TYPE B-3 FINAL

Specification Divisions 26-33

Repair B403 for Cyber

Project Number PBXP222050

Prepared for

179th Civil Engineering Squadron
Ohio Air National Guard
Mansfield Lahm ANG Base

May 2026

Jacobs

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PROJECT TABLE OF CONTENTS

DIVISION 01 - GENERAL REQUIREMENTS

01 11 00	02/24	SUMMARY OF WORK
01 14 00	11/22, CHG 1: 02/23	WORK RESTRICTIONS
01 20 00	11/20, CHG 3: 02/23	PRICE AND PAYMENT PROCEDURES
01 30 00	11/20, CHG 3: 08/23	ADMINISTRATIVE REQUIREMENTS
01 32 01.00 10	08/23	PROJECT SCHEDULE
01 32 52	04/26	SPECIAL SECURITY (24 NOV 2025)
01 33 00	08/18, CHG 4: 02/21	SUBMITTAL PROCEDURES
01 33 29	02/21	SUSTAINABILITY REQUIREMENTS AND REPORTING
01 35 13	11/20, CHG 1: 02/22	SPECIAL PROJECT PROCEDURES
01 35 26	11/20, CHG 4: 08/23	GOVERNMENTAL SAFETY REQUIREMENTS
01 42 00	02/19, CHG 1: 08/23	SOURCES FOR REFERENCE PUBLICATIONS
01 45 00	08/23	QUALITY CONTROL
01 45 35	05/24	SPECIAL INSPECTIONS
01 50 00	11/20, CHG 2: 08/22	TEMPORARY CONSTRUCTION FACILITIES AND CONTROLS
01 57 19	08/22	TEMPORARY ENVIRONMENTAL CONTROLS
01 58 00	08/19, CHG 5: 08/22	PROJECT IDENTIFICATION
01 74 19	02/19, CHG 3: 11/21	CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL
01 78 00	05/19, CHG 1: 08/21	CLOSEOUT SUBMITTALS
01 78 23	05/23	OPERATION AND MAINTENANCE DATA
01 91 00.15	05/23, CHG 2: 11/23	BUILDING COMMISSIONING

DIVISION 02 - EXISTING CONDITIONS

02 41 00	08/22	DEMOLITION AND DECONSTRUCTION

DIVISION 03 - CONCRETE

03 01 00	02/18	REHABILITATION OF CONCRETE
03 30 00	02/19, CHG 9: 08/24	CAST-IN-PLACE CONCRETE

DIVISION 04 - MASONRY

04 20 00	11/15, CHG 2: 05/19	UNIT MASONRY

DIVISION 05 - METALS

05 05 20	05/22, CHG 1: 08/24	POST-INSTALLED CONCRETE AND MASONRY ANCHORS
05 05 23.13 10	08/18	ULTRASONIC INSPECTION OF WELDMENTS
05 05 23.16	08/18	STRUCTURAL WELDING
05 12 00	08/18, CHG 2: 05/21	STRUCTURAL STEEL
05 50 13	08/24	MISCELLANEOUS METAL FABRICATIONS
05 51 33	08/24	METAL LADDERS
05 52 00	08/23	METAL RAILINGS

DIVISION 06 - WOOD, PLASTICS, AND COMPOSITES

06 41 16.00 10	08/10, CHG 1: 11/18	PLASTIC-LAMINATE-CLAD ARCHITECTURAL CABINETS
06 61 16	08/20	SOLID SURFACING FABRICATIONS

DIVISION 07 - THERMAL AND MOISTURE PROTECTION

07 19 00	08/23	WATER REPELLENTS
07 21 13	08/23	BOARD AND BLOCK INSULATION
07 21 16	08/23	MINERAL FIBER BLANKET INSULATION
07 21 23	08/23	LOOSE FILL THERMAL INSULATION
07 27 10	08/23	BUILDING AIR BARRIER SYSTEM
07 42 63	05/11, CHG 4: 08/20	FABRICATED WALL PANEL ASSEMBLIES
07 60 00	08/23	FLASHING AND SHEET METAL
07 84 00	05/10, CHG 1: 08/13	FIRESTOPPING
07 92 00	08/23	JOINT SEALANTS

DIVISION 08 - OPENINGS

08 11 13	08/20	STEEL DOORS AND FRAMES
08 13 73	02/11	SLIDING DOORS
08 31 00	05/17, CHG 1: 08/18	ACCESS DOORS AND PANELS
08 34 73	11/19, CHG 1: 02/21	SOUND CONTROL DOOR ASSEMBLIES
08 71 00	02/16, CHG 4: 02/22	DOOR HARDWARE
08 81 00	05/19	GLAZING
08 91 00	08/20	METAL WALL LOUVERS

DIVISION 09 - FINISHES

09 22 00	08/24	SUPPORTS FOR PLASTER AND GYPSUM BOARD
09 29 00	08/24	GYPSUM BOARD
09 30 10	08/20	CERAMIC, QUARRY, AND GLASS TILING
09 51 00	08/20	ACOUSTICAL CEILINGS
09 62 38	08/17, CHG 1: 08/18	STATIC-CONTROL FLOORING
09 65 00	11/24	RESILIENT FLOORING
09 68 00	11/24	CARPETING
09 69 13	11/24	RIGID GRID ACCESS FLOORING
09 84 20	08/16, CHG 1: 08/18	ACOUSTICAL WALL PANELS
09 90 00	02/21	PAINTS AND COATINGS

DIVISION 10 - SPECIALTIES

10 14 00.10	08/17, CHG 1: 11/18	EXTERIOR SIGNAGE
10 14 00.20	08/20	INTERIOR SIGNAGE
10 21 13	08/20	TOILET COMPARTMENTS
10 22 39	08/20	FOLDING PANEL PARTITIONS
10 26 00	08/20	WALL AND DOOR PROTECTION
10 28 13	08/20	TOILET ACCESSORIES
10 44 16	11/19	FIRE EXTINGUISHERS
10 51 13	08/24	LOCKERS

DIVISION 11 - EQUIPMENT

11 31 13	08/17, CHG 2: 11/24	ELECTRIC KITCHEN EQUIPMENT

DIVISION 12 - FURNISHINGS

12 00 01.00 20	02/23	FURNITURE, FIXTURES AND EQUIPMENT (FF&E) PACKAGE
12 48 13	08/23	ENTRANCE FLOOR MATS AND FRAMES
12 50 00.13 10	08/17, CHG 1: 11/18	FURNITURE AND FURNITURE INSTALLATION
12 59 00	08/17, CHG 1: 08/18	SYSTEMS FURNITURE

DIVISION 13 - SPECIAL CONSTRUCTION

13 49 20.00 10	10/07	RF SHIELDING
DIVISION 21 - FIRE SUPPRESSION		
21 13 13	08/20	WET PIPE SPRINKLER SYSTEMS, FIRE PROTECTION
DIVISION 22 - PLUMBING		
22 00 00	05/24, CHG 1: 11/24	PLUMBING, GENERAL PURPOSE
DIVISION 23 - HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)		
23 05 48.19	02/25	SEISMIC BRACING FOR MECHANICAL SYSTEMS
23 05 93	11/15	TESTING, ADJUSTING, AND BALANCING FOR HVAC
23 07 00	08/24	THERMAL INSULATION FOR MECHANICAL SYSTEMS
23 08 00	05/23, CHG 1: 08/24	COMMISSIONING OF MECHANICAL AND PLUMBING SYSTEMS
23 09 00	08/24	INSTRUMENTATION AND CONTROL FOR HVAC
23 09 13	11/15, CHG 2: 05/21	INSTRUMENTATION AND CONTROL DEVICES FOR HVAC
23 09 23.02	08/24	BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS
23 09 53.00 20	02/10, CHG 3: 08/24	SPACE TEMPERATURE CONTROL SYSTEMS
23 11 20	05/20	FACILITY GAS PIPING
23 23 00	08/21	REFRIGERANT PIPING
23 30 00	02/25	HVAC AIR DISTRIBUTION
23 81 00	05/24	DECENTRALIZED UNITARY HVAC EQUIPMENT
23 81 23	11/20	COMPUTER ROOM AIR CONDITIONING UNITS
DIVISION 25 - INTEGRATED AUTOMATION		
25 05 11.21	08/24	CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS FIRE & LIFE SAFETY
25 05 11.23	08/24	CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS BUILDING CONTROL SYSTEM
25 05 11.28	08/24	CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS ELECTRONIC SECURITY SYSTEMS
DIVISION 26 - ELECTRICAL		
26 05 48	11/23	SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT
26 05 73	08/23	POWER SYSTEM STUDIES
26 08 00	11/22	APPARATUS INSPECTION AND TESTING
26 12 19	05/24	PAD-MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS
26 20 00	08/23	INTERIOR DISTRIBUTION SYSTEM
26 27 13.10 30	10/07, CHG 2: 08/18	ELECTRIC METERS
26 29 23	02/20, CHG 1: 05/21	ADJUSTABLE SPEED DRIVE (ASD) SYSTEMS UNDER 600 VOLTS
26 32 15	05/24	ENGINE-GENERATOR SET STATIONARY 15-2500 KW, WITH AUXILIARIES
26 33 53	05/19	STATIC UNINTERRUPTIBLE POWER SUPPLY (UPS)
26 36 23	05/20, CHG 1: 08/21	AUTOMATIC TRANSFER SWITCHES AND

		BY-PASS/ISOLATION SWITCH
26 41 00	08/23	LIGHTNING PROTECTION SYSTEM
26 51 00	05/20, CHG 2: 11/21	INTERIOR LIGHTING
26 56 00	08/21	EXTERIOR LIGHTING

DIVISION 27 - COMMUNICATIONS

27 10 00	08/11	BUILDING TELECOMMUNICATIONS CABLING SYSTEM

DIVISION 28 - ELECTRONIC SAFETY AND SECURITY

28 08 10	08/23	ELECTRONIC SECURITY SYSTEM ACCEPTANCE TESTING
28 10 05	05/24	ELECTRONIC SECURITY SYSTEMS (ESS)
28 31 76	08/20	INTERIOR FIRE ALARM AND MASS NOTIFICATION SYSTEM, ADDRESSABLE

DIVISION 31 - EARTHWORK

31 00 00	08/23	EARTHWORK

DIVISION 32 - EXTERIOR IMPROVEMENTS

32 11 20	05/22	BASE COURSE FOR RIGID PAVING
32 13 13.06	05/20	PORTLAND CEMENT CONCRETE PAVEMENT FOR ROADS AND SITE FACILITIES
32 15 00	05/17	AGGREGATE SURFACING
32 16 19	05/18	CONCRETE CURBS, GUTTERS AND SIDEWALKS
32 31 13	11/21	CHAIN LINK FENCES AND GATES

DIVISION 33 - UTILITIES

33 71 02	08/21	UNDERGROUND ELECTRICAL DISTRIBUTION
33 82 00	02/26	TELECOMMUNICATIONS OUTSIDE PLANT (OSP)

-- End of Project Table of Contents --

CODES AND STANDARDS REFERENCED HEREIN

THIS PROJECT IS DESIGNED IN ACCORDANCE WITH THE 2024 INTERNATIONAL BUILDING CODE (IBC) AS MODIFIED BY UFC 1-200-01, 17 DECEMBER 2024.

