newark, DE
THO	Thorndale
TRE	Trenton Transit Center
WAW	Wawa
WAY	Wayne
WIL	Wilmington

Safety Tips

- **Never** pass between cars when a train is moving
- **Never** attempt to board a moving train
- **Always** wait for the train to come to a complete stop **before** exiting
- **Never** ride in the vestibule or on the steps of a moving train
- **Never** lean against the train doors

For more information, visit **www.septa.org/safety**.

♿ – **Accessible station**
D – Train stops to discharge or pick up passengers, but may depart ahead of schedule.

SEPTA SILVERLINER-VI RAILCAR

TECHNICAL SPECIFICATIONS

Appendix VII

Style Guide

SEPTA

Publications Style Guide

Revision 1 - 2025

SEPTA Publications Style Guide

This Publications Style Guide has been created for the SEPTA Running Maintenance Manuals, Heavy Repair Manuals, Illustrated Parts Catalogs, and Operator's Manual. Any addition of items to this document must be approved, in writing, by authorized SEPTA personnel. No changes to current items are permitted unless agreed upon, in writing, by SEPTA, and the Contractor. If additions/changes are made to this document, such actions shall be noted on the Record of Revisions below.

RECORD OF REVISIONS

REVISION	DATE	TITLE OR BRIEF DESCRIPTION	REQUESTED BY
0	2021	Original Release	----
1	2025	Minor Edits	----

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RAIL CARS PUBLICATIONS STYLE GUIDE

1 INTRODUCTION

SEPTA considers the publications which accompany the car to be of great significance and a major responsibility of the Contractor. The manuals described herein shall be delivered to SEPTA in 3 formats: printed hard copy, master authoring electronic files and portable document format (PDF) version electronic files. Additionally, SEPTA requires the electronic files used to create illustrations.

Manual format throughout the documents shall be consistent from subsystem to subsystem.

The manuals described herein, shall use Microsoft Word as the publishing software.

2 PROJECT TECHNICAL SPECIFICATIONS

The following technical specifications were utilized as general references in compiling this Style Guide:

ATA-101 GROUND EQUIPMENT TECHNICAL DATA [Rev 5, 01-12-2013]
MIL-M-38784B MILITARY SPECIFICATION: MANUALS, TECHNICAL: GENERAL STYLE AND FORMAT REQUIREMENTS [Rev B, 11-16-2020]
MIL-STD-40051-1C PREPARATION OF DIGITAL TECHNICAL INFORMATION FOR INTERACTIVE ELECTRONIC TECHNICAL MANUALS (IETMs) [12-15-2015]
ASME-Y14.38M ABBREVIATIONS AND ACRONYMS FOR USE IN PRODUCT DEFINITION AND RELATED DOCUMENTS [2019]
U.S. GOVERNMENT PRINTING OFFICE STYLE MANUAL [9-1-2000]
Applicable Procurement Technical Specification

3 COLLECTION DEFINITIONS

VOLUME — A collection of chapters as required to fill a binder meeting the requirements of Section 13 of this Style Guide.

CHAPTER — The Running Maintenance Manual (RMM), Heavy Repair Manual (HRM), and Illustrated Parts Catalog (IPC) shall be broken down into chapters which shall be identified by sequential Arabic numbers. Each chapter shall cover a major subsystem of the car (breakdown appears in sample 1).

SECTION — Each chapter shall be further broken down into unique sections. Each section shall specifically cover a topic such as Introduction, Troubleshooting, Scheduled Maintenance, etc. Each chapter (excluding chapter 1) shall have identical section headings and numbers. If a section does not apply to a chapter, the section number and heading shall be inserted followed by a brief statement that it is not applicable.

PARAGRAPH Each section shall be further broken down into paragraphs as required and shall be numbered as described in Section 35 of this Style Guide.

4 SAMPLES

Samples are provided in the appendix for format reference only. The technical accuracy of the samples is not guaranteed. Sample pages have been reduced in size for display purposes.

5 PAGE MARGINS AND BINDING

Blank gutters for all publications shall be as follows:

OPERATOR'S MANUAL

6.75 by 3.875-inch page size 0.75 inch on binding edge
0.375 inch on outside edge
0.25 inch above header at top
0.25 inch below page number/footer at bottom
One line space minimum between bottom of text and footer

OTHER PUBLICATIONS

8.5 by 11-inch page size 1.125 inch on binding edge (sample 2)
0.625 inch on outside edge
1 inch above text at top
0.25 inch above header at top
1.25 inch below text at bottom
0.25 inch below page number/footer at bottom

11 by 17-inch page size same as 8.5 by 11 inch above

6 DELETED

7 PAGE NUMBERING

Pages are numbered consecutively within each chapter (using Arabic numerals). They are located on the lower outer edge of the page, in boldface type.

Example: **2-1**

Page numbers for front matter are in consecutive lower case Roman numerals.

8 HEADERS

Headers are centered at the top of each page. They shall be two lines which shall contain basic equipment description and publication type. Headers shall be initial capital letter in boldface type.

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Example:

Project Commuter Rail Car
Running Maintenance Manual

9 FOOTERS

The footers shall contain the revision level located on the binding edge, the chapter number and name which shall be centered, and the page number on the outer edge (per Section 6 of this Style Guide). Footers shall be initial capital letter in boldface type.

Example:

Revision A Chapter 8. Friction Brakes and Pneumatic Equipment 8-1

10 TYPE SIZE AND STYLE

Normal text for all manuals except Operator's: 12-point type
Normal text for Operator's Manual: 10-point type
IPC table: minimum 8-point type
IPC callouts: 10-point type is preferred, 8-point type minimum
Headers and footers: 9-point bold of normal text
Chapter and appendix titles: 14-point bold of normal text
Section headings: 12-point bold of normal text
Paragraph headings: 12-point bold of normal text

The Arial font shall be used.

Examples:

Normal text:	12-point Arial.
Headers and footers:	**9-point Arial Bold.**
Chapter/appendix title:	**14-POINT ARIAL BOLD**.
Paragraph/section headings:	**12-POINT ARIAL BOLD.**

11 CHAPTER OUTLINES

MAINTENANCE MANUALS	Sample 1 lists chapter numbers and names.
ILLUSTRATED PARTS CATALOG	Shall follow the same chapter arrangement as the Running Maintenance Manual and the Heavy Repair Manual.
OPERATOR'S MANUAL	Front Matter 1. Car Description 2. Operating Procedures 3. Emergency Operation Procedures Appendix A. Terms

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ENGINEERING DATA BOOK	Front Matter 1. Introduction 2. Materials 3. Shop Practices 4. Wreck Repair 5. Drawings Appendix A. Spot Welding

12 TAB DIVIDERS

Plasticized tab dividers shall be used to identify chapters and appendices. They shall be five-part tab dividers, containing the chapter/appendix number and name printed on both sides (sample 3).

13 CHAPTER TITLE PAGES

Chapter title pages, listing all chapters by number and name, shall appear after each tab divider. Each chapter title page shall contain the same information, except for the arrow which shall point to the specific chapter shown in 18-point type (sample 4). The sheet shall also contain the SEPTA name and logo.

14 BINDER/COVER PAGE

Binders for 8.5 by 11-inch manuals shall be 3 inches thick maximum and have five posts; the Operator's Manual shall have three aluminum screw posts. One-color screen printing shall be done. The approval process shall be from the Subcontractor (if applicable) to Contractor to SEPTA. The type font and style, and the cover art, shall be determined during a design review.

15 VOLUME TITLE PAGE

The Volume Title Page shall be unnumbered. Chapter headings shall appear on the title page of every volume of the RMM, HRM, and IPC. The Volume Title Page shall contain a "prepared by" identification statement (sample 5).

16 WARNING PAGE

The Warning Page shall include each general type of warning and warning symbol used within the publication. This shall not be a roll-up summary of specific warnings; rather it shall address general subject data (chemicals, pressures, etc.) (sample 6). General subject data headers shall be added.

17 LIST OF EFFECTIVE PAGES

The List of Effective Pages shall appear after the Chapter Title Page and start on an odd numbered page. The List of Effective Pages (LoEP) shall list all pages in the manual along with their current revision level (sample 7). The list of pages shall be in two columns. Consecutive pages existing at the same revision level may be listed with a comma between them for two pages or the word “thru” between them for 3 or more pages. The LoEP shall also state the total

number of pages contained in the manual.

18 RECORD OF REVISIONS

The Record of Revisions shall list all revisions (sample 8). It shall follow the List of Effective Pages and shall be included in each separate chapter.

19 TABLE OF CONTENTS

A comprehensive Table of Contents (TOC) shall follow the Record of Revisions page in each volume; it shall list volumes, chapters, sections, and paragraphs (sample 9). Each chapter shall have its own Table of Contents which shall follow the chapter title page; it shall list sections and paragraphs contained in the particular chapter (sample 10). The TOC should be auto-created by the authoring software.

20 LIST OF ILLUSTRATIONS

The List of Illustrations shall appear after the Table of Contents (sample 11) for each chapter. ~~It~~ shall have two page references for foldouts; one to the blank reference page, and one to the foldout page. For multiple-sheet figures, only the first sheet needs to be listed and the text "(Sheet 1 of …)" should be removed.

21 LIST OF TABLES

The List of Tables shall appear after the List of Illustrations (sample 12) for each chapter.

22 SUBDIVISION OF SECTIONS AND PARAGRAPHS

Sample 13 shows section and paragraph breakdown. Breakdowns beyond the third subsubordinate are not used (i.e., (a), (b), etc. are the lowest breakdowns allowed).

All sideheads begin flush with the left margin; they are typed initial capped, boldface. Two typewriter spaces (1 pica) separate the sidehead number and title. The maximum number for digits in subordinate sideheads is five (i.e., 1-1.1.1.1.). Periods shall be placed after all section and paragraph headers. Standard styles should be created by the publishing software for each section level.

23 PERSON AND VOICE

Second person imperative shall be used for operational procedures, avoiding passive voice; third person shall be used for descriptive discussion.

24 WARNINGS, CAUTIONS, AND NOTES

Warnings, cautions, and notes shall be used to attract attention to essential or critical

information. When the information is given to prevent personal injury or loss of life, it shall become a warning; when the information is given to prevent damage to equipment, it shall become a caution; and when the information aids in job performance, it shall become a note. For precise definitions of a warning, caution, or note, refer to the Chapter 1 material.

Warnings and cautions must precede text but follow paragraph headers if applicable text is at the beginning of a paragraph. Notes may precede or follow applicable text depending on the content of the note. The words WARNING, CAUTION, or NOTE shall be centered above (sample 14). Only one warning per warning header, one caution per caution header, and one note with one theme per note header.

Warnings, cautions, and notes shall not contain procedural steps; but they can reference applicable procedural paragraphs. The order of appearance, as applicable, shall always be warnings first, followed by cautions, followed by notes. The hazard and/or result shall be stated in warnings and cautions, unless obvious. As applicable, a short lead in shall be added to warnings and cautions: i.e., SMOKE HAZARD.

25 UNITS OF MEASURE

When specifying a unit of measure, the U.S. measure shall be given first, followed by the metric conversion in parenthesis, if applicable.

26 ILLUSTRATIONS

Sharp, clear, blackline drawings shall be used throughout the documents for illustration. Photographs may be used only where explicitly approved, on a case basis. There shall be no visible pixilation, aliasing or blurring of any line art, photo, or screenshot included within the manuals.

The following guidelines apply to all illustrations:

Location: As close as possible to the point in the text where they are first referenced; except for foldouts, which are according to Section 29 of this Style Guide.

Placement: Vertically (portrait) wherever possible. If full page size (wider than 7 inches), the illustration should be placed horizontally with the top of the art turned toward the left-hand edge of the page (turned 90 degrees counterclockwise); the figure caption shall remain in the normal position. Figures should be enlarged or shrunk, maintaining aspect ratio, to 6.75” wide unless this dimension forces the caption to the next page for A-size pages in portrait mode. It is preferred that text be wrapped using the “top and bottom” option, but other options may be used if a more pleasing appearance is needed. The portrait illustrations should be centered horizontally relative to the margins. When a page is devoted to a single figure, it shall be centered vertically between top and bottom margins

Figure Title: All illustrations shall have figure titles (captions) which shall be numbered consecutively within each chapter. Figure titles shall be brief and descriptive. Titles shall be formatted as follows:

Figure 2-3. Fuel Indicator.