THE UNITED FACILITIES GUIDE SPECIFICATIONS (UFGS) ARE UPDATED REGULARLY. THE VERSION OR EDITION OF CODES AND STANDARDS REFERENCED HEREIN MAY DIFFER FROM THOSE SPECIFIED IN CHAPTER 35 OF THE IBC. IN THE EVENT OF DISCREPENCIES REGARDING VERSION OR EDITION OF CODES AND STANDARDS, THE IBC WILL TAKE PRECEDENCE.

SECTION 26 05 48

SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT
11/23

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 7-16	(2017; Errata 2018; Supp 1 2018) Minimum Design Loads and Associated Criteria for Buildings and Other Structures

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B18.21.1	(2009; R 2016) Washers: Helical Spring-Lock, Tooth Lock, and Plain Washers (Inch Series)
ASME B18.22M	(1981; R 2017) Metric Plain Washers

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2025) Structural Welding Code - Steel

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel
ASTM A53/A53M	(2024) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A153/A153M	(2023) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A307	(2021) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM A500/A500M	(2023) Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A563	(2021; E 2022a) Standard Specification for Carbon and Alloy Steel Nuts
ASTM A572/A572M	(2021; E 2021) Standard Specification for High-Strength Low-Alloy Columbium-Vanadium

	Structural Steel
ASTM A603	(2019) Standard Specification for Zinc-Coated Steel Structural Wire Rope
ASTM A992/A992M	(2022) Standard Specification for Structural Steel Shapes
ASTM B695	(2021) Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel
ASTM E580/E580M	(2024) Standard Practice for Installation of Ceiling Suspension Systems for Acoustical Tile and Lay-in Panels in Areas Subject to Earthquake Ground Motions
ASTM F436	(2011) Hardened Steel Washers
ASTM F959/F959M	(2017a; R 2023) Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners, Inch and Metric Series
ASTM F1554	(2020) Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength
ASTM F3125/F3125M	(2019) Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 MPa and 1040 MPa Minimum Tensile Strength
METAL FRAMING MANUFACTURERS ASSOCIATION (MFMA)	
MFMA-4	(2004) Metal Framing Standards Publication
U.S. DEPARTMENT OF DEFENSE (DOD)	
MIL-STD-810	(2022; Rev H; Change 1) Environmental Engineering Considerations and Laboratory Tests
UFC 3-301-01	(2023; with Change 2, 2024) Structural Engineering
UL SOLUTIONS (UL)	
UL 1598	(2021; Reprint Jan 2024) UL Standard for Safety Luminaires
VIBRATION ISOLATION AND SEISMIC CONTROL MANUFACTURERS ASSOCIATION (VISCMA)	
VISCMA 413	(2014) Installing Seismic Restraints for Electrical Equipment

1.2 SYSTEM DESCRIPTION

1.2.1 General Requirements

Provide seismic supports and attachments as indicated and in accordance with UFC 3-301-01 and ASCE 7-16.

Components, supports, and attachments must comply with following structural design criteria:

Risk Category: II .
Seismic Design Category: B.
Seismic Design Spectral Response Acceleration Parameter at Short Period (SDS): 0.12g.
Seismic Design Spectral Response Acceleration Parameter at period of 1 second (SD1): 0.084g.

Apply the seismic requirements described in this section and on the drawings to the electrical components listed in paragraph ELECTRICAL COMPONENTS.

Electrical components and their supports must be attached or anchored to structure.

1.2.2 Electrical Components

Provide seismic supports and attachments for the following electrical components in accordance with the requirements of this specification:

Components with Importance Factor (Ip) = 1.0:
Battery Systems
Control Panels
Generators
Light Fixtures
Motors
Storage Racks
Transformers
Uninterruptible Power Supply Systems
Distribution Systems Conduit, Cable Tray, Busway, and Raceway
Utility and Service Lines
Automatic Transfer SwitchesLoad Bank

Components with Importance Factor (Ip) = 1.5
Standby power systems
Fire detection and suppression systems
Emergency exit lighting

1.2.3 Contractor Designed Supports and Attachments

Provide seismic supports and attachments, and isolation and energy dissipation systems for electrical components.

Contractor must retain services of a Registered Professional Engineer to

design supports and attachments, and isolation and energy dissipation systems for electrical components. Supports and attachments, and isolation and energy dissipation systems that induce torsion in structural members are not permitted.

Submit copies of the Design Calculations and Design Drawings. Calculations and Drawings must be stamped and signed by Contractor's Registered Professional Engineer.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Equipment Requirements; G

Lighting Fixtures; G

SD-03 Product Data

Supports and Attachments; G

Equipment Requirements; G

Lighting Fixtures; G

Flexible Fittings; G

Anchors; G

Isolation And Energy Dissipation Systems; G

SD-05 Design Data

Design Calculations; G

Design Drawings; G

SD-06 Test Reports

Anchors; G

PART 2 PRODUCTS

2.1 EQUIPMENT REQUIREMENTS

Equipment must be rugged enough to survive design seismic event. Equipment components designated as Designated Seismic Systems or MC-1 (Mission Critical Level 1) must remain operational as required in paragraph SPECIAL TESTING FOR SEISMIC-RESISTING EQUIPMENT.

Submit detail drawings of supports and attachments, and isolation and energy dissipation systems along with calculations, catalog cuts,

templates, and erection and installation details, as appropriate, for the items listed in paragraph ELECTRICAL COMPONENTS. Indicate thickness, type, grade, class of metal, and dimensions; and show construction details, reinforcement, anchorage, and installation with relation to the building construction.

Submit calculations and drawings that are stamped and signed by Contractor's registered professional engineer. Design must be based on actual equipment and system layout. Design must include calculated loads and capacity of materials utilized for the connection of the equipment or system to the structure. Analysis must detail anchoring methods. Include drawing for Designated Seismic System Equipment indicating the equipment location in the facility to be used for the installation. Equipment must be rigidly or flexibly mounted as indicated. Roof mounted equipment both vibration isolated and nonisolated, must have support members designed and anchored to building structure.

2.1.1 Rigidly (Base and Suspended) Mounted Equipment

The following specific items of equipment must be constructed and assembled to withstand the seismic forces specified in UFC 3-301-01 . Entirely locate each item of rigid electrical equipment and rigidly attach on one side only of a building expansion joint. Provide items such as electrical conduit, which cross the building expansion joint with flexible joints that are capable of accommodating displacements equal to the full width of the joint in each orthogonal direction.

Engine-Generators
Transformers
Free Standing Electric Motors
Automatic Transfer Switches

Equipment furnished under this Contract must be rigidly mounted using cast-in-place anchor bolts or post-installed anchors that are qualified for use in cracked concrete. Cast-in-place anchor bolts must conform to ASTM F1554. For any rigid equipment which is rigidly anchored, provide flexible joints for electrical conduit, cabletray, busway, and raceway, that are capable of accommodating displacements equal to the full width of the joint in both orthogonal directions. Designated Seismic Systems (DSS) for RC IV buildings assigned to Seismic Design Category (SDC) C, D, E, or F and Risk Category IV components needed for continued operation after an earthquake must have two nuts provided on each bolt.

2.2 LIGHTING FIXTURES

Provide lighting fixtures and supports and attachments conforming to UL 1598.

2.3 SUPPORTS AND ATTACHMENTS

Material used for members listed in this section and on the drawings, must conform with the following:

a. Plates, rods, and rolled shapes, ASTM A36/A36M, ASTM A572/A572M Grade 50, or ASTM A992/A992M.

b. Wire rope, ASTM A603 pre-stretched, with Class C weight zinc-coated wires throughout rope. Connect rope at ends using ferrule or saddle-type wire rope clamp systems. Ferrule clamps must be qualified by testing for use in seismic applications per VISCMA 413.

Saddle-type clamps must be used with minimum of two clamps at each end of wire rope.

c. Tubes, ASTM A500/A500M, Grade B.

d. Pipes, ASTM A53/A53M, Grade B.

e. Angles, ASTM A36/A36M.

f. Channels (Struts) with in-turned lips and associated hardware for fastening to channels at discrete points conforming to MFMA-4.

g. Fasteners:

(1) High-strength bolts, ASTM F3125/F3125M, Grade A325, heavy hex.

(2) Nuts, ASTM A563. Use heavy hex nuts for high strength bolts and anchor bolts.

(3) Washers, ASME B18.22M and ASME B18.21.1, except use ASTM F436 washers for high strength bolts.

(4) Galvanized coating, ASTM A153/A153M.

(5) Direct Tension Indicator Washers, ASTM F959/F959M. Provide ASTM B695, Class 55, Type 1 galvanizing. Submit product data for direct tension indicator washers.

(6) Standard bolts, ASTM A307.

h. Anchor bolts:

(1) Cast in anchors: Refer to Section 05 12 00 STRUCTURAL STEEL for requirements.

(2) Post-installed anchors: Refer to Section 05 05 20 POST-INSTALLED CONCRETE AND MASONRY ANCHORS for requirements.

i. Welding: Refer to Section 05 12 00 STRUCTURAL STEEL for requirements.

2.4 FLEXIBLE FITTINGS

Provide flexible fittings to allow conduit, cabletray, busway, and raceway systems to accommodate seismic movement between equipment and conduit, cabletray, busway, and raceway systems and supporting structure. Use specification grade steel fittings conforming to Section 26 20 00 INTERIOR DISTRIBUTION SYSTEMMIL-STD-810. Provide suitable watertight expansion fittings that maintain electrical continuity by bonding jumper or other means. Flexible fittings must accommodate minimum of 4 inches seismic movement in each orthogonal directions.

PART 3 EXECUTION

3.1 SUPPORTS AND ATTACHMENTS

Provide supports and attachments with continuous load path to distribute electrical component seismic loads to structure.

Provide supports and attachments for electrical components that conform to

the arrangements shown to UFC 3-301-01 requirements. Install vertical diagonal braces at a 45-degree slope. Where interference is present, the slope may be minimum of 30 degrees or a maximum of 60 degrees per VISCMA 413.

Provide bolted and welded connections for supports and attachments in accordance with UFC 3-301-01.

Provide welding in accordance with AWS D1.1/D1.1M. Grind visible welds smooth in the finished installation.

3.2 BUILDING DRIFT

Do not attach electrical components to two dissimilar structural elements of a building that may respond differentially during an earthquake unless a flexible joint is provided. Electrical components, supports, and attachments must be capable of accommodating building story drifts, deflections, and relative displacements.

3.3 CONDUIT, CABLETRAY, BUSWAY, AND RACEWAY

Provide supports and attachments for conduit, cabletray, busway, and raceway conforming to the requirements of UFC 3-301-01.

3.4 LIGHTING FIXTURES

Provide lighting fixtures and supports conforming to the following:

3.4.1 Pendant Fixtures

Provide pendant fixtures conforming to the requirements of UFC 3-301-01.

3.4.2 Ceiling Attached Fixtures

3.4.2.1 Recessed Fixtures

Support recessed individual or continuous-row mounted fixtures by a seismic-resistant suspended ceiling support system built in accordance with ASTM E580/E580M. Provide supports and attachments for the fixtures conforming to the requirements of UFC 3-301-01. Recessed lighting fixtures not over 56 pounds in weight and not required to be supported separately from the structure, may be supported by and attached directly to the ceiling system runners using screws or bolts, number and size as required by the seismic design. Provide lock or screw attachments for fixture accessories, including diffusers and lenses.

3.4.2.2 Surface-Mounted Fixtures

Attach surface-mounted individual or continuous-row fixtures to a seismic-resistant ceiling support system built in accordance with ASTM E580/E580MSection 09 51 00 ACOUSTICAL CEILINGS. Provide supports and attachments for the fixtures conforming to the requirements of UFC 3-301-01.

3.4.3 Assembly Mounted on Outlet Box

Design a supporting assembly, that is intended to be mounted on an outlet box, to accommodate mounting features on 4 inch boxes, plaster rings, and fixture studs.

3.4.4 Wall-Mounted Emergency Light Unit

Design and secure attachments for wall-mounted emergency light units for the worst expected seismic disturbance at the site.

3.5 ANCHORS

3.5.1 General

Submit copies of test results to verify the adequacy of the specific anchor and application, as specified. Ensure housekeeping pads have adequate space to mount equipment and seismic restraint devices allowing adequate edge distance and embedment depth for restraint anchor bolts. Identify position of reinforcing steel and other embedded items prior to drilling holes for post-installed anchors. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength. Fill annular gap with nonshrink grout at equipment anchor bolts where clearance between anchor and equipment support hole exceeds 0.125 inches.

3.5.2 Cast-In-Place Anchors

Use templates to locate cast-in-place bolts accurately and securely in formwork. Provide anchor bolts with an embedded straight length with heavy hex nut and plate washer as to provide required strength and ductility. Anchor bolts that exceed the normal depth of equipment foundation piers or pads must either extend into concrete floor or the foundation or increase depth of the piers or pads to accommodate bolt lengths.

3.5.3 Post-Installed Anchors

Refer to Section 05 05 20 POST-INSTALLED CONCRETE AND MASONRY ANCHORS for requirements.

3.6 EQUIPMENT SUPPORT REQUIREMENTS

3.6.1 Suspended Equipment

Provide supports and attachments for components supported from structural systems. Provide supports and attachments that consist of angles, rods, wire rope, bars, channels (struts) or pipes arranged as shown in bracing submittals and secured at both ends with not less than 1/2 inch bolts. Provide sufficient supports and attachments to resist seismic forces as specified in UFC 3-301-01 without exceeding capacity of structural components. Provide, for approval, specific force calculations in accordance with UFC 3-301-01 for the project.

Submit details of supports and attachments for acceptance. In lieu of bracing with vertical supports, these items may be supported with hangers inclined at 45 degrees directed up and radially away from equipment and oriented symmetrically in 90-degree intervals on the horizontal plane, bisecting the angles of each corner of the equipment, provided that supporting members are properly sized to support operating weight when hangers are inclined. Where interference is present, the inclined hanger slope may be minimum of 30 degrees or a maximum of 60 degrees per VISCMA 413.

3.6.2 Floor or Pad Mounted Equipment

3.6.2.1 Shear Resistance

Bolt components to floor or pads. Provide bolts to resist seismic forces in accordance with paragraph ANCHORS.

3.6.2.2 Overturning Resistance

Use the ratio of the overturning moment from seismic forces to the resisting moment due to gravity loads to determine if overturning forces need to be considered in the sizing of anchor bolts. Provide calculations to verify the adequacy of the anchor bolts for combined shear and tension. Provide bolts to resist seismic forces in accordance with paragraph ANCHORS.

-- End of Section --

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SECTION 26 05 73

POWER SYSTEM STUDIES
08/23

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 1584	(2018; E 2019) Guide for Performing Arc-Flash Hazard Calculations
IEEE 1584.1	(2022) Guide for the Specification of Scope and Deliverable Requirements for an Arc-Flash Hazard Calculation Study
IEEE 3002.2	(2018) Recommended Practice for Conducting Load-Flow Studies and Analysis of Industrial and Commercial Power Systems
IEEE 3002.3	(2018) Recommended Practice for Conducting Short-Circuit Studies and Analysis of Industrial and Commercial Power Systems
IEEE C2	(2023) National Electrical Safety Code

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70E	(2024) Standard for Electrical Safety in the Workplace

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-560-01	(2017; with Change 3, 2023) Operation and Maintenance: Electrical Safety

1.2 SYSTEM DESCRIPTION

The power system covered by this specification consists of: a power distribution system that includes a 12.47kV-480Y/277V pad-mount transformer that supplies power to Building 403 and the building next door. The study must include the distribution systems for both buildings to ensure that all existing electrical equipment in the building next door fault current ratings that exceed the available fault current while connected to the new pad-mount transformer. The study must also evaluate the worst case fault current scenario for B403, whether it's connected to the utility source or the generator via the automatic transfer switch (ATS). The power system studies must evaluate all electrical distribution equipment provided as part of this project, including the UPS, which will be government provided, government installed (GFGI).

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Field Examination Plan; G

Arc Flash Label Formats; G

SD-06 Test Reports

Field Examination

SD-07 Certificates

System Analyzer; G

SD-11 Closeout Submittals

Model Files; G

Load Flow Study; G

Fault Current Study; G

System Coordination Study; G

Arc Flash Hazard Study; G

1.4 QUALITY ASSURANCE

1.4.1 System Analyzer

The System Analyzer must perform the power system studies. The System Analyzer must be a registered professional electrical engineer with a minimum of 3 years of experience with power system studies. Include a list of three comparable jobs performed by the System Analyzer with specific names and telephone numbers for reference. Include the license number and state of the registered Professional Engineer.

1.4.2 System Verifier

The System Verifier may inspect and record settings, markings, and otherwise document the existing equipment. The System Verifier may also place appropriate hazard labels on equipment. The System Verifier must not make any calibrations or adjustments or place equipment into service. When working with energized equipment, the system verifier must be a Qualified Person per NFPA 70E or working under the direct supervision of a Qualified Person. The System Verifier may communicate with the system owner to determine if the equipment within the studied system has received maintenance and testing in accordance with NETA MTS or NFPA 70B.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.1 FIELD EXAMINATION

For each pre- and post-study inspection, submit a field examination plan identifying which facilities must be examined to complete the required work. Include a complete information verification procedure, where Qualified Personnel will be required, PPE requirements for "live" equipment examinations, and equipment to be used within the limited approach boundary of the equipment.

3.1.1 General

Perform field inspections of the site and equipment before the first study and after the last study to determine the state and settings of the equipment and to verify the final settings agree with the studies. Perform the post-study inspection(s) after changing settings, after performing acceptance tests, and before placing equipment in service.The post-study inspection may be performed by the testing organization approved in 26 08 00 APPARATUS INSPECTION AND TESTING.

Schedule the field examination by the System Verifier with the Contracting Officer at least 10 business days before conducting examination. Furnish all materials, labor, and equipment necessary to conduct the examination. Maintain a written record of the all equipment examined, equipment location, equipment ratings, settings, personnel involved, and the date the examination was performed. Submit the written record of each field examination.