Figure titles shall be centered below the applicable illustration. There shall be a 1 pica space (two typewriter spaces) between the period following the figure number and the title. If figure title is more than one line, any continued lines of type shall be placed in block format under the figure title.

Highlight: Color shall be kept to an absolute minimum, used only when needed to clarify functional operations. Cross hatching, screening, spot art, inserts, and multiple panels should be used instead.

Word Callouts: Shall be all upper case. Size shall be consistent within a manual even as drawings are reduced or enlarged. They shall be used with descriptive text. They shall be 9-point in all manuals.

Number Callouts: Shall be used in procedural text. Legends shall be used; refer to samples 15 and 16 for format. Whenever possible, callouts in maintenance manuals shall be sequential in order of disassembly; callouts in the Illustrated Parts Catalog shall not follow disassembly order. Circled number callouts (balloons) shall be used in ~~the Running Maintenance, Heavy Repair, and Operator's~~ all Manuals. Up to forty callouts are recommended for a full-page size illustration; fifty callouts is the maximum number allowed, only when their use does not overly clutter the illustration. The numbered callouts for first issues of manuals shall be sequential integers for each figure set. Subsequent inserted numbered items in manual revisions shall be designated by adding alphabetic characters to the index number (examples: 24A, 24B).

Callout Lines: Shall end close to or just touch the object. They should not parallel too close to image envelope or contour lines; no mass of parallel lines shall be allowed. Lines should be uniform, short, and straight if possible; they should not cross or touch other callout lines. They shall be 1 point wide. Also, lines should not obscure essential detail. For clarity, the black callout lines should have thin white borders on either side (glow). Solid arrowheads shall be used.

Sweep Arrows: Shall be used to show location of spot art (sample 15).

Multi-Sheet Illustrations: Shall be consecutively sheet numbered (i.e., Sheet 1 of 3). The same item number shall be used for the same object throughout the multi-sheets. Item numbers on spot art shall be numbered the same as multi-sheet illustrations.

Diagrams and Symbols: All nonstandard symbols (excluding icons) shall be defined in the"list of abbreviations/acronyms" paragraph of the general information work package. (Refer to MIL-STD-40051-2.) New symbols shall not duplicate those presently listed in MIL-STD-12 where possible. Type: Line art is required.

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Illustration Line Weight: Maximum line weight for art shall be 0.7 point. All outer art lines shall be 0.7 point. As required for clarity, inside art lines can be thinner, with 0.3 point being the thinnest allowed.

Master Illustrations: Illustrations shall be created using the latest version of AutoCAD as vector images and then exported to the master manual document at a minimum of 600 dpi with no loss in quality. Exploded isometric view drawings of assemblies shall be used to permit identification of each and all parts. Each illustration shall have an identifying number in the lower right corner that corresponds to the filename(s) that will appear in the printed manuals. Illustrations may be used in multiple manuals as appropriate.

Samples 15, 16, and 17 show typical illustrations for the Operator's Manual, the Running Maintenance and Heavy Repair Manuals, and the Illustrated Parts Catalog respectively.

27 COLOR ILLUSTRATIONS

The use of color and/or photographs may be used only where explicitly approved by SEPTA. They must first pass a test of being printed in black and white via ink jet printer, laser printer, and/or copier and found to have no loss of detail in the supporting text it is illustrating. Where color is used to differentiate categories, status, or screenshots of software monitors, the colors must be chosen so that if printed in black and white, the categories or status and/or nature of the screenshot must be easily identifiable and clearly understood. Photographs being submitted for approval by SEPTA shall reflect full details of the items meant to be shown; shall have professional properties with special detail given to contrast where they are not blended into the background or flared by flash and maintain the clarity and detail of the subject when printed out in gray scale and tested as mentioned above.

28 AVOIDED LAYOUT PRACTICES

The following page layout practices shall be avoided:

The first line of a paragraph at the bottom of a page or column (widow).

The last line of a paragraph at the top of a new page or column

(orphan).A sidehead falling on the last line of a page or column.

WARNINGS, CAUTIONS, and NOTES being divided so as to appear on more than one page.

29 BLANK PAGE FORMAT

When the following page is blank, the page number shall be formatted as follows:1-9/(1-10 blank)

When the preceding page is blank, the page number shall be formatted as

follows:(1-9 blank)/1-10

Blank pages shall have the text: THIS PAGE LEFT INTENTIONALLY BLANK. centered in bold, 14-point font.

30 NUMBERING OF PAGES, TABLES, AND ILLUSTRATIONS

Pages, tables, and illustrations shall be consecutively numbered per chapter. When as part of a revision, new pages need to be inserted, they shall be numbered using a format of adding a period to a preceding page number followed by an integer sequence (Example page 12 would have 12.1 and 12.2 inserted as a single sheet insert). Care should be taken so that odd and even inserted pages follow the same formatting for the gutter, page numbers being on the outside, etc.

31 FOLDOUT PAGES

Foldout pages shall be printed on one side only. A full blank apron shall not be used unless specifically advised in writing by SEPTA Engineer at initial review.

Foldouts shall be placed at the end of each applicable chapter; they shall be repeated from one chapter to another as needed, rather than referenced. Foldouts shall be numbered as all other figures.

The figure title shall appear on a blank page close to where the foldout is referenced in the text; this blank page shall also contain a reference to the page where the foldout appears (sample 18). The foldout shall contain a reference to the blank reference page. Foldout-foldup pages are not permitted.

Pages shall be folded and page numbers shall be placed so the page number is visible on the folded page. Margins shall be a minimum 0.25 inch on top and side opposite binding; 0.5 inch on bottom. Maximum page size is 11 by 17 inches.

32 JUSTIFICATION

All text shall be fully justified (flush right margin).

33 INDENTURES

The first line of a subparagraph shall be indented the equivalent of two spaces or characters from the preceding paragraph (sample 13) by setting up a style with the left indentation of 0.15 inches. All text in the Running Maintenance and Heavy Repair Manuals shall be block format. The Operator's Manual shall have the second and all following lines of the paragraph return to the left margin; except for procedural steps, which shall be block format.

The text for warnings, cautions, and notes shall be indented 1.5 inches from both the left and right gutter margins (sample 14). The headers shall be centered above the text. If text for a warning, caution, or note does not fill an entire line, then the text shall be centered on the page.

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34 TABLES

Tables require horizontal rules at the beginning and the end; the end rule shall be omitted at the foot of a continued table.

Vertical rules are required for all tables, except those tables in the IPC. IPC tables are not to have vertical rules.

The table number and title shall be centered above the table, with a 1 pica space (two typewriter spaces) separating the period following the table number and the title. There shall be a line space between the table title and table head (set the style to have a paragraph spacing of 12-point after it).

Each principal word shall be initial capped in the table title. Table titles shall not be boldface type (except IPC tables). Boxhead titles in non-IPC tables shall have each principal word initial capped in boldface type. Boxhead titles in an IPC table shall be all uppercase, 8 point boldface type. Related entries shall be aligned in the different columns. In the boxhead, the entries shall be aligned along the top line.

Carryover lines shall be indented 1 pica. Table numbers and titles with (Cont.) and boxhead titles shall be repeated on each additional page. Boldface type may be used within the columns for emphasis.

Where possible, line item identifiers shall be added for each new subject. A visual tracking system shall be used for tabular data (sample 19). Warnings and cautions should be used as required andbe brief; they shall be placed in the column to which they apply. Footnotes (sample 19, sheet 2 of 2) shall be numbered consecutively within each table, placed a double line space below table end, and indented five spaces. Any carryover lines of a footnote shall be block formatted under the firstline of footnote text.

35 CONTINUED HEADERS

Continuation headers shall be formatted with the word (Cont.). Continuation headers shall be placed on both left and right-hand pages, as material is continued. There shall be only one header continued, and it shall be the lowest level header that is applicable.

Example: **3-4.11.1. Removal. (Cont.)**
[this is placed on all applicable continued pages]

36 PUBLICATION THICKNESS

The manual size shall not exceed 3 inches bound thickness. If it does, the manual shall be divided into volumes (if needed, the volumes can be divided further into parts). Volumes shall be numbered: Volume 1, Volume 2, Volume 3, etc.

37 PARAGRAPH NUMBERING

Decimal paragraph numbering shall be used (sample 13). Sections shall be numbered with

consecutive Arabic numerals. Chapters shall be numbered with consecutive Arabic numerals. Sections numbers shall be in accordance with the Book Plan.

38 REFERENCES

When referring to a numbered callout on an illustration, the index number shall be given followed by the figure number, for example: (22, Figure 2-1). If multiple references occur in a paragraph to the same figure, only the first reference shall need the figure number.

References in text or tables shall be to the paragraph, table, or figure number of a volume referenced.

References to figures shall be worded "See Figure 2-1" and references to paragraphs and tables shall be worded "Refer to Paragraph 2-1", "Refer to Table 2-1".

If space is limited, such as in a table column, the abbreviations "Fig." and "Para." may be used in place of the words "Figure" and "Paragraph".

All references to other paragraphs, figures, and tables shall use the built-in feature of MS Word that will create a clickable link in the master file that will carry through to the PDF.

39 ABBREVIATIONS AND ACRONYMS

Abbreviations and acronyms shall be used at a minimum. They shall be defined at their first appearance in each paragraph and each procedure. This includes common abbreviations such as "in." and "F". In long paragraphs, abbreviations and acronyms shall be redefined occasionally. Each chapter shall have a summary list of all abbreviations and acronyms used within it. A master glossary of all abbreviations and acronyms shall also appear in the manuals.

To determine the correct abbreviations, the Glossary shall be used first, then ASME-Y14.38M MIL-STD-12.

40 TABULAR MATERIAL

When there is a small amount of tabulated information (four or less items) to be inserted, which shall not require referencing, it may be included within a paragraph of text without being identified as a table. All other tabular information requires a table format.

41 GRAMMAR

Grammar guidelines (compounding, spelling, etc.) may be located in the U.S. Government Printing Office Style Manual. Those documents shall not be replicated in this Style Guide; however, some areas where style differences commonly occur are listed below for clarification.

a. A comma shall be used before "and" and "or" in a series of three or more. Exp: a, b, and c.
b. A comma shall not be used in numerals of four digits. Exp: 3594.
c. Numerals of five digits or more shall have a comma. Exp: 13,549.

d. A comma shall not be added between an equipment or part name and its type or part number. Exp: clip 92384-3.
e. "Data" shall be used as a singular noun when the word is synonymous with information. Exp: Data is stored.
f. "Ensure" is preferred over "insure".
g. Articles a, an, and the shall be omitted in procedural steps, unless needed for emphasis.
h. Abbreviations and symbols — shall not be possessive. Common abbreviations (i.e.; in., ft, lb) shall not be pluralized; however, equipment group acronyms (i.e.; CPUs, LRVs, etc.) can be pluralized.
i. Common typewriter symbols (%, &, ", and ') shall be avoided in text; they shall be used only in charts or tables where necessary.
j. Spacing for temperature shall be as follows: 5 °F.
k. The single letter in single-letter compound nouns shall be capitalized. Exp: X-ray.
l. Numbers under 10 shall be spelled out in text unless they are followed by a unit of measurement, time, or quantity. Exp: three screws, 3 hours, 3 inches, 3 quarts.
m. A zero shall be added before the decimal point for any decimal number less than one; it shall be treated as singular grammatically. Exp: 0.15 inch.
n. Trade names shall be used only if necessary.
o. Use hyphens, en dashes and em dashes per their defined use.

42 READING GRADE LEVEL

Maximum reading grade level shall be set at the tenth-grade level. A sampling of text as it is prepared shall be checked by an electronic program to determine the actual reading grade level.

43 DELETED

44 OPERATOR'S MANUAL NOTES

At least two blank pages shall be inserted at the back of the Operator's Manual. They shall be labeled "NOTES" and shall be lined.

45 GLOSSARY

The glossary shall contain all SEPTA approved terms, acronyms, abbreviations, and symbols. A comprehensive Vehicle Program Glossary shall be added as part of the Chapter 1 for the IPC, HRM and RMM.

46 REQUIRED MAINTENANCE ITEMS LISTING

Required maintenance items listings shall appear at the beginning of each maintenance task and shall list all special tools and consumable items required to complete the task (sample 20). The headers shall be Consumable Items and Special Tools. If not applicable, it shall be stated.