3.1.2 Safety

Where examination of the equipment requires energized equipment to be opened, provide a Qualified Person to directly supervising any non-Qualified Person within the hazard area. Use PPE, protective barriers, danger signs and other safety devices to protect and warn personnel in the vicinity of "live" equipment being examined.

3.1.3 Application of Arc Flash Labels

Install arc flash warning labels using Qualified Personnel as necessary after the setting and inspection is complete. For new or modified equipment, install labels before the equipment is energized for the first time after installation/modification or setting changes. Schedule the label placement with the Contracting Officer at least 5 business days before label placement. Furnish all materials, labor, and equipment necessary to place the labels. Maintain a written record of the all equipment that received labels, personnel involved, and the date labels were placed.

3.2 POWER SYSTEM STUDIES

Perform power system studies to demonstrate that the equipment selected and system constructed meet the contract requirements for fault current and interrupt ratings, coordination, protection, and Arc Flash Hazard. Submit reports of the studies along with protective device equipment submittals. Apply Arc Flash Hazard labels to equipment after the studies are approved. Update and resubmit the studies after any changes to the equipment or systems which may affect the study results, and re-apply Arc

Flash Hazard labels to equipment after the resubmitted studies are approved. The Government is not responsible for any changes to equipment, device ratings, settings, or additional labor for installation of equipment or devices or labels ordered and/or procured before approval of the study.

3.2.1 Scope of Studies

The scope of the studies must begin at primary side of the 12.47kV-480Y/277V pad-mount transformer and extend down to system buses where fault current availability is 10,000 amperes or less (symmetrical) and at each 600 volts for facility-level distribution buses.

The "source bus" is the source of energy for system being analyzed. This may be the energy feed from a utility, the first bus upstream of the work, generators within the work or upstream of the work, or any other source capable of contributing significant energy into the system being analyzed.

In the systems model for the studies, incorporate all existing and new equipment within the scope of the studies. Incorporate any additional sources or load equipment necessary to accurately model the system's performance.

Where multiple sources of power may be in service in various combinations or where electrical loops are in the system, incorporate into the studies all the modes of operation to evaluate the impact of the modes of operation on the system. The primary modes of operation are listed below.

1. Utility power via the 12.47kV-480Y/277V pad-mount transformer

2. Generator via the ATS.

3.2.2 Determination of Facts

Determine and document the time-current characteristics, features, ratings, ampacities, and nameplate data for each existing protective device, electrical equipment, and feeder cables. Obtain the available fault current from the base electrical engineer. For multiple modes of operation, use the mode with available fault current that produces the greatest incident energies in the arc flash hazard study.

Utilize field-verified data in the power system studies. Document the field-verified data in the report.

3.2.3 Single Line Diagram

Provide a single line diagram showing the electrical system buses, devices, transformation points, and all sources of load current and fault current, including generator and motor contributions. Provide a diagram from the system model. Each bus, device or transformation point must have a unique identifier. Show the location of switches, breakers, and circuit interrupting devices on the diagram together with available fault data, and the device interrupting rating.

The naming of existing components within the system model and single line diagram must match existing installed equipment names. The naming of new

components within the system model and single line diagram must use unique identifiers and be coordinated with the Government.

3.2.4 Load Flow Study

Perform the load flow study in accordance with IEEE 3002.2 to identify initital steady-state conditions for the fault current study. For each operating scenario, provide load flow results on the diagram or in the report. Show or describe the loading factors and assumptions used in each operating mode.

3.2.5 Fault Current Study

Use the results of the load flow study to perform the fault current study in accordance with IEEE 3002.3. Provide balanced three-phase fault, bolted line-to-line fault, and single line-to-ground fault current values at each voltage transformation point and at each power distribution bus. For each location, show in tabular form on the diagram or in the report the maximum and minimum available fault currents of all modes of operation for that location.

Where the available fault current at the source bus is not available, describe how the fault contribution from the source bus was determined and why this method is reasonable for the study.

3.2.6 System Coordination Study

Use the results of the load flow study and fault current study. For normal modes of operation, demonstrate that selectivity has been obtained between the devices within the scope of the project. Demonstrate the equipment, machines, and conductors are protected from damage from overloads and fault conditions. Include a description of the coordination of the protective devices in this project. Provide a written narrative describing which devices may operate in the event of a fault at each bus; the logic used to arrive at device ratings and settings; situations where system coordination is not achievable due to device limitations; coordination between upstream and downstream devices; and relay settings. Provide recommendations to improve or enhance system reliability, and detail where such changes would involve additions or modifications to the contract and cost damages (addition or reduction). Provide composite coordination plots on a log-log scale. Where recommendations are provided to improve or enhance system reliability, provide separate coordination plots on log-log scale showing the system coordination before and after the implementation of the recommendations. Where coordination has been adjusted to lower arc flash values, include a discussion of the change and the impact on the system within the report.

3.2.7 Arc Flash Hazard Study

Perform the arc flash hazard study in accordance with IEEE 1584.1. Utilize the data from the fault current study to determine the worst case incident energy per IEEE 1584, IEEE C2, and OSHA 29 CFR 1910.269 Appendix E. Use identified modes of operation to determine the worst case arc flash energy. If not included in another study, include a description of the devices and device settings for the operating modes that provided the highest arc flash energy. Where the adjusting the coordination of devices to obtain lower arc flash values, include a discussion of the change and the impact on the system within the report. Where the arc flash energies

exceed 4 cal/cm^2 provide recommendations to reduce the arc flash energy to 1.2 cal/cm^2.

3.2.8 Study report(s)

a. Include a narrative describing the studies performed; the bases and methods used; and the desired method of coordinated protection of the power system.

b. Include descriptive and technical data for existing devices and new protective devices proposed. Include manufacturers published data, nameplate data, and definition of the fixed or adjustable features of the existing or new protective devices. For existing devices, included statements on the condition of the equipment based upon field inspections and owner's statements and reports.

c. Document utility company data including system voltages, fault MVA, system X/R ratio, time-current characteristic curves, current transformer ratios, and relay device numbers and settings;generator resistance and reactance values, and time constants; and existing power system data including time-current characteristic curves and protective device ratings and settings. Identify all assumptions about the protection devices, equipment, and system where data was not available.

d. For each bus in the system, provide fully coordinated composite time-current characteristics (TCC) curves as required to ensure coordinated power system protection between protective devices and equipment. In a tabular format, provide recommended ratings and settings of all protective devices.

e. Provide an arc flash study report in accordance with IEEE 1584.1.

f. Provide the calculations performed for the studies, including computer programs utilized. Provide the name of the software package, developer, and version number.

3.2.9 Arc Flash Labels

Provide arc flash warning labels on electrical equipment likely to require examination, servicing, or maintenance while energized. Typical types of equipment include pad-mounted transformers, switchgear, switchboards, panelboards, disconnect switches, industrial control panels, meter socket enclosures, and motor control centers that are in other than dwelling occupancies. The arc flash label naming must match the naming used in the system modeling and the single line diagram.

Comply with the label requirements specified in UFC 3-560-01. Obtain approval of arc flash label formats before printing.

a. Provide a 3.5 inch x 5 inch to 4 inch x 6 inch thermal transfer type label of high adhesion polyester for each location device analyzed. The label must remain in place and be legible for at least 5 years in the installed environment.

b. Labels must be machine printed with no field markings. Provide arc flash labels in the following manner. All labels must be based on implemented overcurrent devices and settings.

1. Provide at least one arc flash label for each 480 volt and 208 volt panelboards.

2. Provide at least one arc flash label for each low voltage (less than 1000 V) switchboard.

3. Where the equipment construction has different hazards levels in different areas, provide a single label representing the worst case hazard for all branch circuits and a separate unique label for the compartment containing the main protective device. On the worst case label, indicate which branch circuit compartments have the worst case hazard.

c. Use the worst case hazard of all operating scenarios unless mitigation procedures are used. If mitigation procedures are used, explain the procedures on the label.

3.3 MODELING

Develop a software model of the electrical system identified in the scope of the studies. Use the latest version of SKM PowerTools(TM). Develop the model with accurate, verified information. Model existing electrical equipment, machines, devices, and conductors directly connected to, altered by, or otherwise affected by the work. This includes, but is not limited to generators, transformers, switchgear, switchboards, panelboards, motor control centers, motors, voltage regulators, tap changers, protective relays, circuit breakers, switches, fuses, conductors, capacitors, reactors, grounding system, and control equipment.

Provide the final model files in their native editable formats for future use by the Government. Include device information for devices not in the software vendor's standard distribution.

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SECTION 26 08 00

APPARATUS INSPECTION AND TESTING
11/22

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

1.2 RELATED REQUIREMENTS

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM applies to this section with additions and modifications specified herein.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-06 Test Reports

Acceptance Tests and Inspections; G

SD-07 Certificates

Qualifications of Organization, and Lead Engineering Technician

Acceptance Test and Inspections Procedure; G

1.4 QUALITY ASSURANCE

1.4.1 Qualifications

Engage the services of a qualified testing organization to provide inspection, testing, calibration, and adjustment of the electrical distribution system and generation equipment listed in paragraph ACCEPTANCE TESTS AND INSPECTIONS herein. Organization must be independent of the supplier, manufacturer, and installer of the equipment. The organization must be a first tier subcontractor. No work required by this section of the specification may be performed by a second tier subcontractor.

a. Submit name and qualifications of organization. Organization must have been regularly engaged in the testing of electrical materials, devices, installations, and systems for a minimum of 5 years. The organization must have a calibration program, and test instruments

used must be calibrated in accordance with NETA ATS.

b. Submit name and qualifications of the lead engineering technician performing the required testing services. Include a list of three comparable jobs performed by the technician with specific names and telephone numbers for reference. Testing, inspection, calibration, and adjustments must be performed by an engineering technician, certified by NETA (Level III) or the National Institute for Certification in Engineering Technologies (NICET) with a minimum of 5 years' experience inspecting, testing, and calibrating electrical distribution and generation equipment, systems, and devices.

1.4.2 Acceptance Tests and Inspections Reports

Submit certified copies of inspection reports and test reports. Include certification of compliance with specified requirements, identify deficiencies, and recommend corrective action when appropriate. Type and neatly bind test reports to form a part of the final record. Submit test reports documenting the results of each test not more than 10 days after test is completed.

1.4.3 Acceptance Test and Inspections Procedure

Submit test procedure reports for each item of equipment to be field tested at least 45 days prior to planned testing date. Do not perform testing until after test procedure has been approved.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.1 ACCEPTANCE TESTS AND INSPECTIONS

Testing organization will perform acceptance tests and inspections. Test methods, procedures, and test values must be performed and evaluated in accordance with NETA ATS, the manufacturer's recommendations, and paragraph FIELD QUALITY CONTROL of each applicable specification section. Tests identified as optional in NETA ATS are not required unless otherwise specified. Place equipment in service only after completion of required tests and evaluation of the test results have been completed. Supply to the testing organization complete sets of shop drawings, settings of adjustable devices, and other information necessary for an accurate test and inspection of the system prior to the performance of any final testing. Notify Contracting Officer at least 14 days in advance of when tests will be conducted by the testing organization. Perform acceptance tests and inspections on applicable equipment and systems specified in the following sections:

a. Section 26 32 15 ENGINE-GENERATOR SET STATIONARY 15-2500 KW, WITH AUXILIARIES. Functional engine shutdown tests, vibration base-line test, and load bank test will not be performed by the testing organization, but by the start-up engineer.

b. Section 26 12 19 PAD-MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS

c. Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Medium voltage

cables and grounding systems only.

d. Section 26 36 23 AUTOMATIC TRANSFER SWITCHES AND BY-PASS/ISOLATION SWITCH

3.2 SYSTEM ACCEPTANCE

Final acceptance of the system is contingent upon satisfactory completion of acceptance tests and inspections.

3.3 PLACING EQUIPMENT IN SERVICE

A representative of the approved testing organization must be present when equipment tested by the organization is initially energized and placed in service.

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SECTION 26 12 19

PAD-MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS
05/24

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A240/A240M	(2024b) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM D92	(2012a) Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester
ASTM D97	(2017b) Standard Test Method for Pour Point of Petroleum Products
ASTM D877/D877M	(2019) Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
ASTM D1535	(2014; R 2018) Standard Practice for Specifying Color by the Munsell System

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide https://www.approvalguide.com/

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 386	(2016) Separable Insulated Connector Systems for Power Distribution Systems Rated 2.5 kV through 35 kV
IEEE C2	(2023) National Electrical Safety Code
IEEE C37.47	(2011) Standard for High Voltage Distribution Class Current-Limiting Type Fuses and Fuse Disconnecting Switches
IEEE C57.12.00	(2021) General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.12.28	(2023) Standard for Pad-Mounted Equipment - Enclosure Integrity
IEEE C57.12.34	(2022) Standard Requirements for

	Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers, 10 MVA and Smaller; High Voltage, 34.5 kV Nominal System Voltage and Below; Low Voltage, 15 kV Nominal System Voltage and Below
IEEE C57.12.80	(2010) Standard Terminology for Power and Distribution Transformers
IEEE C57.12.90	(2021) Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.98	(2011) Guide for Transformer Impulse Tests
IEEE C62.11	(2020) Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1kV)
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 260	(1996; R 2004) Safety Labels for Pad-Mounted Switchgear and Transformers Sited in Public Areas
NEMA Z535.4	(2023) Product Safety Signs and Labels

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2026; TIA 26-1; ERTA 26-1; TIA 26-2; TIA 26-3; TIA 26-4; TIA 26-5; TIA 26-6; TIA 26-7; ERTA 26-2; ERTA 26-3) National Electrical Code

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD)

OECD Test 203	(1992) Fish Acute Toxicity Test

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 712-C-98-075	(1998) Fate, Transport and Transformation Test Guidelines - OPPTS 835.3100- "Aerobic Aquatic Biodegradation"
EPA 821-R-02-012	(2002) Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

10 CFR 431	Energy Efficiency Program for Certain Commercial and Industrial Equipment

UL SOLUTIONS (UL)

UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment

1.2 RELATED REQUIREMENTS

Section 26 08 00 APPARATUS INSPECTION AND TESTING applies to this section, with the additions and modifications specified herein.

1.3 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE Stds Dictionary.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Pad-mounted Transformer Drawings; G

SD-03 Product Data

Pad-mounted Transformers; G

SD-06 Test Reports

Acceptance Checks and Tests; G

SD-07 Certificates

Transformer Efficiencies; G

SD-09 Manufacturer's Field Reports

Transformer Test Schedule; G

Pad-mounted Transformer Design Tests; G

Pad-mounted Transformer Routine and Other Tests; G

SD-10 Operation and Maintenance Data

Transformer(s), Data Package 5; G

1.4.1 Reduced Submittal Requirements

Transformers designed and manufactured by ABB/Hitachi Energy in Jefferson

City, MO; by Eaton's Cooper Power Series Transformers in Waukesha, WI; by ERMCO in Dyersburg, TN; or by Howard Industries in Laurel, MS need not submit the entire submittal package requirements of this contract. Instead, submit the following items:

a. A certification, signed by the manufacturer, stating that the manufacturer will meet the technical requirements of this specification.

b. An outline drawing of the transformer with devices identified (paragraph PAD-MOUNTED TRANSFORMER DRAWINGS, item a).

c. ANSI nameplate data of the transformer (paragraph PAD-MOUNTED TRANSFORMER DRAWINGS, item b).

d. Manufacturer's published time-current curves in PDF format and in electronic format suitable for import or updating into the SKM PowerTools for Windows computer program of the transformer high side fuses (paragraph PAD-MOUNTED TRANSFORMER DRAWINGS, item e).

e. Provide transformer test schedule and routine and other tests required by submittal item "SD-09 Manufacturer's Field Reports".

f. Provide acceptance test reports required by submittal item "SD-06 Test Reports".

g. Provide operation and maintenance manuals required by submittal item "SD-10 Operation and Maintenance Data".

1.5 QUALITY ASSURANCE

1.5.1 Pad-Mounted Transformer Drawings

Include the following as a minimum:

a. An outline drawing, including front, top, and side views.

b. IEEE nameplate data.

c. Elementary diagrams and wiring diagrams.

d. One-line diagram, including switch(es).

1.5.2 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, except of NFPA 70 when more stringent requirements are specified or indicated, as though the word "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Provide equipment, materials, installation, and workmanship in accordance with NFPA 70 unless more stringent requirements are specified or indicated.

1.5.3 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship, and:

a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.

b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.

c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.3.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.3.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site are not acceptable.

1.6 MAINTENANCE

1.6.1 Additions to Operation and Maintenance Data

Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and as specified herein. In addition to requirements of Data Package 5, include the following on the actual transformer(s) provided:

a. An instruction manual with pertinent items and information highlighted

b. An outline drawing, front, top, and side views

c. Prices for spare parts and supply list

d. Routine and field acceptance test reports

e. Fuse curves for primary fuses

f. Actual nameplate diagram

g. Date of purchase

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

Products and materials not considered to be pad-mounted transformers and related accessories are specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, and Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.2 THREE-PHASE PAD-MOUNTED TRANSFORMERS

IEEE C57.12.34, IEEE C57.12.28 and as specified herein. Submit manufacturer's information for each component, device, insulating fluid, and accessory provided with the transformer.

2.2.1 Compartments

Provide high- and low-voltage compartments separated by steel isolating barriers extending the full height and depth of the compartments. Compartment doors: hinged lift-off type with stop in open position and three-point latching.

2.2.1.1 High Voltage, Dead-Front

High-voltage compartment contains: the incoming line, insulated high-voltage load-break connectors, bushing well inserts, six high-voltage bushing wells configured for loop feed application, load-break switch handle(s), access to oil-immersed bayonet fuses, dead-front surge arresters, tap changer handle, connector parking stands and ground pad.

Minimum high-voltage compartment dimensions: IEEE C57.12.34, Figures 16 and 17.

a. Insulated high-voltage load-break connectors: IEEE 386, rated 15 kV, 95 kV BIL. Current rating: 200 amperes rms continuous. Short time rating: 10,000 amperes rms symmetrical for a time duration of 0.17 seconds. Connector must have a steel reinforced hook-stick eye, grounding eye, test point, and arc-quenching contact material.

b. Insulated high-voltage dead-break connectors: IEEE 386, rated 15 kV, 95 kV BIL. Current rating: 600 amperes rms continuous. Short time rating: 25,000 amperes rms symmetrical for a time duration of 0.17 seconds. Connector must have a 200 ampere bushing interface for surge arresters, steel reinforced hook-stick eye, grounding eye, test point, and arc-quenching contact material.

c. Load-break switch

Loop feed sectionalizer switches: Provide three, two-position, oil-immersed type switches to permit closed transition loop feed and sectionalizing. Each switch must be rated at 15 kV, 95 kV BIL, with a continuous current rating and load-break rating of 200 amperes, and a make-and-latch rating of 12,000 rms amperes symmetrical. Locate the switch handles in the high-voltage compartment. Operation of switches must be as follows:

ARRANGEMENT NO.	DESCRIPTION OF SWITCH ARRANGEMENT	SWITCH POSITION					
		LINE A SW.		LINE B SW		XFMR. SW	
		OPEN	CLOSE	OPEN	CLOSE	OPEN	CLOSE
1	Line A connected to Line B and both lines connected to transformer		X		X		X

ARRANGEMENT NO.	DESCRIPTION OF SWITCH ARRANGEMENT	SWITCH POSITION					
		LINE A SW.		LINE B SW		XFMR. SW	
		OPEN	CLOSE	OPEN	CLOSE	OPEN	CLOSE
2	Transformer connected to Line A only		X	X			X
3	Transformer connected to Line Bonly	X			X		X
4	Transformer open and loop closed		X		X	X	
5	Transformer open and loop open	X		X		X	

d. Provide bayonet oil-immersed, expulsion fuses in series with oil-immersed, partial-range, current-limiting fuses. The bayonet fuse links sense both high currents and high oil temperature in order to provide thermal protection to the transformer. Coordinate transformer protection with expulsion fuse clearing low-current faults and current-limiting fuse clearing high-current faults beyond the interrupting rating of the expulsion fuse. Include an oil retention valve inside the bayonet assembly housing, which closes when the fuse holder is removed, and an external drip shield to minimize oil spills. Display a warning label adjacent to the bayonet fuse(s) cautioning against removing or inserting fuses unless the transformer has been de-energized and the tank pressure has been released.