At the end of each chapter, Consumable Materials and Special Tools sections shall appear which shall include tables of all consumable materials and special tools that are required in that chapter.

47 RECOMMENDED TOOLS APPENDIX

An appendix shall be included at the end of the Running Maintenance and Heavy Repair Manuals which shall contain recommended standard and special tools tables.

48 FLOW CHARTS

Where flow charting is required, instructions shall be given on how to read the flow chart and explanations shall be given of the symbols used.

49 RUNNING MAINTENANCE MANUAL AND HEAVY REPAIR MANUAL CONTENT

The body of the technical content shall be broken down into basic sections as follows:

a. Introduction — The introduction shall contain a general description of the subject or system in layman's terms and include safety precautions, warning notices, and notes pertaining to the subject of the chapter. Safety precautions and alerts shall be reproduced within the associated procedures, as applicable, throughout the maintenance related chapters.

b. Operational and Functional Description — This section shall describe the integrated operation of the subject within the car's design then introduce the major components of the system and provide detailed information of their function and purpose.

c. Troubleshooting — The troubleshooting section shall be split into two (2) subsections for system type chapters. The first section shall contain detailed troubleshooting information based on the system's integration into the car and will cover car wiring, power, and any interfacing points with other systems. The second subsection shall contain the troubleshooting of the system's equipment as supplied by the supplier both with and without any portable test device. The troubleshooting charts shall contain the symptom, probable cause, test, and checks for fault isolation and detailed corrective action.

d. Corrective Maintenance — The corrective maintenance section shall contain subsections of detailed instructions for the full repair, adjustment, removal, and installation associated with the subject of the section. Special attention shall be given to adjustment details to ensure they are easily understood and of sufficient detail so that adjustments can be made by inexperienced personnel. Each subsection shall contain a table where the consumable items special tools needed for the work can be listed. Special tools shall be other than a basic took kit (sockets, wrenches, pliers, screwdrivers, etc.). Where some system components have been allowed metric hardware, "metric tools required" shall be noted in the special tools' section of the table.

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e. Preventative Maintenance — Procedures for all preventative maintenance requirements associated with the maintenance allocation chart shall be included in this section. The procedures shall be divided into subsections based on their calendar scheduled events as required by the system. The format, content, and level of detail shall be the same as required for the corrective maintenance section.

f. Portable Test Equipment — In system related chapters where portable test units (PTUs) will be used to troubleshoot or adjust parameters, a devoted section shall be included in the system's chapter describing the full functionality of the unit and detailed instructions for its use.

g. Testing — A full system's test shall be included. The test shall include step-by-step sequential details to fully test and confirm operation and include a test data sheet for recording the test. Any step requiring a particular value and/or tolerance shall be included in both the instructions and the data sheet.

h. Appendix — An appendix section shall be included with each chapter where any associated information to the chapter's subject may be added. At a minimum, each appendix shall contain a torque chart for fasteners. The torque chart shall contain both wet and dry torque values. If some fasteners require additives such as anti-gauling or locking solutions, instructions shall be included to use the wet torque value.

50 ILLUSTRATED PARTS CATALOG (IPC)

The parts catalog chapters shall enumerate and describe every item used on the car along with the diagnostic test equipment and special tools with any related parts. All parts shall be included including materials down to the subcomponent levels of electronic printed circuit boards potentially used during repairs. Parts that are available on the common market ("brand name" items) and/or typical supply house catalog items shall be identified with the original manufacturer's name and part numbers or the catalog supply house catalog numbers. Each component that can be disassembled shall be broken down in illustrations to its indexed parts.

Any added figures/tables shall be numbered sequentially. If overhaul or repair kits are available, they shall be listed at the end of each applicable figure (sample 20.1).

Select parts may not appear in the illustrations. These should be identified with an asterisk next to the index number and the table footnoted with "*Not Illustrated". These parts shall be kept to a minimum and "Not Illustrated" status should be approved by SEPTA.

If the vehicle fleet has different car configurations (e.g. Married Pair, Single Car, Car A, Car B, …), a column shall be added to the right of all others and designated: "USE ON CODE" that denotes which configurations the parts are used on.

An introduction shall appear in Chapter 1. It shall identify and explain all the columns in the tables. For the Description column, it shall explain the indenturing parts.

Organizations developing any IPC for SEPTA shall also supply a spreadsheet of all the parts tables for each chapter, in order to ensure that identical parts are described identically and for use in matching parts with SEPTA's class-and-lot system.

Refer to sample 20.1 for the approved IPC table format. Note that any description after the part nomenclature in the Description column appears lowercase with initial letter uppercase.

An appendix giving the original supplier's complete address, internet address, and telephone numbers for their offices responsible for parts ordering shall be included. If the suppliers have an email address for parts handling, that should also be included. This listing may be a unified one for the whole IPC or as chapter appendices. This listing shall be tied to the supplier code (SUPL CODE) in the parts tables. The codes shall be limited to five alphanumeric characters. For items where the supplier is the carbuilder, the SUPL CODE may be left blank.

Identical parts, regardless of where used in the car, shall use only one part number. Each part or other item shall be identified as being part of the next higher assembly. For hardware such as nuts, bolts, washers, etc., information relative to material, coating if any, all dimensions and types shall be included.

51 DESCRIPTIVE LISTINGS

Paragraphs introducing an expanded list of items must use bullets with the headings of those items, followed by a full titled paragraph of each item.

A lead-in sentence shall be added after each paragraph header when the paragraph is comprisedof a listing.

52 REVISIONS

Manual updates done after the publication date are called revisions. They shall be numbered A, B, C, etc. in sequence. The original submittal shall be identified as "Original" and appear in the LoEP as “0”.

The revision level shall pertain to each chapter and the pages need not be replaced by new ones if nothing on them is revised. Revision levels for pages should coincide with the chapter as a whole and any new updates should be at the revision level stated on the Record of Revisions.

Numbering of Material Added after the Manual Publication Date: Paragraphs, illustrations, tables, and pages shall be numbered by adding a decimal (2-4.1) to the preceding paragraph, illustration, table, or page number, except when added at the end of a sequence (in which case the next consecutive number shall be used). All new "point" pages shall be right-hand pages or begin on a right-hand page if multiple pages are to be added; text and/or art shall be shifted as necessary to accomplish this. If only one page is added, the backup page shall be blank.

Deleted Pages: When one or more pages are deleted, a statement indicating the deletion shall be placed at the bottom of the preceding page or at the top of the succeeding page; for example, "All data on page ...., including figure ..., deleted." Material deleted and not substituted, that is less than one page in length, shall have a statement added to the blank space stating the deletion; for example, "Figure 2-1 deleted."

Change Symbols — Text: Changes shall be indicated by a 6-point wide vertical line in the outer margin opposite the entire area of the material affected. Previous change symbols on a page

shall be deleted when a page is subsequently revised. Change symbols shall not be required for a complete new chapter or section, or opposite blank space due to a deletion.

Change Symbols — Art: A miniature pointing hand (☜) shall be used to highlight the area changed on an illustration. A vertical line in the outer margin shall be used when the corrections are more extensive than one pointing hand can indicate. IPC illustrations shall not require change symbols. Screening shall be used to show changes on diagrams or schematics. The filename and lower right illustration identifier shall be changed noting the revision.

A revision sheet shall be prepared and sent with each revision (sample 21). A new List of Effective Pages sheet shall be sent with each revision.

53 TROUBLESHOOTING

A combined Symptoms Chart/Diagnostic Sequence/Test Procedure type troubleshooting methodology shall be used. This troubleshooting method is described below.

To initiate a troubleshooting action, the Maintainer utilizes the Symptoms Chart logic tree (sample 22). The decision logic of the Symptoms Chart process directs troubleshooting analysis either to another lower-level Symptoms Chart, to a Diagnostic Sequence table, or to a Test Procedure.

The Diagnostic Sequence tables (sample 23) are provided so that the Maintainer is provided with diagnostic steps which lead to additional diagnostics, follow-on tests (Test Procedures), or a successful troubleshooting completion (adjust, repair, replace, etc.).

The Test Procedures (sample 24) direct Maintainers to conduct subsequent troubleshooting tests leading to problem identification or troubleshooting completion (adjust, repair, replace, etc.).

Each troubleshooting step shall be numbered. Illustrations shall be added for clarity.

The most suitable format for troubleshooting computer-identified faults shall be decided on a case- by-case basis.

54 MAINTENANCE PROCEDURE SAMPLE

The final sample, sample 25, is a sample of a typical maintenance procedure. It adheres to the styles set forth in this Style Guide. Because the look and feel of the publication is desired, sample 25 is not captioned, has the Running Maintenance Manual headers and footers, and is page numbered similar to a Running Maintenance Manual.

55 PORTABLE DOCUMENT FORMAT (PDF) SOFTWARE

Distillation of authoring files into PDF documents shall be performed using Adobe Acrobat Pro. All manual chapter files shall be fully bookmarked and available in the navigation window when viewed by the PDF viewer software. The properties of each file shall be set to show both bookmarks and page during the initial opening. All files shall be “tagged” for easy copying of

text. No scans will be allowed, and all information must be distilled from the authoring file software. PDF chapter files shall contain spacer pages stating “Intentionally Left Blank” so that when printed double sided, the first page of the table of contents and the first page of each major section will end up on the right hand page.

56 VEHICLE TECHNICAL INFORMATION LIBRARY (VTIL)

All manual documents will be integrated into SEPTA’s online Vehicle Technical Information Library (VTIL) as PDFs. Documents shall have bookmarks to the fourth-tier paragraphs, table-of-contents hyperlinks, and cross reference hyperlinks.

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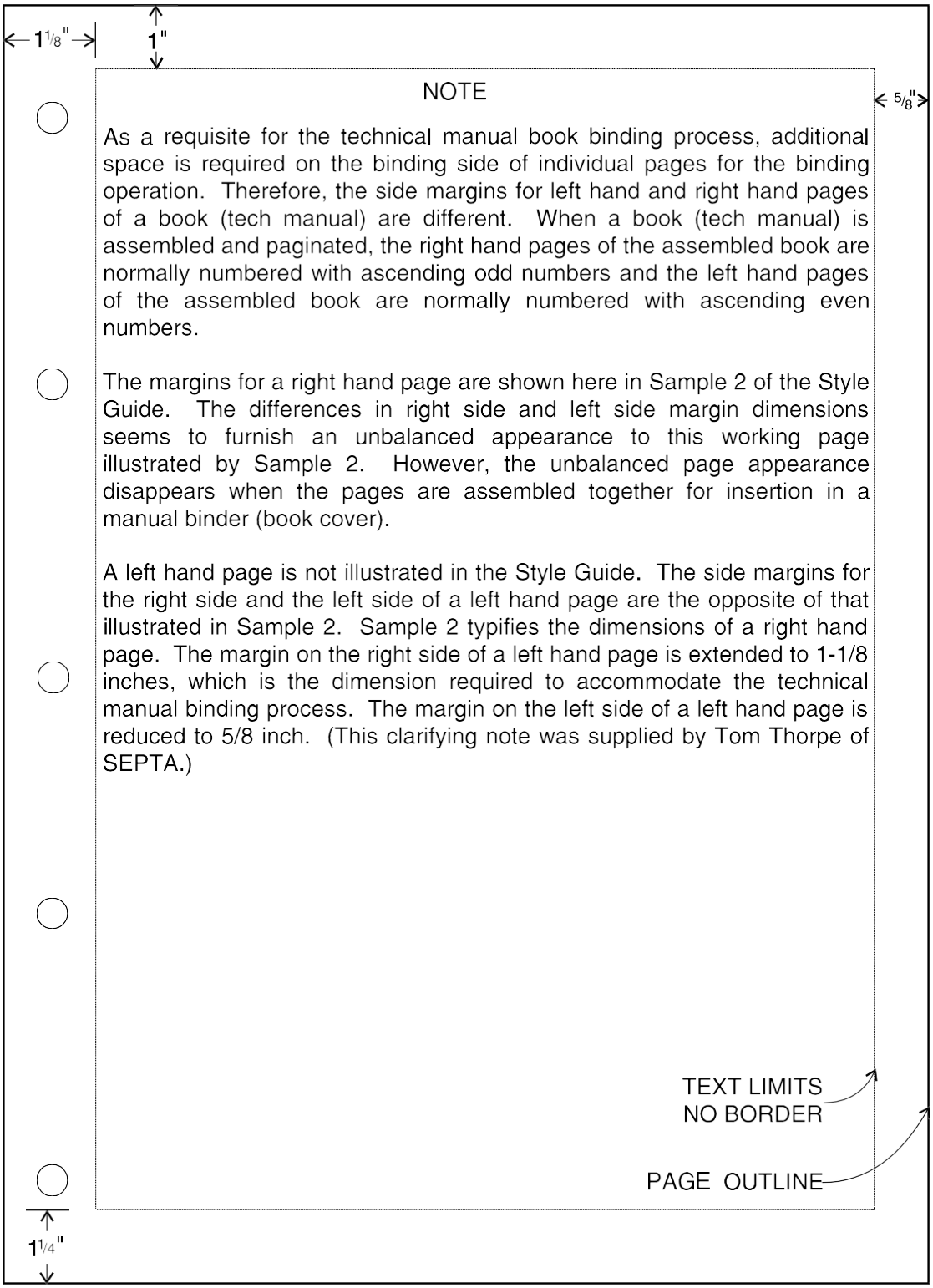
APPENDIX A — SAMPLES