Bayonet fuse assembly: 150 kV BIL.

Oil-immersed current-limiting fuses: IEEE C37.47; 50,000 rms amperes symmetrical interrupting rating at the system voltage specified. Connect current-limiting fuses ahead of the radial-feed load-break switch.

e. Surge arresters: IEEE C62.11, rated 15 kV, fully shielded, dead-front, metal-oxide-varistor, elbow type with resistance-graded gap. Provide six arresters for loop feed circuits.

f. Parking stands: Provide a parking stand near each bushing.

2.2.1.2 Low Voltage

Low-voltage compartment contains: low-voltage bushings with NEMA spade terminals, accessories, metering, stainless steel or laser-etched anodized aluminum diagrammatic transformer nameplate, and ground pad.

a. Include the following accessories: drain valve with sampler device, fill plug, pressure relief device, liquid level gage, pressure-vacuum gage, and dial type thermometer with maximum temperature indicator.

b. Metering: Provide as specified in Section 26 27 13.10 30 ELECTRIC

METERS.

2.2.2 Transformer

a. Less-flammable bio-based liquid-insulated, two winding, 60 hertz, 65 degrees C rise above a 30 degrees C average ambient, self-cooled type.

b. Transformer rated 750 kVA.

c. Transformer voltage ratings: 12.4k V Delta 480 - 277 V GrdY.

d. Tap changer: externally operated, manual type for changing tap setting when the transformer is de-energized. Provide four 2.5 percent full capacity taps, two above and two below rated primary voltage. Indicate which tap setting is in use, clearly visible when the compartment is opened.

e. Minimum tested percent impedance at 85 degrees C:

(1) .50 for units rated 75kVA and below
(2) .87 for units rated 112.5kVA to 300kVA
(3) .03 for 500kVA rated units
(4) .32 for units rated 750kVA and above

f. Comply with the following audible sound level limits:

kVA	DECIBELS (MAX
75	51
112.5	55
150	55
225	55
300	55
500	56
750	57
1000	58
1500	60
2000	61
2500	62

g. Include:

(1) Lifting lugs and provisions for jacking under base, with base construction suitable for using rollers or skidding in any direction.

(2) An insulated low-voltage neutral bushing with NEMA spade terminal, and with removable ground strap.

(3) kVA rating conspicuously displayed on its enclosure.

2.2.2.1 Specified Transformer Efficiencies

Provide transformer efficiency calculations utilizing the actual no-load and load loss values obtained during the routine tests performed on the actual transformer(s) prepared for this project. Reference no-load losses (NLL) at 20 degrees C. Reference load losses (LL) at 55 degrees C and at 50 percent of the nameplate load. The transformer is not acceptable if the calculated transformer efficiency is less than the efficiency indicated in the "KVA / Efficiency" table below. The table is based on requirements contained within 10 CFR 431, Subpart K. Submit certification, including supporting calculations, from the manufacturer indicating conformance.

kVA	EFFICIENCY (percent)
15	98.65
30	98.83
45	98.92
75	99.03
112.5	99.11
150	99.16
225	99.23
300	99.27
500	99.35
750	99.40
1000	99.43
1500	99.48
2000	99.51
2500	99.53
above 2500	99.54

2.2.3 Insulating Liquid

a. Less-flammable transformer liquids: NFPA 70 and FM APP GUIDE for less-flammable liquids having a fire point not less than 300 degrees C tested per ASTM D92 and a dielectric strength not less than 33 kV

tested per ASTM D877/D877M. Provide identification of transformer as "non-PCB" and "manufacturer's name and type of fluid" on the nameplate.

Provide a fluid that is a biodegradable, electrical insulating, and cooling liquid classified by UL and approved by FM as "less flammable" with the following properties:

(1) Pour point: ASTM D97, less than -15 degree C

(2) Aquatic biodegradation: EPA 712-C-98-075, ultimately biodegradable as designated by EPA.

(3) Trout toxicity: OECD Test 203, zero mortality of EPA 821-R-02-012, pass

2.2.3.1 Liquid-Filled Transformer Nameplates

Provide nameplate information in accordance with IEEE C57.12.00 and as modified or supplemented by this section.

2.2.4 Corrosion Protection

Provide corrosion resistant bases and cabinets of transformers, fabricated of stainless steel conforming to ASTM A240/A240M, Type 304 or 304L. Base includes any part of pad-mounted transformer that is within 3 inches of concrete pad.

Paint entire transformer assembly Munsell 7GY3.29/1.5 green, with paint coating system complying with IEEE C57.12.28 regardless of base, cabinet, and tank material. The Munsell color notation is specified in ASTM D1535.

2.3 WARNING SIGNS AND LABELS

Provide warning signs for the enclosures of pad-mounted transformers having a nominal rating exceeding 600 volts in accordance with NEMA Z535.4 and NEMA 260.

a. When the enclosure integrity of such equipment is specified to be in accordance with IEEE C57.12.28, such as for pad-mounted transformers, provide self-adhesive warning labels on the outside of the high voltage compartment door(s)with nominal dimensions of 7 by 10 inches with the legend "WARNING HIGH VOLTAGE" printed in two lines of nominal 2 inch high letters. Include the work "WARNING" in white letters on an orange background and the words "HIGH VOLTAGE" in black letters on a white background.

b. When such equipment is guarded by a fence, mount signs on the fence. Provide metal signs having nominal dimensions of 14 by 10 inches with the legend "WARNING HIGH VOLTAGE KEEP OUT" printed in three lines of nominal 3 inch high white letters on an orange and black field.

2.4 ARC FLASH WARNING LABEL

Provide arc flash warning label for the enclosure of pad-mounted transformers. Locate this self-adhesive warning label on the outside of the high voltage compartment door warning of potential electrical arc flash hazards and appropriate PPE required. Provide label format as indicated.

2.5 GROUNDING AND BONDING

UL 467. Provide grounding and bonding as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.6 PADLOCKS

Provide padlocks for pad-mounted equipment, keyed . Comply with Section 08 71 00 DOOR HARDWARE.

2.7 CAST-IN-PLACE CONCRETE

Provide concrete associated with electrical work for other than encasement of underground ducts rated for 4000 psi minimum 28-day compressive strength unless specified otherwise. Conform to the requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE.

2.8 SOURCE QUALITY CONTROL

2.8.1 Transformer Test Schedule

The Government reserves the right to witness tests. Provide transformer test schedule for tests to be performed at the manufacturer's test facility. Submit required test schedule and location, and notify the Contracting Officer 30 calendar days before scheduled test date. Notify Contracting Officer 15 calendar days in advance of changes to scheduled date.

a. Test Instrument Calibration

(1) Provide a calibration program which assures that all applicable test instruments are maintained within rated accuracy.

(2) Accuracy: Traceable to the National Institute of Standards and Technology.

(3) Instrument calibration frequency schedule: less than or equal to 12 months for both test floor instruments and leased specialty equipment.

(4) Dated calibration labels: visible on all test equipment.

(5) Calibrating standard: higher accuracy than that of the instrument tested.

(6) Keep up-to-date records that indicate dates and test results of instruments calibrated or tested. For instruments calibrated by the manufacturer on a routine basis, in lieu of third party calibration, include the following:

(a) Maintain up-to-date instrument calibration instructions and procedures for each test instrument.

(b) Identify the third party/laboratory calibrated instrument to verify that calibrating standard is met.

2.8.2 Design Tests

IEEE C57.12.00, and IEEE C57.12.90. Section 5.1.2 in IEEE C57.12.80

states that "design tests are made only on representative apparatus of basically the same design." Submit design test reports (complete with test data, explanations, formulas, and results), in the same submittal package as the catalog data and drawings for the specified transformer, with design tests performed prior to the award of this contract.

a. Tests: certified and signed by a registered professional engineer.

b. Temperature rise: "Basically the same design" for the temperature rise test means a pad-mounted transformer with the same coil construction (such as wire wound primary and sheet wound secondary), the same kVA, the same cooling type (KNAN), the same temperature rise rating, and the same insulating liquid as the transformer specified.

c. Lightning impulse: "Basically the same design" for the lightning impulse dielectric test means a pad-mounted transformer with the same BIL, the same coil construction (such as wire wound primary and sheet wound secondary), and a tap changer, if specified. Design lightning impulse tests includes the primary windings only of that transformer.

   (1) IEEE C57.12.90, paragraph 10.3 entitled "Lightning Impulse Test Procedures," and IEEE C57.98.

   (2) State test voltage levels.

   (3) Provide photographs of oscilloscope display waveforms or plots of digitized waveforms with test report.

d. Lifting and moving devices: "Basically the same design" requirement for the lifting and moving devices test means a test report confirming that the lifting device being used is capable of handling the weight of the specified transformer in accordance with IEEE C57.12.34.

e. Pressure: "Basically the same design" for the pressure test means a pad-mounted transformer with a tank volume within 30 percent of the tank volume of the transformer specified.

f. Short circuit: "Basically the same design" for the short circuit test means a pad-mounted transformer with the same kVA as the transformer specified.