CHAPTER #

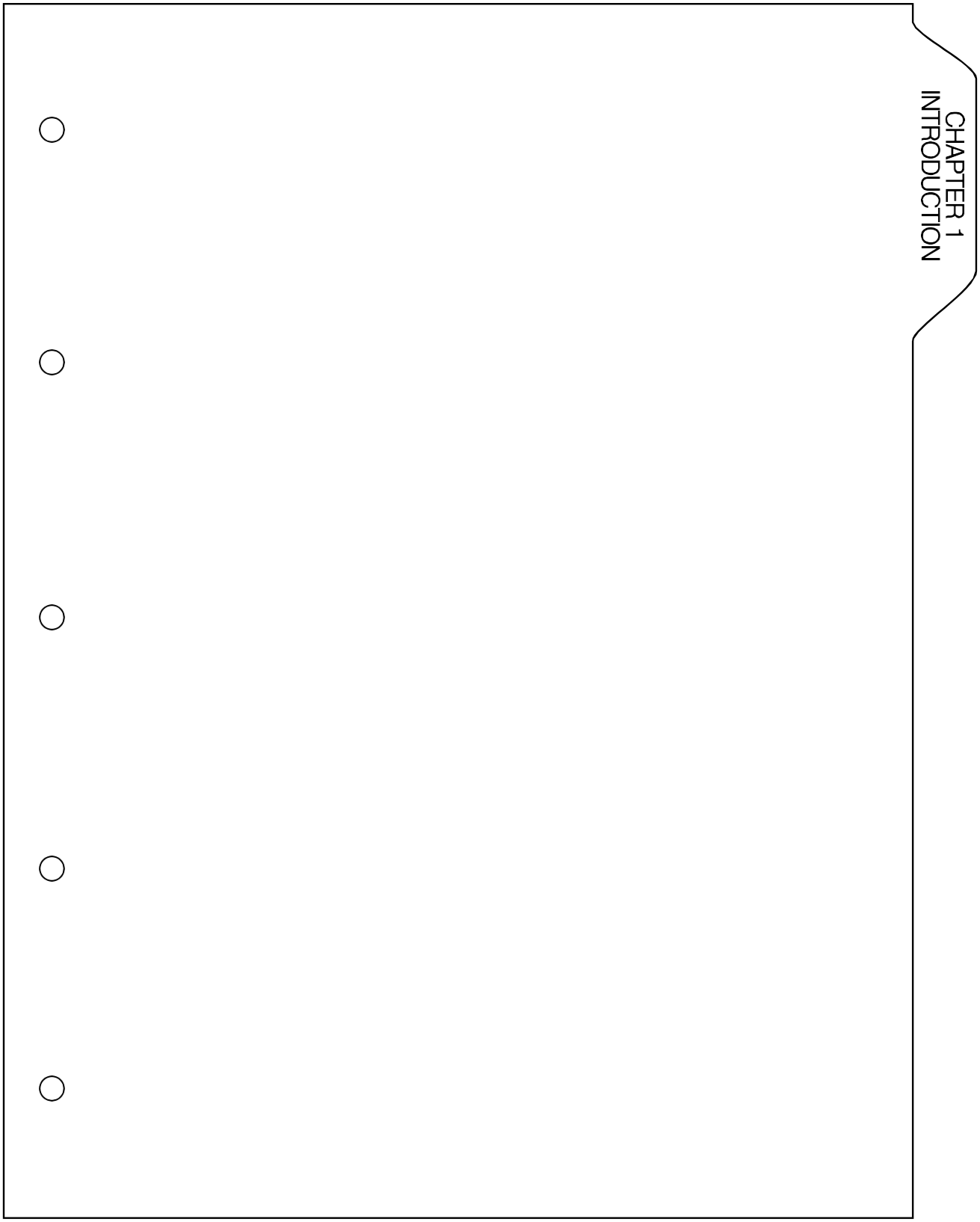
1	INTRODUCTION
2	CAR SYSTEMS (OVERVIEW)
3	HIGH VOLTAGE POWER SYSTEM AND DISTRIBUTION
4	LOW VOLTAGE POWER SYSTEM AND DISTRIBUTION
5	CAB CONTROLS AND EQUIPMENT
6	COMPUTER SYSTEMS
7	PROPULSION SYSTEM AND REGENERATIVE BRAKING
8	FRICTION BRAKES AND PNEUMATIC EQUIPMENT
9	CARBORNE COMMUNICATION SYSTEMS
10	CAB SIGNALS AND AUTOMATIC TRAIN CONTROL
11	DOOR SYSTEMS
12	HEATING, VENTILATION, AND AIR CONDITIONING (HVAC)
13	COUPLERS AND DRAFT GEAR
14	TRUCKS
15	CARBODY, EXTERIOR EQUIPMENT
16	CARBODY, INTERIOR EQUIPMENT
17	LIGHTING
18	DIAGNOSTIC TEST EQUIPMENT
19	WAYSIDE COMMUNICATION SYSTEM

APPENDIX A SILVERLINER V PROGRAM
GLOSSARYAPPENDIX B RECOMMENDED TOOLS

Sample 1. Typical Manual Outline(redo)



Sample 2. Page Margins



Sample 3. Tab Divider

Southeastern Pennsylvania Transportation Authority®

PROJECT RAIL CARS

RUNNING MAINTENANCE MANUAL

CHAPTER

1 INTRODUCTION

2 CAR SYSTEMS (OVERVIEW)

3 HIGH VOLTAGE POWER SYSTEM AND DISTRIBUTION

4 LOW VOLTAGE POWER SYSTEM AND DISTRIBUTION

5 CAB CONTROLS AND EQUIPMENT

6 COMPUTER SYSTEMS

7 PROPULSION SYSTEM AND REGENERATIVE BRAKING

⇨ **8 FRICTION BRAKES AND PNEUMATIC EQUIPMENT**

9 CARBORNE COMMUNICATION SYSTEMS

10 CAB SIGNALS AND AUTOMATIC TRAIN CONTROL

11 DOOR SYSTEMS

12 HEATING, VENTILATION, AND AIR CONDITIONING (HVAC)

13 COUPLERS AND DRAFT GEAR

14 TRUCKS

15 CARBODY, EXTERIOR EQUIPMENT

16 CARBODY, INTERIOR EQUIPMENT

17 LIGHTING

18 DIAGNOSTIC TEST EQUIPMENT

19 WAYSIDE COMMUNICATION SYSTEMS

Sample 4. Chapter Title Page

Southeastern Pennsylvania Transportation Authority

SILVERLINER V COMMUTER RAIL CARS

RUNNING MAINTENANCE MANUAL

CHAPTER	1	INTRODUCTION
	2	CAR SYSTEMS (OVERVIEW)
	3	HIGH VOLTAGE POWER SYSTEM AND DISTRIBUTION
	4	LOW VOLTAGE POWER SYSTEM AND DISTRIBUTION
	5	CAB CONTROLS AND EQUIPMENT
	6	COMPUTER SYSTEMS
	7	PROPULSION SYSTEM AND REGENERATIVE BRAKING
	8	FRICTION BRAKES AND PNEUMATIC EQUIPMENT
	9	CARBORNE COMMUNICATION SYSTEMS
	10	CAB SIGNALS AND AUTOMATIC TRAIN CONTROL
	11	DOOR SYSTEMS
	12	HEATING, VENTILATION, AND AIR CONDITIONING (HVAC)
	13	COUPLERS AND DRAFT GEAR
	14	TRUCKS
	15	CARBODY, EXTERIOR EQUIPMENT
	16	CARBODY, INTERIOR EQUIPMENT
	17	LIGHTING
	18	DIAGNOSTIC TEST EQUIPMENT
	19	WAYSIDE COMMUNICATION SYSTEMS
APPENDIX	A	SILVERLINER V PROGRAM GLOSSARY
	B	RECOMMENDED TOOLS

Prepared by: **Publisher Name**
Number & Street Address City, State, Zip Code
Phone: (xxx) xxx-xxxx
www.publisherxyz.com

Sample 5. Volume Title Page

Silverliner V Rail Cars
Running Maintenance
Manual

WARNING

AIR PRESSURE DANGER

Although the pressures encountered on the Silverliner V rail cars are low compared to other applications, a danger still exists when handling a pressurized system. Blood embolisms (air bubbles) can occur if escaping air comes into direct contact with an open wound. Precautions must be taken to avoid contact with escaping air.

- Never open a fitting of the air pressure system without first ensuring that the pressure has beencompletely released.
- When bleeding air pressure from a pressurized system, avoid being directly in the path of escapingair.
- Never assume that the pressure is bled from a line. Always release the pressure or check appropriate gauges for an indication of pressure.

ELECTRIC SHOCK HAZARD

Electrical shock hazard is present during several test and troubleshooting procedures. Take appropriate precautions to prevent shock.

FLAMMABLE/TOXIC COMPOUNDS

Certain compounds used in painting or repairing the equipment are flammable or toxic. When the use of any of these is indicated, instructions are accompanied with the appropriate warning. Do not use these items near open flames. No smoking. Use only in well ventilated area. Store in a flame-proof cabinet. Observe aging of product.

FIRST AID

For information on First Aid, refer to FM 21-11.

Original Warning Page i

Sample 6. Warning Page(delete)

Project
Illustrated Parts Catalog

TOTAL NUMBER OF PAGES IN THIS PUBLICATION IS 232
CONSISTING OF THE FOLLOWING:

PAGE NO.	*REVISION	PAGE NO.	*REVISION
Title Page	G	4-69 thru 4-73	0
Title Page Back-up	0	4-74	C
A thru C/(D blank)	G	4-75 thru 4-77	0
4-i thru 4-iv	B	4-78	C
4-1	B	4-79 thru 4-81	0
4-2	A	4-82	C
4-3, 4-4	C	4-83	0
4-5	B	4-84	E
4-6 thru 4-8	A	4-85, 4-86	0
4-9	0	4-87, 4-88	A
4-10, 4-11	A	4-89	F
4-12	0	4-90 thru 4-92	A
4-13, 4-14	A	4-93	0
4-15	0	4-94	C
4-16	A	4-95	F
4-17 thru 4-21	0	4-96	E
4-22	A	4-97	B
4-23, 4-24	0	4-98	0
4-25	A	4-99	A
4-26 thru 4-28	C	4-100 thru 4-102	0
4-29	0	4-103 thru 4-105	C
4-30, 4-31	E	4-106	E
4-32	C	4-107	A
4-33	0	4-108	G
4-34	C	4-109, 4-110	A
4-35	0	4-111	C
4-36	C	4-111.1, 4-111.2	B
4-37	E	4-111.3	E
4-38, 4-39	A	4-111.4, 4-111.5	B
4-40	0	4-111.6	E
4-41	E	4-112, 4-113	A
4-42	C	4-114	B
4-43 thru 4-51	0	4-115 thru 4-117	A
4-52 thru 4-54	C	4-118	E
4-55 thru 4-60	0	4-119 thru 4-123	0
4-61, 4-62	C	4-124	A
4-63, 4-64	0	4-125	B
4-65	C	4-126	E
4-66, 4-67	0	4-127	A
4-68	C	4-128	0

NOTE
The portion of the text affected by the changes is indicated by a vertical line in the outer margin of the page.

* Zero in this column indicates an original page.

Sample 7. List of Effective Pages

RECORD OF REVISIONS

REVISION	DATE	TITLE OR BRIEF DESCRIPTION	ENTERED BY
Original		Original Issue.	N/A
A	28 Feb 01	Incorporation of ECN's through 31 Dec 1999.	D & R Technical Solutions, Inc.
B	30 Sep 02 31 Mar 03 30 Sep 03	a. Incorporation of ECN's through 15 Apr 2002. b. General comments against previous Revisions were addressed. c. Additional comments against previous Revisions were addressed. d. Addition of Class-and-Lot numbers and incorporation of SEPTA ECN's 3661, 3663, 3668, 3681, 3685, 3710, 3764 and 3774.	D & R Technical Solutions, Inc. Bombardier Inc. SEPTA
C	30 Jan 04	Addition of Class-and-Lot numbers and incorporation of SEPTA ECN's 3779 & 3790.	SEPTA
D	29 Aug 05	Incorporation of SEPTA ECN 3889-1.	SEPTA
E	06 Oct 05	Incorporation of SEPTA ECN 3897.	SEPTA
F	08 Mar 06	Incorporation of SEPTA ECN 3910.	SEPTA
G	22 Mar 06	Incorporation of SEPTA ECN 3912.	SEPTA
H	30 Nov 06	Addition of Class-and-Lot numbers and corrections per SEPTA ECN 3946 and incorporation of SEPTA ECN 3942-1.	SEPTA
J	30 Mar 07	Incorporation of SEPTA ECN 3960.	SEPTA
K	2 Apr 07	Incorporation of SEPTA ECN's 3974 & 3897-1.	SEPTA
L	29 Feb 08	Incorporation of SEPTA ECN 4007 (Includes Truck Retrofit Program).	Bombardier/ SEPTA
M	31 Mar 08	Incorporation of SEPTA ECN 4039.	SEPTA
N	31 Jan 09	Incorporation of SEPTA ECN 4084.	SEPTA
O	30 Sep 09	Incorporation of SEPTA ECN 4126.	SEPTA
P	30 Sep 09	Incorporation of SEPTA ECN 4127.	SEPTA
R	31 Jan 10	Incorporation of SEPTA ECN 4157.	SEPTA
S	31 Dec 10	Incorporation of SEPTA ECN 4212.	SEPTA
T	31 Jul 13	Incorporation of SEPTA ECN 3897-3, 4232-2 and update on pages 7-50 & 7-60.	SEPTA

Sample 8. Record of Revisions

Sample 9. Deleted

CHAPTER 14
TRUCKS

TABLE OF CONTENTS

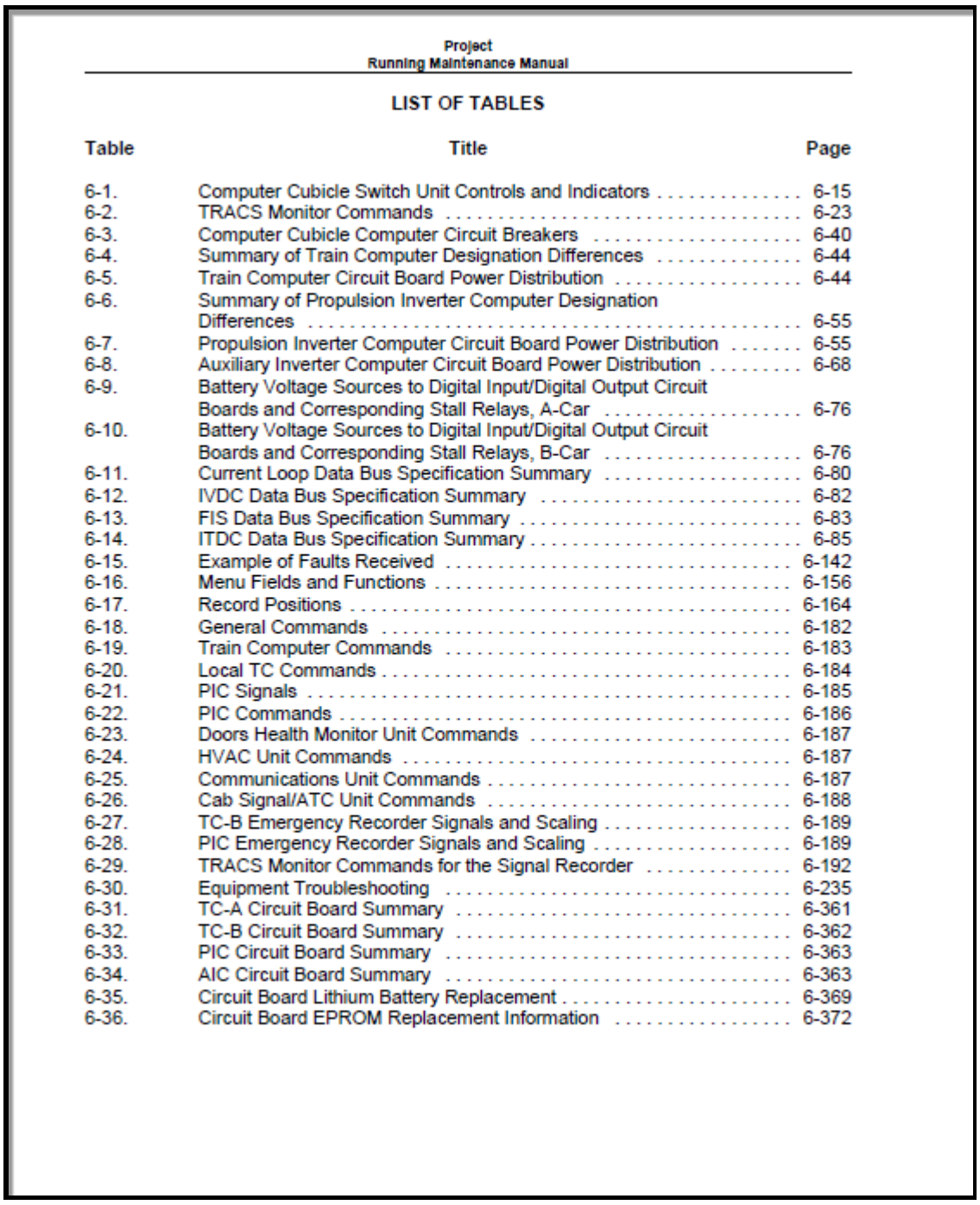
Sect.	Para.	Title	Page
14-1.		**INTRODUCTION**	**14-1**
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	14-1.2.	Warnings, Cautions, Notices, and Notes.	14-2
14-2.		**OPERATIONAL AND FUNCTIONAL SYSTEM DESCRIPTION.**	**14-3**
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	14-2.2.	System Operational Description.	14-3
	14-2.2.1.	System Physical Description.	14-5
	14-2.3.	Truck Component Descriptions.	14-12
	14-2.3.1.	Primary Suspension Arrangement.	14-12
	14-2.3.1.1.	Truck Frame.	14-14
	14-2.3.1.2.	Truck Bolster.	14-15
	14-2.3.1.3.	Central Bearing.	14-16
	14-2.3.1.4.	Side Bearing Safety Stops.	14-17
	14-2.3.1.5.	Bolster Anchors.	14-19
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	14-2.3.2.	Secondary Suspension Arrangement.	14-24
	14-2.3.2.1.	Firestone 222C Air Spring.	14-24
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	14-2.3.2.3.	Vertical Bumpers.	14-27
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	14-2.3.5.	Truck Wiring.	14-33

Sample 10. Chapter Table of Contents

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8-2.	Friction Brakes and Pneumatic Piping	8-5
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Sample 11. List of Illustrations



Project
Running Maintenance Manual

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Sample 12. List of Tables

Order of Heading	Running Maintenance and Heavy Repair Manuals
(1)	**1.1 SECTION HEADING**
(2)	**1-1.1. Primary Sidehead.**
	(xxxxxxx body text xxxxxxxx)
(3)	**1-1.1.1. First Subordinate Sidehead**.
	(xxxxxxx body text xxxxxxxx)
(4)	**1-1.1.1.1. Second Subordinate Sidehead.**
	(xxxxxxx body text xxxxxxxx)
	a. First procedural step. (xxxxxxxxxxxxxxxxxxxx)
	(1) First subordinate procedural step.(xxxxxxxxxxxxxxxxxxx)
	(a) First subsubordinate procedural step.(xxxxxxxxxxxxxxxxxxxx)
(1)	**1-2. NEXT SECTION HEADING.**
(2)	**1-2.1. Next Primary Sidehead.**

Sample 13. Section/Paragraph Subdivision — Running Maintenance and Heavy Repair Manuals

Order of Heading	Operator's Manual
(1)	**1-1. SECTION HEADING.**
	(xxxxxxx body text xxxxxxxx)
(2)	**1-1.1. Primary Sidehead.**
	(xxxxxxx body text xxxxxxxx)
(3)	**1-1.1.1. First Subordinate Sidehead**.
	(xxxxxxx body text xxxxxxxx)
(4)	**1-1.1.1.1. Second Subordinate Sidehead.**
	(xxxxxxx body text xxxxxxxx)
	b. First procedural step. (xxxxxxxxxxxxxxxxxxx) (1) First subordinate procedural step.(xxxxxxxxxxxxxxxxxxx) (a) First subsubordinate procedural step.(xxxxxxxxxxxxxxxxxxx)
(2)	**1-2. NEXT SECTION HEADING.**
	(xxxxxxx body text xxxxxxxx)

Sample 13. Section/Paragraph Subdivision — Operator's Manual

WARNING

SHOCK HAZARD. 120 VAC PRESENT AT THE INPUT SIDE OF THE CAPACITOR. USE EXTREME CAUTIONWHEN DISCONNECTING THE LEADS ON THIS DEVICE.

CAUTION

Corrosive Flux. All aluminum welding fluxes are highly corrosive. Exercise care to prevent the flux from enteringthe cooler core. Complete removal of the flux residue isessential for the same reason.

NOTE

Two flange bolts adjacent to each of the leakage air hose fittings are installed with the heads aft.

Sample 14. Warnings, Cautions, and Notes

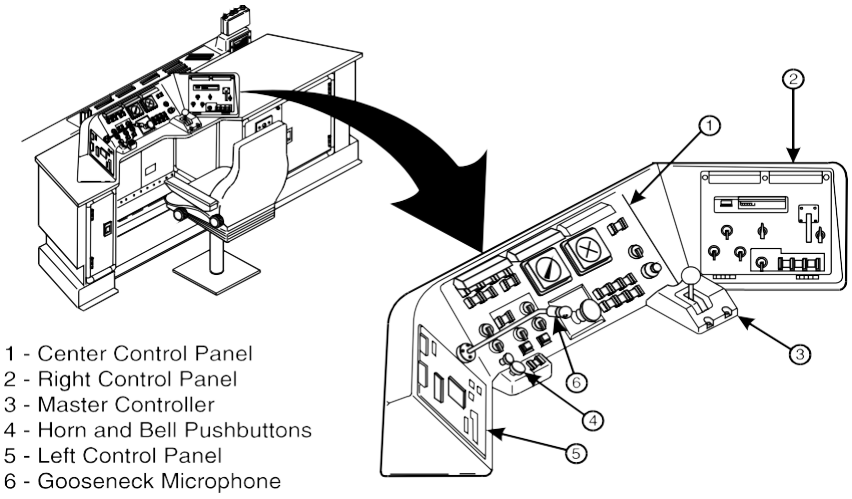


Figure 2-17. Console Layout.