2.8.3 Routine and Other Tests

IEEE C57.12.00. Routine and other tests: performed in accordance with IEEE C57.12.90 by the manufacturer on the actual transformer prepared for this project to ensure that the design performance is maintained in production. Submit test reports, by serial number and receive approval before delivery of equipment to the project site. Required tests and testing sequence as follows:

a. Phase relation

b. Ratio

c. No-load losses (NLL) and excitation current

d. Load losses (LL) and impedance voltage

e. Dielectric

(1) Impulse

(2) Applied voltage

(3) Induced voltage

f. Leak

PART 3 EXECUTION

3.1 INSTALLATION

Conform to IEEE C2, NFPA 70, and to the requirements specified herein. Provide new equipment and materials unless indicated or specified otherwise.

3.2 GROUNDING

NFPA 70 and IEEE C2, except provide grounding systems with a resistance to solid earth ground not exceeding 25 ohms.

3.2.1 Grounding Electrodes

Provide driven ground rods as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Connect ground conductors to the upper end of ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors.

3.2.2 Pad-Mounted Transformer Grounding

Provide a ground ring around the transformer with 1/0 AWG bare copper. Provide four ground rods in the ground ring, one per corner. Install the ground rods at least 10 feet apart from each other. Provide separate copper grounding conductors and connect them to the ground loop as indicated. When work in addition to that indicated or specified is required to obtain the specified ground resistance, the provision of the contract covering "Changes" applies.

3.2.3 Connections

Make joints in grounding conductors and loops by exothermic weld or compression connector. Install exothermic welds and compression connectors as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.2.4 Grounding and Bonding Equipment

UL 467, except as indicated or specified otherwise.

3.3 INSTALLATION OF EQUIPMENT AND ASSEMBLIES

Install and connect pad-mounted transformers furnished under this section as indicated on project drawings, the approved shop drawings, and as specified herein.

3.4 FIELD APPLIED PAINTING

Where field painting of enclosures is required to correct damage to the

manufacturer's factory applied coatings, provide manufacturer's recommended coatings and apply in accordance with manufacturer's instructions.

3.5 WARNING SIGN MOUNTING

Provide the number of signs required to be readable from each accessible side, but space the signs a maximum of 30 feet apart.

3.6 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES

Mount transformer on concrete slab as follows:

a. Unless otherwise indicated, provide the slab with dimensions at least 8 inches thick, reinforced with a 6 by 6 inches - W2.9 by W2.9 mesh placed uniformly 4 inches from the top of the slab.

b. Place slab on a 6 inch thick, well-compacted gravel base.

c. Install slab such that top of concrete slab is approximately 4 inches above the finished grade with gradual slope for drainage.

d. Provide edges above grade with 1/2 inch chamfer.

e. Provide slab of adequate size to project at least 8 inches beyond the equipment.

Stub up conduits, with bushings, 2 inches into cable wells in the concrete pad. Coordinate dimensions of cable wells with transformer cable training areas.

3.6.1 Cast-In-Place Concrete

Provide cast-in-place concrete work in accordance with the requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.6.2 Sealing

When the installation is complete, seal all entries into the equipment enclosure with an approved sealing method. Provide seals of sufficient strength and durability to protect all energized live parts of the equipment from rodents, insects, or other foreign matter.

3.7 FIELD QUALITY CONTROL

3.7.1 Performance of Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS. Submit reports, including acceptance criteria and limits for each test in accordance with NETA ATS "Test Values".

3.7.1.1 Pad-Mounted Transformers

a. Visual and mechanical inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition. Check for damaged or cracked insulators and leaks.

(3) Inspect anchorage, alignment, and grounding.

(4) Verify the presence of PCB content labeling.

(5) Verify the bushings and transformer interiors are clean.

(6) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

(7) Verify correct liquid level in tanks and bushings.

(8) Verify that positive pressure is maintained on gas-blanketed transformers.

(9) Perform specific inspections and mechanical tests as recommended by manufacturer.

(10) Verify de-energized tap changer position is left as specified.

(11) Verify the presence of transformer surge arresters.

b. Electrical tests

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter.

(2) Verify proper secondary voltage phase-to-phase and phase-to-neutral after energization and prior to loading.

3.7.1.2 Grounding System

a. Visual and mechanical inspection

(1) Inspect ground system for compliance with contract plans and specifications.

b. Electrical tests

(1) Perform ground-impedance measurements utilizing the fall-of-potential method. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground resistance tester in accordance with manufacturer's instructions to test each ground or group of grounds. Use an instrument equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

(2) Submit the measured ground resistance of each ground rod and grounding system, indicating the location of the rod and grounding system. Include the test method and test setup (i.e.,

pin location) used to determine ground resistance and soil conditions at the time the measurements were made.

3.7.1.3 Surge Arresters, Medium- and High-Voltage

a. Visual and mechanical inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Inspect anchorage, alignment, grounding, and clearances.

(4) Verify the arresters are clean.

(5) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

(6) Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.

b. Electrical tests

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

(2) Perform an insulation-resistance test on each arrester, phase terminal-to-ground.

(3) Test grounding connection.

3.7.2 Follow-Up Verification

Upon completion of acceptance checks and tests, show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. As an exception to requirements stated elsewhere in the contract, notify the Contracting Officer 5 working days in advance of the dates and times of checking and testing.

-- End of Section --

SECTION 26 20 00

INTERIOR DISTRIBUTION SYSTEM
08/23

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 90.1 - IP	(2019) Energy Standard for Buildings Except Low-Rise Residential Buildings

ASTM INTERNATIONAL (ASTM)

ASTM B1	(2013) Standard Specification for Hard-Drawn Copper Wire
ASTM B8	(2023) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE C2	(2023) National Electrical Safety Code
IEEE C37.90.1	(2023; ERTA) Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION (NECA)

NECA NEIS 1	(2015) Standard for Good Workmanship in Electrical Construction

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C80.1	(2020) American National Standard for Electrical Rigid Steel Conduit (ERSC)
ANSI C80.3	(2020) American National Standard for Electrical Metallic Tubing (EMT)
NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA AB 1	(2002) Molded-Case Circuit Breakers, Molded Case Switches, and Circuit-Breaker Enclosures
NEMA BU 1.1	(2010) General Instructions for Proper Handling, Installation, Operation and Maintenance of Busway Rated 600 V or Less
NEMA FU 1	(2012) Low Voltage Cartridge Fuses
NEMA ICS 1	(2022) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 4	(2015) Application Guideline for Terminal Blocks
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA KS 1	(2013) Enclosed and Miscellaneous Distribution Equipment Switches (600 V Maximum)
NEMA MG 1	(2021) Motors and Generators
NEMA MG 10	(2017) Energy Management Guide for Selection and Use of Fixed Frequency Medium AC Squirrel-Cage Polyphase Induction Motors
NEMA MG 11	(1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors
NEMA PB 1	(2011) Panelboards
NEMA RN 1	(2018) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA ST 20	(2014) Dry-Type Transformers for General Applications
NEMA TC 2	(2020) Standard for Electrical Polyvinyl Chloride (PVC) Conduit

NEMA TC 3	(2021) Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing
NEMA VE 2	(2018; ERTA 1-2 2018) Cable Tray Installation Guidelines
NEMA WD 1	(1999; R 2020) Standard for General Color Requirements for Wiring Devices
NEMA WD 6	(2021) Wiring Devices Dimensions Specifications
NEMA Z535.4	(2023) Product Safety Signs and Labels

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2026; TIA 26-1; ERTA 26-1; TIA 26-2; TIA 26-3; TIA 26-4; TIA 26-5; TIA 26-6; TIA 26-7; ERTA 26-2; ERTA 26-3) National Electrical Code
NFPA 70E	(2024) Standard for Electrical Safety in the Workplace
NFPA 780	(2023) Standard for the Installation of Lightning Protection Systems

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-568.1	(2020e) Commercial Building Telecommunications Infrastructure Standard
TIA-569	(2019e; Add 1 2022) Telecommunications Pathways and Spaces
TIA-607	(2019d) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

10 CFR 431	Energy Efficiency Program for Certain Commercial and Industrial Equipment
29 CFR 1910.147	The Control of Hazardous Energy (Lock Out/Tag Out)
29 CFR 1910.303	Electrical, General

UL SOLUTIONS (UL)

UL 1	(2005; Reprint Jan 2022) UL Standard for Safety Flexible Metal Conduit
UL 5	(2016; Reprint Jul 2022) UL Standard for Safety Surface Metal Raceways and Fittings
UL 5A	(2015; Reprint Apr 2024) Nonmetallic

	Surface Raceways and Fittings
UL 6	(2022) UL Standard for Safety Electrical Rigid Metal Conduit-Steel
UL 20	(2018; Reprint May 2023) UL Standard for Safety General-Use Snap Switches
UL 44	(2018; Reprint May 2021) UL Standard for Safety Thermoset-Insulated Wires and Cables
UL 50	(2024) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations
UL 67	(2018; Reprint Aug 2025) UL Standard for Safety Panelboards
UL 83	(2017; Reprint Oct 2025) UL Standard for Safety Thermoplastic-Insulated Wires and Cables
UL 248-4	(2010; Reprint Apr 2019) Low-Voltage Fuses - Part 4: Class CC Fuses
UL 248-8	(2011; Reprint Aug 2020) Low-Voltage Fuses - Part 8: Class J Fuses
UL 248-10	(2011; Reprint Aug 2020) Low-Voltage Fuses - Part 10: Class L Fuses
UL 248-12	(2011; Reprint Aug 2020) Low Voltage Fuses - Part 12: Class R Fuses
UL 248-15	(2018) Low-Voltage Fuses - Part 15: Class T Fuses
UL 360	(2013; Reprint Jan 2024) UL Standard for Safety Liquid-Tight Flexible Metal Conduit
UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment
UL 486A-486B	(2018; Reprint Jul 2023) UL Standard for Safety Wire Connectors
UL 486C	(2018; Reprint May 2021) UL Standard for Safety Splicing Wire Connectors
UL 489	(2025) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 498	(2017; Reprint Jun 2024) UL Standard for Safety Attachment Plugs and Receptacles
UL 506	(2017; Reprint Jan 2022) UL Standard for Safety Specialty Transformers