Sample 15. Operator's Manual Illustration

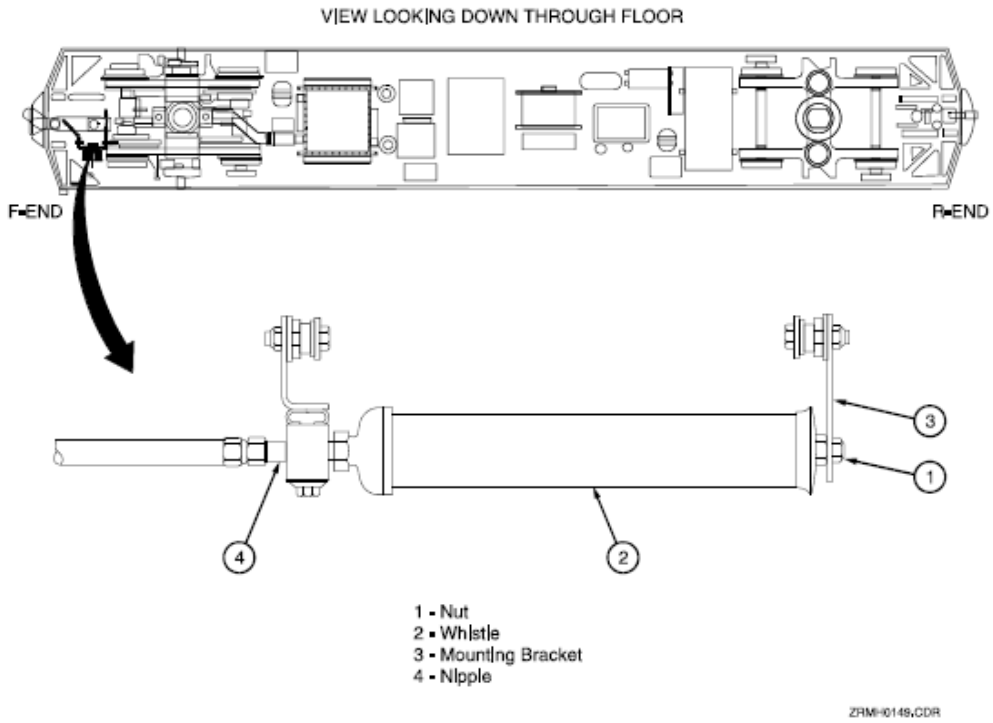


Figure 8-97. Whistle Replacement

Sample 16. Maintenance Manual Illustration

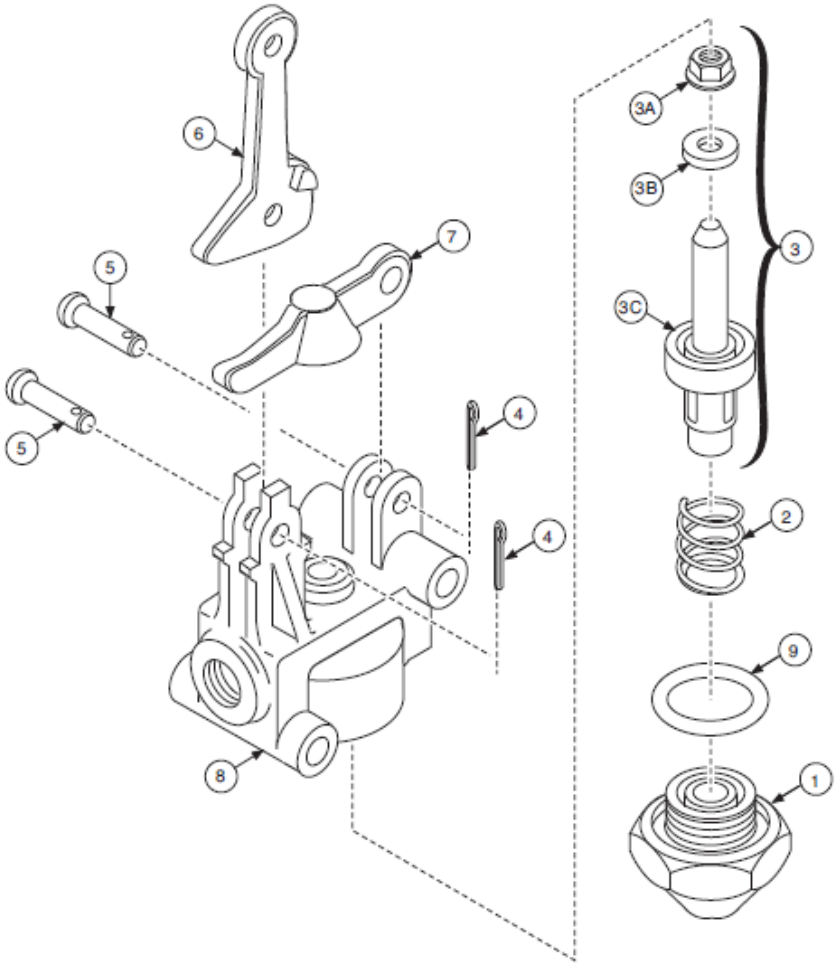


Figure 13-24. B-3-B Brake Application Valve

Sample 17. IPC Illustration

See foldout, Figure 8-55, page 8-128.

Figure 8-1. Car Layout.

Sample 18. Reference to Foldout Page

Table 8-3. Cab Circuit Breaker Panel Circuit Breakers.

Circuit Breaker	Placard	Description
CB19	PA/IC	Public Address and Intercom
CB32	VHF RADIO	VHF Radio
CB33	TMS	Event Recorder/Train Monitor System
CB34	BELL SANDER	Bell and Sander
CB35	SPDO	Speedometer
CB36	HEADLIGHTS	Headlights
CB37	MARKER LIGHTS	Marker Lights
CB38	CAB LIGHTS	Cab Lights
CB43	DITCHLIGHTS	Ditch Lights
CB44	STROBE LIGHT	Strobe Lights

Sample 19. Visual Tracking System (Sheet 1 of 2)

Table 8-1. Friction Braking System Troubleshooting Guide.

Symptom	Malfunction	Corrective Action
1. Car will not go into emergency (auto and handle) brake application.	a. 26-C control valve inoperative. b. 26-B1 brake valve inoperative. c. E-3 emergency brake valve inoperable (cab only).	a. Replace 26-C control valve. Refer to paragraph 9-4.3. b. Replace 26-B1 brake valve. Refer to paragraph 9-4.2 c. Replace E-3 emergency brake valve. Refer to paragraph 9-4.5.
2. Improper service braking.	a. 26-B1 brake valve improperly adjusted or inoperative. b. P-2-A brake application valve inoperative.	a. Adjust 26-B1 brake valve per paragraph 9-4.7. Replace 26-B1 brake valve. Refer to paragraph 9-4.2. b. Replace P-2-A brake application valve. Refer to paragraph 9-4.14.

Sample 19. Visual Tracking System (Sheet 2 of 2)

8-4. MAINTENANCE. (Cont.)

8-4.4. Brake Control Unit (BCU).

8-4.4.1. Installation.

Consumable Items

Item	Part Number	Qty
Gasket	77654-213	1
O-Ring	77654-332	2
Lock-Tite	23452587-1	A/R

Special Tools

Item	Part Number	Qty
Alignment Gauge		1
Trainline Tester	22765-32 0006754-12A	1

Sample 20. Required Maintenance Items Listing(Redo)

Table 8-22. Magnet Valve.

FIG. & INDEX NO.	PART NUMBER	SEPTA C/L	DESCRIPTION	UNITS PER ASSY	SUPPLIER PART NO.	SUPL CODE
8-22 -	3EUV011112	50-08198-054	VALVE, MAGNET (Refer to Figure 8-1 for Next Higher Assembly)	REF REF	STU11053 839-004	KNB GW
-1	RAILCARBUILDER#	50-00058-040	• ADAPTER ASSEMBLY (Includes Items 2-4)	1 ALT	STU11778 364-3	KNB GW
-2			•• ADAPTER	1 ALT	U11781 1561-2	KNB GW
-3			•• SEAL	1 ALT	U11779 1434	KNB GW
-4			•• NUT, PLAIN, HEXAGON	1 ALT	U11780 1704-1	KNB GW
-5			• SEAL (Part of Magnet Repair Kit, P/N STU11170)	1 ALT	U11791 1604-000	KNB GW
-6			• CASE, COIL	1 ALT	U11776 1934	KNB GW
-7			• SEAL	1 ALT	U11790 1469	KNB GW
-8			• POLE, COIL	1 ALT	U11777 1565	KNB GW
-9		50-07013-051	• SPRING (Part of Magnet Repair Kit, P/N STU11170)	1 ALT	U11787 1508-1	KNB GW
-10			• PLUNGER ASSEMBLY (Includes Items 11-14)	1 ALT	STU11771 361-1	KNB GW
-11			•• BODY, PLUNGER	1 ALT	U11773 1700	KNB GW
-12			•• SEAT, PLUNGER (Part of Magnet Repair Kit, P/N STU11170)	1 ALT	U11775 3055	KNB GW
-13			•• BODY, PLUNGER	1 ALT	U11774 3056	KNB GW
-14			•• CAP, PLUNGER	1 ALT	U11772 1701	KNB GW
-15		50-06499-042	• SEAL	1 ALT	U11789 2741	KNB GW
-16			• BODY, VALVE	1 ALT	U11784 5386	KNB GW
-17			• SCREW, CAP, HEX HEAD, 8-32 X ½	1 ALT	B48978 1556-000	KNB GW

Sample 20.1. IPC Table (Sheet 1 of 2)

Table 8-22. Magnet Valve. (Cont.)

FIG. & INDEX NO.	PART NUMBER	SEPTA C/L	DESCRIPTION	UNITS PER ASSY	SUPPLIER PART NO.	SUPL CODE
8-22 (Cont.) -18			• WASHER, LOCK, #8, INTERNAL TOOTHED, CAD-PLT	1	B48979	KNB
				ALT	3752-000	GW
-19	TK10061-WRP		• TERMINAL ASSEMBLY (Includes Item 20) (Part of Magnet Repair Kit, p/n STU11170)	1 ALT	U11783 5153-6	KNB GW
-20			•• VARISTOR (MOV) (Part of Magnet Repair Kit, p/n STU11170)	1 ALT	2239767 2146-062	KNB GW
-21			• COIL (36 VDC)	1 ALT	U11788 1711-A	KNB GW
-22*			• KIT, REPAIR, MAGNET VALVE (Includes Items 5, 9, 12, 19, & 20)	REF	STU11170	KNB

*Not Illustrated

Sample 20.1. IPC Table (Sheet 2 of 2)

Rail Cars
Running Maintenance Manual

RAIL CARS

RUNNING MAINTENANCE MANUAL

The Running Maintenance Manual Chapter 6 has been updated to Revision A and is changed as follows:

1. Remove old pages and insert new pages as indicated below.
2. New or changed material is indicated by a vertical bar in the margin of the page.
3. Added or revised illustrations are indicated by a pointing hand (7) or a vertical bar adjacent to the illustration.

Remove Pages	Insert Pages
6-1 and 6-2	6-1 and 6-2
6-23 and 6-24	6-23 and 6-24
6-25 and 6-26	6-25, 6-26, and 6-26.1/(6-26.2 blank)
6-27 and 6-28	6-27 and 6-28
6-43 through 6-46	6-43 through 6-44.4 through 6-46
6-51 through 6-56	6-51 through 6-56
6-75 through 6-80	6-75 through 6-80, 6-80.1 and 6-80.2
6-81 through 6-88	6-81 through 6-88
6-95 and 6-96	6-95 and 6-96

File this change sheet in front of the publication for reference purposes.

Revision A Revision Sheet

Sample 21. Revision Package Cover Sheet

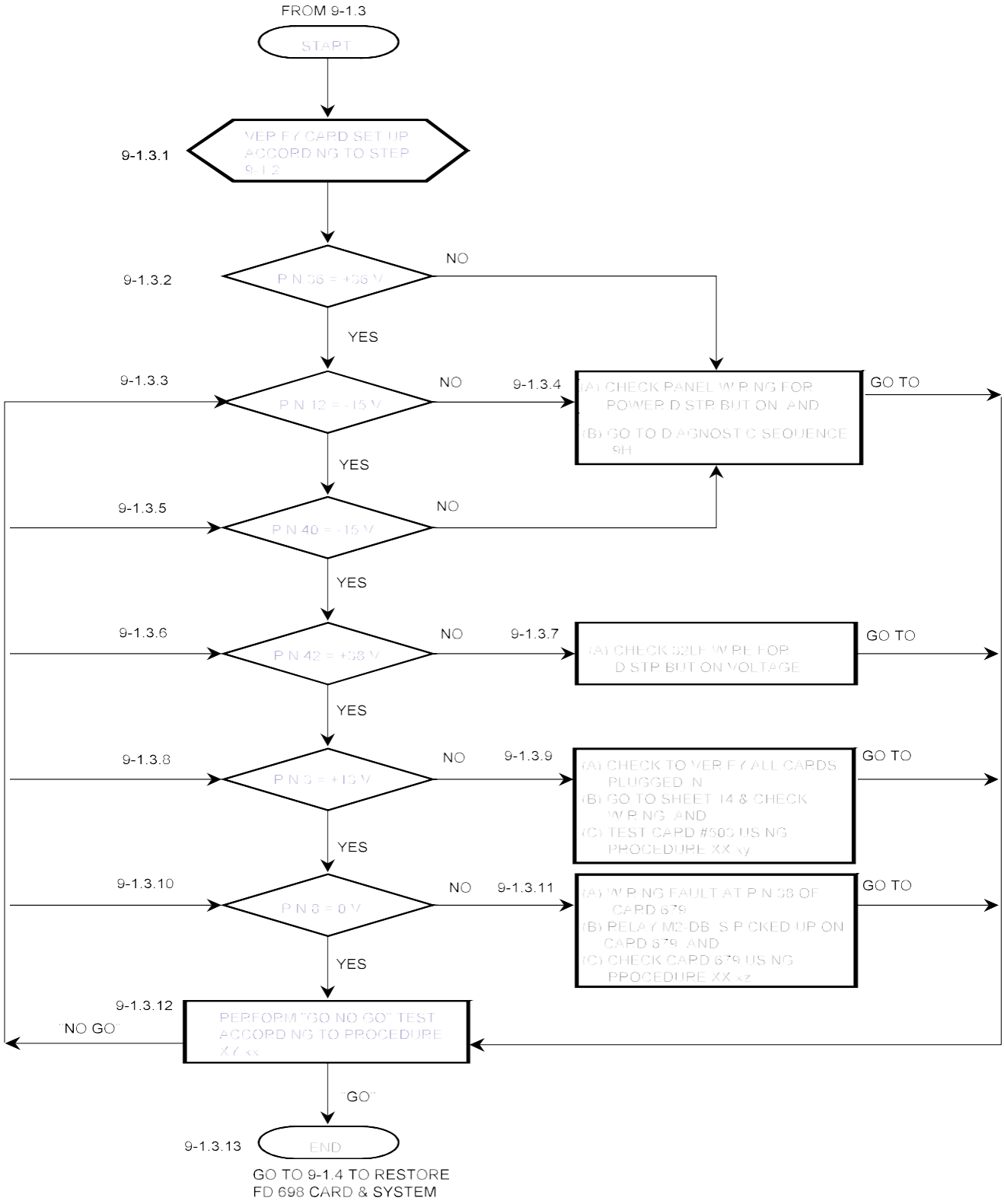
7-3.4.18. FIS Fault Code 832, INT AIR OVERTEMP, PI-R.

Review each symptom in the first column of Table 7-21, then note the probable causes listed in the second column. Perform procedures listed in the Remedy column until the fault is corrected and equipment is operating properly.

Table 7-21. INT AIR OVERTEMP, PI-R

Symptom	Probable Cause	Remedy
1. PI-R internal air temperature sensor indicates temperature above +70 °C. PI-R is shut down until internal air temperature drops below +65 °C. PI-R is permanently disabled after too many faults.	a. Bottom heatsink is dirty.	a. Visually inspect bottom heatsink fins (1, Figure 7-48). Clean as necessary.
	b. Dirty PI covers.	b. Visually inspect inside and outside of PI covers. Clean as necessary.
	c. Faulty operation of PI fans.	c. Inspect fans for impeller rotation and condition of fan motor bearings; refer to Paragraph 7-3.4.35.2. Replace fan(s), if appropriate; refer to Section 7-4.
	d. Faulty PI-R air temperature sensor.	d. Replace internal air temperature sensor (2, Figure 7-48), if faulty; refer to Section 7-4.
	e. Faulty analog input circuit board DTAI101H-T (pos 121).	e. Troubleshoot analog input circuit board DTAI101H-T (pos 121); refer to Section 6-3. Replace any faulty circuit board; refer to Section 6-4.
	f. Propulsion inverter fault.	f. Follow propulsion inverter test procedure with high voltage; refer to Paragraph 7-3.6.4.

Sample 22. Symptoms Troubleshooting Chart



Sample 23. Diagnostic Sequence Troubleshooting Chart

Air Brake System

Page 1 of 1 (Refer to Air Brake Schematic)

Test Procedure

Perform this Test Procedure if: Single caremergency brakes are not applying.

Do the following:

1. Check the main reservoir pressure. It should be between 130 and 140 psi. If itis not correct, refer to **Diagnostic Sequence 4K.**
2. Make sure brake cylinder cutout cocksare cut in.
3. Be sure that during the testing of singlecar emergency that one of the brake valves on the unit being tested is cut in.
4. Check for air exhaust at the single car emergency valve where application is being attempted. If there is no exhaust when the valve is fully engaged, replacethe valve.
5. Observe both truck assemblies for brake application. If application does not occur on both trucks, replace the following:
   a. Brake valve cutout cock. Note: Prior to replacing the valve, look for exhaust at brake valve cutout valve when cutting inand out. If there is no exhaust, replace the valve.
   b. The 26-A double check valve.
6. If braking application does not occur onone truck assembly only, inspect and replace as needed the following:
   a. N-1-A reducing valve
   b. H-5 (80 psi) relay air reduction valve(nullification)
   c. H-3 (80 psi) relay air reduction valve(application)

Note: The above valves are only to be changed on the single car emergency manifold onthe same end of the unit with the defect.

Sample 24. Test Procedure Troubleshooting Chart

Refer to sample section 8-4.11 on the following pages. Note this sample does not use the footer style that would be in the finished manual.

Sample 25. Typical Maintenance Procedure

8-4. MAINTENANCE. (Cont.)

8-4.11. Oil/Water Separator.

8-4.11.1. Removal.

Consumable Items			Special Tools
Item	**Part Number**	**Qty**	**No Special Tools Required.**
Locknut	12765-441	2	
Mineral Spirits	AR123456B	A/R	
Pipe Thread Seal.	1257-B23	A/R	
Repair Kit, Oil/Water Sep	16754-12	1	
Seal Ring	16754-47	1	

NOTE

Before removing the drain valve adapter nipple, thedrain valve must be removed from the adapter nipple.

a. Disconnect pressure hoses from Oil/Water Separator (1, Figure 8-1) and drainvalve (2) at fittings (3 and 4).

b. Loosen compression nut of fitting (4) on Oil/Water Separator.

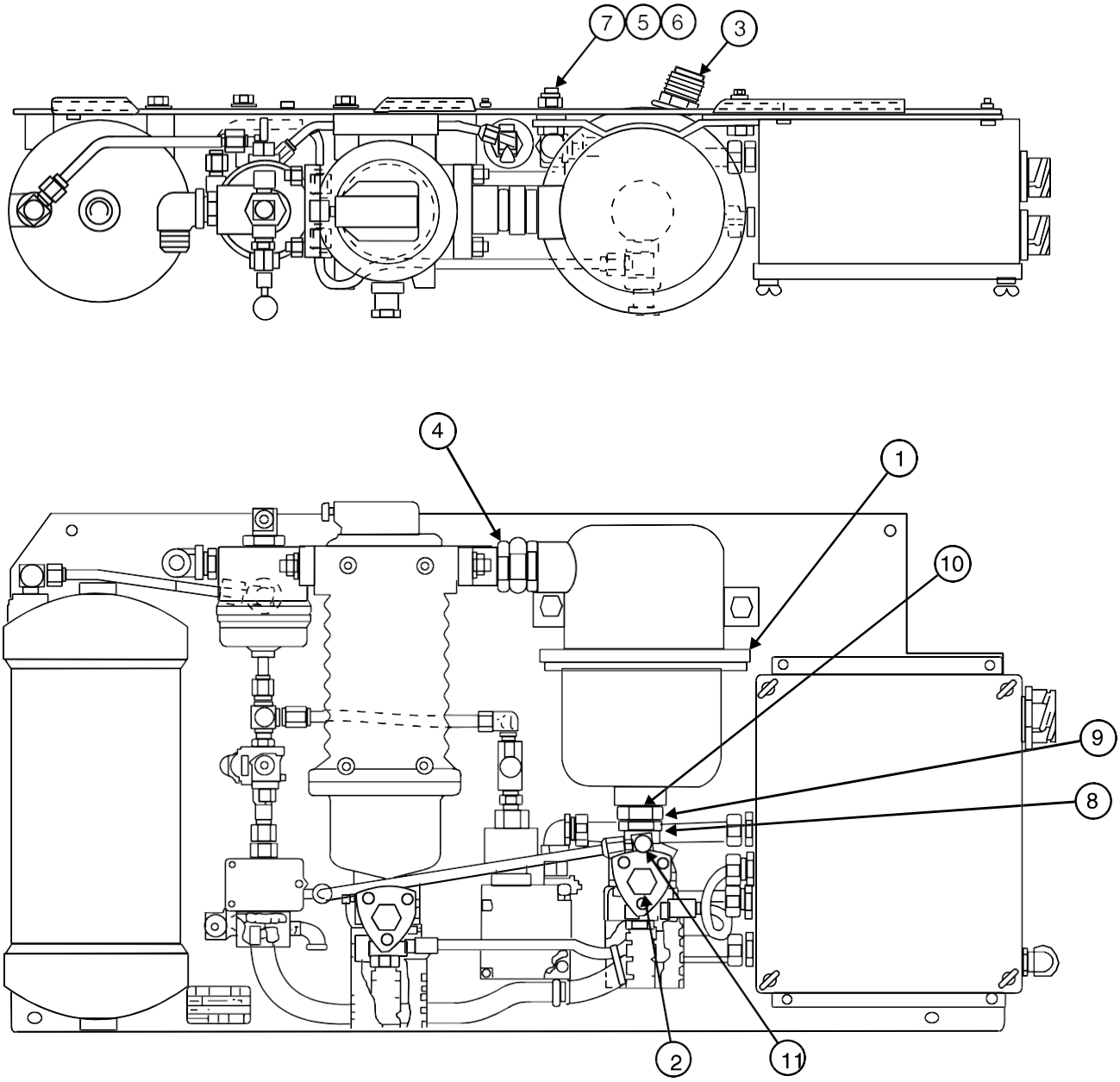
c. Disconnect heater assembly electrical connections from motor starter boxterminal bus connections 5 and 10. Tag wires for reassembly.

d. Loosen compression fitting on motor starter box through which heater connections pass. Carefully slide out heater unit connections.

e. Remove two locknuts (5) and washers (6) (from inside air drier panel) thatsecure Oil/Water Separator to air drier panel. Discard locknuts.

f. Remove two screws (7) from Oil/Water Separator mounting ears.

8-4.11.1. Removal. (Cont.)



1 - Oil/Water Separator
2 - Drain Valve
3 - Hose Fitting
4 - Fitting
5 - Locknut
6 - Washer
7 - Screw
8 - Jam Nut
9 - Adapter Nipple
10 - Seal Ring
11 - Fitting

Figure 8.1 Air Drier Panel.

8-4.11.1. Removal. (Cont.)

g. Remove Oil/Water Separator from air drier panel.

h. Loosen jam nut (8) one-half turn.

i. Measure distance from top of drain valve to bottom of Oil/Water Separator. Record this distance for alignment purposes during installation.

j. Remove drain valve.

k. Remove adapter nipple (9) and seal ring (10) from Oil/Water Separator. Discardseal ring.

8-4.11.2. Installation.

a. Install seal ring (10, Figure 8-1) on solenoid/drain valve adapter nipple (9).

b. Apply pipe thread sealant to threads of solenoid/drain valve adapter nipple.

c. Install adapter nipple in drain port of Oil/Water Separator (1).

d. Install drain valve (2) on adapter nipple so that distance from top of drain valve to bottom of Oil/Water Separator is the same distance as recorded during disassembly.

e. Tighten jam nut (8) against drain valve.

f. Install fittings (4 and 3) on Oil/Water Separator.

g. Secure Oil/Water Separator to air drier panel with screws (7), washers (6), andlocknuts (5) on Oil/Water Separator mounting ears.

h. Install pressure hose fitting (3) and tube assembly on fitting (11).

i. Tighten compression nut of fitting (4) on Oil/Water Separator.

j. Carefully slide heater unit connections through compression fitting on motor starter box and tighten compression fitting. Be sure to form a drip loop in the wires that are to be connected.

k. Connect heater assembly electrical connections to motor starter box terminal bus connections 5 and 10.

8-4.11.3 Raschig Ring Replacement.

a. Disassembly.

(1) Remove any attached adapter fittings.

(2) Remove ten nuts (1, Figure 8-2), bolts (2), and lockwashers (3). Discard lockwashers.

(3) Remove sump (4), cap (5), and gasket (6). Discard gasket.

(4) Remove jam nuts (7) from bolt stud in Oil/Water Separator cap (5).

(5) Remove retaining plate (8) and pour Raschig Rings (9) into container.

(6) Remove spacer sleeve (10) and second retaining plate (8).

b. Cleaning and Inspection.

(1) Clean all metal parts with mineral spirits. Thoroughly dry all parts with compressed air.

(2) Inspect all bolts and nuts for signs of wear and replace as required.

(3) Inspect sump (4, Figure 8-2) of Oil/Water Separator for rust, weld breaks,thread wear, and bolting flange wear or distortion.

(4) Inspect both retaining plates (8) for flatness and damage to holes.

(5) Inspect cap (5) for rust, weld breaks, thread wear, distorted or worn mounting flange, bent or damaged mounting ears, and bent or damaged holding bracket with welded bolt.

c. Assembly.

NOTE

Replacement parts for items discarded during disassembly are contained in repair kit.

(1) With holding cap (5, Figure 8-2) inverted, position one retaining plate (8) and spacer sleeve (10) over bolt in cap (5).

8-4.11.3. Raschig Ring Replacement. (Cont.)

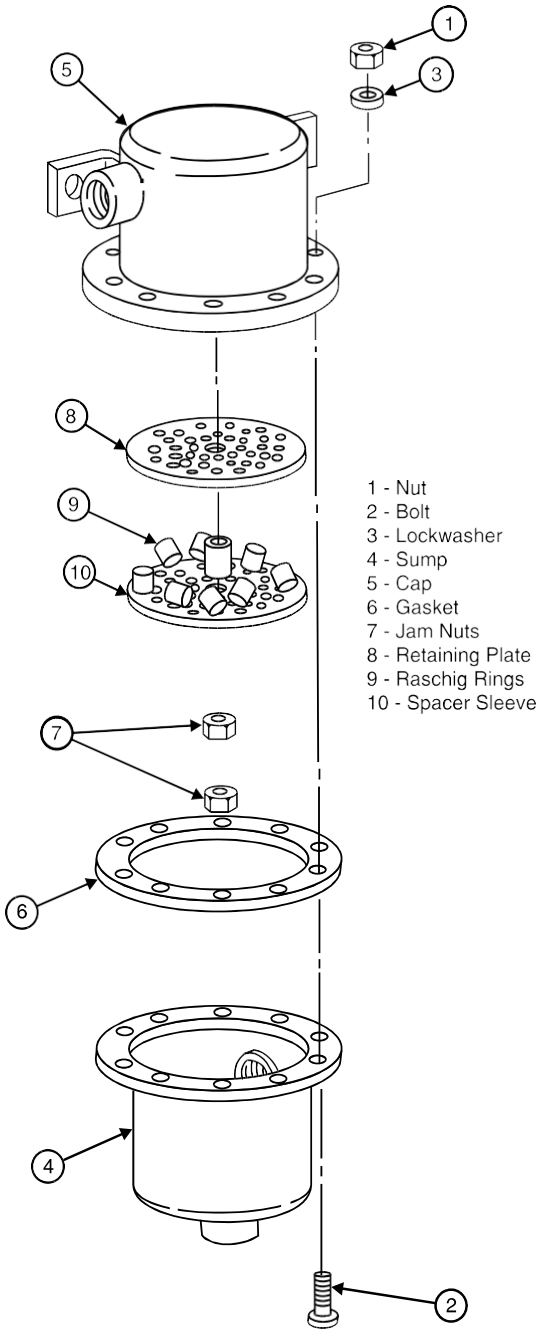


Figure 8-2. Oil/Water Separator.

8-4.11.3. Raschig Ring Replacement. (Cont.)

(2) Pour approximately 6.5 pounds of Raschig Rings (9) into Oil/Water Separator cap (5) until they have reached the top of spacer sleeve (10).

NOTE

Make sure both retaining plates are flat and that Raschig Rings are held by a light pressure between the plates (shake the Oil/Water Separator to check). If necessary, add a few more Raschig Rings.

(3) Position second retaining plate (8) over bolt in cap (5) and secure with one jam nut (7). Attach second jam nut (7) to cap bolt, tightening against the first jam nut.

(4) Position gasket (6) into recess at bolting flange of cap and position sump (4) over cap so that outlet port of cap is positioned 180 degrees away from the inlet port of sump and is parallel to mounting ears.

NOTE

Make sure that torquing of the sump and cap is performed by tightening consecutively opposite bolts to the minimum required torque.

(5) Insert ten bolts (2) and lockwashers (3) and secure with nuts (1). Torque to 36 foot/pound (ft/lb) (49 Newton meters (Nm)).

(6) Plug inlet and outlet ports with 1 inch British Standard Pipe Plug (BSPP) plugs. Connect air supply to 1 inch BSPP drain port. Apply 125 pounds per square inch (psi) (8.6 bar) pressure and perform leak test at bolting flange.

(7) Slowly increase pressure to approximately 145 psi (10 bar) and again perform leak test at bolting flange.

8-4.11. Oil/Water Separator. (Cont.)

WARNING

HIGH PRESSURE DANGER. RELEASE PRESSURE FROM THE DRAIN PORT BEFORE REMOVING PLUGS FROM INLET AND OUTLET PORT.

(8) Release pressure from drain port and remove plugs from Oil/Water Separator inlet and outlet port.

(9) Test Oil/Water Separator, refer to Paragraph 8-4.11.4.

8-4.11.4. Test.

a. Seal plug outlet and inlet ports.

NOTE

Inlet and outlet ports have British threads 1 inch BSPP.

b. Connect hose to 1 inch BSPP drain port.

WARNING

SHRAPNEL DANGER. THE OIL/WATER SEPARATOR SHOULD BE PRESSURE TESTED IN A SECURE AREA TO PREVENT INJURY IN CASE OF SEPARATOR FAILURE.

c. Pressurize Oil/Water Separator with water pressure to 175 psi (12 bar) for 5 minutes. Make sure that no air is trapped in the Oil/Water Separator. Water should not leak from Oil/Water Separator within that time frame. If a leak should be detected, repair Oil/Water Separator in accordance with Paragraph8-4.11.3.

d. Disconnect water source and drain Oil/Water Separator.

e. Unplug all ports and thoroughly dry Oil/Water Separator with high pressure air.

f. Stamp test mark and date on bolting flange of successfully tested Oil/Water Separator.

SEPTA SILVERLINER-VI RAILCAR

TECHNICAL SPECIFICATIONS

Appendix VIII

Disaggregated APC Schema

Variable Name	Value Format	Data Type	Type of Information	Description
ActRunTime_s	32	Integer	Time Measurement	Corresponds to the actual duration of the trip between two stops and its values are in seconds format.
ArrDev_s	6	integer	Time Measurement	Corresponds to the difference between the actual stop time and the scheduled stop time for the arrivals in seconds format.
ArrTime_s	32457	integer	Schedule Time	Arrival time in seconds format.
BalancedIns	0	Integer	Ridership	Passenger boards/Ins.
BalancedLoad	5	Integer	Ridership	Max amount of passengers in the vehicle at the given stop.
BalancedOuts	0	Integer	Ridership	Passenger leaves/outs.
BalancedPsgMile	0.98176618	Integer	Distance	Corresponds to the distance traveled by each passenger. Calculated by multiplying the passenger load at each stop by the distance to the next stop.
BlockName	6245	Integer	Schedule	Corresponds to the block code provided by the booking.
BookingCode	Frontier Fall 2025 A	Character	Schedule	Corresponds to the schedule in effect at the time the trip is sampled.
Date	9/17/2025	Date	Schedule	Corresponds to the date when an event had been scheduled or sampled.
DepDev_s	21	Integer	Time Measurement	Corresponds to the difference between the actual stop time and the scheduled stop time for the departures in seconds format.
DepTime_s	32472	Integer	Time Measurement	Depart time in seconds format.
DirectionName	Northbound	Character	Schedule	Corresponds to direction name.
DivisionCode	Frontier	Character	Schedule	Corresponds to the SEPTA Division trip is operating in.
DwellTime_s	0	Integer	Time Measurement	Deviation between actual arrive time and actual departure time [h:mm:ss].
FirstStop	FALSE	Boolean	Schedule	Is stop the first in the pattern sequence.
IsTimePoint	TRUE	Boolean	Schedule	Is stop a timepoint
LastStop	FALSE	Boolean	Schedule	Is stop the final stop in the pattern sequence
Lat	40.065437	Character	Distance	Lattitude
LocationName	Bristol Pk & Edgewood Av	Character	Schedule	Corresponds to the location name of the scheduled stop.
Lon	-74.976188	Character	Distance	Longitude
NextStopTime	30	Integer	Time Measurement	Time to travel to next stop in seconds.
PatternName	FK-OM	Character	Schedule	Corresponds to the Pattern name provided by the booking.
PatternSeq	2	Numeric	Schedule	The sequence position of the stops defined by the pattern.
PeriodName	Midday	Character	Schedule	**Corresponds to the period of the day (e.g., AM Peak, Midday, PM Peak, Evening and Night).**
RouteName	129	Character	Schedule	Route identification name (can be numeric, letter, or combination of the two)
RunDev_s	2	Numeric	Time Measurement	Run deviation in seconds format
Sampled	TRUE	Boolean	Schedule	Has trip been successfully sampled by APC
SchedArrTime_s	32451	Integer	Schedule	Scheduled arrival time in seconds format
SchedDepTime_s	32451	Integer	Schedule	Scheduled departure Time in seconds format
SchedRunTime_s	30	Integer	Schedule	Corresponds to the scheduled duration of the trip between two stops and its values are in seconds format.
SchedTripEndTime_s	37680	Integer	Schedule	Scheduled end time in seconds format
SchedTripRunTime_s	5280	Integer	Schedule	Scheduled running time between stops.
SchedTripStartTime_s	32400	Integer	Schedule	**Scheduled Start Time in seconds format**
Service	Weekday	Character	Schedule	Corresponds to the service name provided by the booking. (Weekday, Saturday, Sunday)
StopCode	21120st	Character	Schedule	Corresponds to the unique stop identification number
TripDistMeter	1231	Integer	Distance	Distance between each stop in meters
TripEndTime_s	37656	Integer	Schedule	**End time in seconds format**
TripID	10371703	Integer	Schedule	The one-way operation of a revenue vehicle between two terminus points on a route.
TripStartTime_s	32438	Integer	Schedule	**Start time in seconds format.**
TripTime_s	5218	Integer	Schedule	**Trip time in seconds format.**
TripTypeName	Revenue	Character	Schedule	Indicates if trip is Revenue, Pull-In, or Pull-Out
VehicleCode	3632	Integer	Schedule	Corresponds to the vehicle code provided by the client.
Sch. Time	04:00:00	Character	Schedule	Schedule time from Trapeze at each stop [hh:mm:ss]
Act. Arr. Time	04:32:33	Character	Time Measurement	Timestamp reflecting the actual time the vehicle arrives at a stop [hh:mm:ss].
Act. Dep. Time	4:32:42	Character	Time Measurement	Timestamp reflecting the actual time the vehicle departs at a stop [hh:mm:ss].
Time Dev.	0:00:26	Character	Time Measurement	Deviation between the scheduled time and actual arrival time [h:mm:ss].
Dwell Time	0:00:05	Character	Time Measurement	Deviation between actual arrive time and actual departure time [h:mm:ss].
Sch. Run Time	0:01:01	Character	Schedule	Corresponds to the scheduled duration of the trip between two stops and its values are in seconds format [h:mm:ss].
Act. Run Time	0:01:01	Character	Time Measurement	Corresponds to the actual duration of the trip between two stops and its values are in seconds format [h:mm:ss].