UL 508	(2018; Reprint Jul 2021) UL Standard for Safety Industrial Control Equipment
UL 510	(2020; Dec 2022) UL Standard for Safety Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 514A	(2024) UL Standard for Safety Metallic Outlet Boxes
UL 514B	(2012; Reprint Mar 2024) UL Standard for Safety Conduit, Tubing and Cable Fittings
UL 514C	(2014; Reprint Apr 2024) UL Standard for Safety Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL 651	(2011; Reprint May 2022) UL Standard for Safety Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings
UL 797	(2007; Reprint Apr 2023) UL Standard for Safety Electrical Metallic Tubing -- Steel
UL 854	(2020; Reprint Jul 2024) Standard for Service-Entrance Cables
UL 857	(2009; Reprint Apr 2021) UL Standard for Safety Busways
UL 869A	(2006; Reprint Jun 2020) Reference Standard for Service Equipment
UL 870	(2016; Reprint Nov 2023) UL Standard for Safety Wireways, Auxiliary Gutters, and Associated Fittings
UL 943	(2016; Reprint Sep 2023) UL Standard for Safety Ground-Fault Circuit-Interrupters
UL 984	(1996; Reprint Sep 2005) Hermetic Refrigerant Motor-Compressors
UL 1004-1	(2012; Reprint Nov 2020) UL Standard for Safety Rotating Electrical Machines - General Requirements
UL 1063	(2017; Reprint Jun 2022) UL Standard for Safety Machine-Tool Wires and Cables
UL 1449	(2021; Reprint Oct 2025) UL Standard for Safety Surge Protective Devices
UL 1561	(2011; Reprint Aug 2023) Dry-Type General Purpose and Power Transformers
UL 1660	(2019; Reprint May 2024) Liquid-Tight Flexible Nonmetallic Conduit

UL 2043	(2023) Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces
UL 4248-1	(2022) UL Standard for Safety Fuseholders - Part 1: General Requirements
UL 4248-12	(2018; Reprint Feb 2022) UL Standard for Safety Fuseholders - Part 12: Class R

1.2 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE Stds Dictionary.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Panelboards; G

Transformers; G

Busway; G

Cable Trays; G

Wireways; G

Marking Strips Drawings; G

SD-03 Product Data

Receptacles; G

Circuit Breakers; G

Switches

Transformers; G

Enclosed Circuit Breakers

Motor Controllers

Manual Motor Starters

Docking Station; G

Surge Protective Devices

Cable Trays; G

Power Distribution Unit (PDU); G

SD-05 Design Data

Cable Tray Design; G

SD-06 Test Reports

600-volt Wiring Test; G

Grounding System Test; G

Transformer Tests; G

Ground-fault Receptacle Test; G

SD-07 Certificates

Fuses; G

SD-09 Manufacturer's Field Reports

Transformer Factory Tests

1.4 QUALITY ASSURANCE

1.4.1 Fuses

Submit coordination data as specified in paragraph, FUSES of this section.

1.4.2 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Provide equipment, materials, installation, and workmanship in accordance with NFPA 70 unless more stringent requirements are specified or indicated. NECA NEIS 1 shall be considered the minimum standard for workmanship.

1.4.3 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship and:

a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.

b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.

c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.4.3.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.4.3.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site are not acceptable.

1.5 MAINTENANCE

1.6 WARRANTY

Provide equipment items supported by service organizations that are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.7 SEISMIC REQUIREMENTS

Provide seismic details conforming to Section 26 05 48 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

As a minimum, meet requirements of UL, where UL standards are established for those items, and requirements of NFPA 70 for all materials, equipment, and devices.

2.2 CONDUIT AND FITTINGS

Conform to the following:

2.2.1 Rigid Metallic Conduit

2.2.1.1 Rigid, Threaded Zinc-Coated Steel Conduit

ANSI C80.1, UL 6.

2.2.2 Rigid Nonmetallic Conduit

PVC Type EPC-40 in accordance with NEMA TC 2,UL 651.

2.2.3 Zinc-Coated Steel Metallic Tubing (EMT)

UL 797, ANSI C80.3.

2.2.4 Plastic-Coated Rigid Steel Conduit

NEMA RN 1, Type 40(40 mils thick).

2.2.5 Flexible Metal Conduit

UL 1, limited to 6 feet.

2.2.5.1 Liquid-Tight Flexible Metal Conduit, Steel

UL 360, limited to 6 feet.

2.2.6 Fittings for Metal Conduit, EMT, and Flexible Metal Conduit

UL 514B. Ferrous fittings: cadmium- or zinc-coated in accordance with UL 514B.

2.2.6.1 Fittings for Rigid Metal Conduit

Threaded-type. Split couplings unacceptable.

2.2.6.2 Fittings for EMT

Steel compression type.

2.2.7 Fittings for Rigid Nonmetallic Conduit

NEMA TC 3 for PVC and UL 514B.

2.2.8 Liquid-Tight Flexible Nonmetallic Conduit

UL 1660.

2.3 SURFACE RACEWAY

2.3.1 Surface Metal Raceway

UL 5, two-piece painted steel, totally enclosed, snap-cover type. Provide multiple outlet-type raceway with grounding-type receptacle where indicated. Provide receptacles as specified herein, spaced a minimum of one every 18 inches. Wire alternate receptacles on different circuits.

2.3.2 Surface Nonmetallic Raceway

UL 5A, nonmetallic totally enclosed, snap-cover type. Provide multiple outlet-type raceway with grounding-type receptacle where indicated. Provide receptacles as specified herein, spaced a minimum of one every 18 inches. Wire alternate receptacles on different circuits.

2.4 BUSWAY

NEMA BU 1.1, UL 857. Provide the following:

a. Buses: copper.

b. Busways: rated 120/208 volts, 600 continuous current amperes, three-phase, four-wire, and include integral or internal ground bus.

c. Short circuit rating: 65 kAIC.

d. Busway systems: suitable for use indoors. Fixed support system.

e. Enclosures: aluminum.

f. Hardware: plated or otherwise protected to resist corrosion.

g. Joints: one-bolt type with through-bolts, which can be checked for tightness without de-energizing system.

h. Maximum hot spot temperature rise at any point in busway at continuous rated load: do not exceed 55 degrees C above maximum ambient temperature of 40 degrees C in any position.

i. Internal barriers to prevent movement of superheated gases.

j. Coordinate proper voltage phasing of entire bus duct system, for example where busway interfaces with transformers, switchgear, switchboards, motor control centers, and other system components.

2.4.1 Feeder Busways

Provide ventilated, except that vertical busways within 6 feet of floors must be unventilated, low-impedance busway. Provide bus bars fully covered with insulating material, except at stabs. Provide an entirely polarized busway system.

2.4.2 Plug-In Busways

Unventilated type. Provide the following:

a. Plug-in units: circuit breaker-type.

b. Bus bars: covered with insulating material throughout, except at joints and other connection points.

c. A hook stick of suitable length for operating plug-in units from the floor.

2.5 CABLE TRAYS

NEMA VE 2. Provide the following:

Submit cable tray design, including dimensional layout, load and seismic calculations, and fill calculations. Dimensional layout includes cable spacings, cable tray splices, and supports. Fill calculations include an index of cables for each section and identification of the lb/ft, cross sectional area, and insulation voltage class for each cable.

a. Cable trays: form a wireway system, with a nominal depth as indicated. Cable tray is to have a span/load class designation NEMA VE 2.

b. Cable trays: constructed of steel that has been hot-dipped galvanized after fabrication.

c. Cable trays: include splice and end plates, dropouts, and miscellaneous hardware.

d. Edges, fittings, and hardware: finished free from burrs and sharp edges.

e. Fittings: ensure not less than load-carrying ability of straight tray sections and have manufacturer's minimum standard radius.

f. Radius of bends: as indicated.

2.5.1 Basket-Type Cable Trays

Provide size as indicated with maximum wire mesh spacing of 2 by 4 inch.

2.5.2 Ladder-Type Cable Trays

Provide size as indicated with maximum rung spacing of 6 inches.

2.6 OPEN TELECOMMUNICATIONS CABLE SUPPORT

2.6.1 Open Top Cable Supports

Provide open top cable supports in accordance with UL 2043. Provide as indicated.

2.6.2 Closed Ring Cable Supports

Provide closed ring cable supports in accordance with UL 2043. Provide as indicated.

2.7 OUTLET BOXES AND COVERS

UL 514A, cadmium- or zinc-coated, if ferrous metal. UL 514C, if nonmetallic.

2.7.1 Floor Outlet Boxes

Provide the following:

a. Boxes: adjustable.

b. Each outlet: consisting of sheet-steel body with knockouts for conduits, adjustable ring, and cover plate with 3/4, 1, 1 1/4 inch threaded plug.

c. Telecommunications outlets: consisting of flush, aluminum or stainless steel housing with a receptacle as specified and one inch bushed side opening, 3/4 inch top opening.

d. Receptacle outlets: consisting of flush aluminum or stainless steel housing with duplex-type receptacle as specified herein.

e. Provide gaskets where necessary to ensure watertight installation.

2.7.2 Outlet Boxes for Telecommunications System

Provide the following:

a. Standard type 4 inches square by 2 1/8 inches deep.

b. Outlet boxes for wall-mounted telecommunications outlets: 4 by 2 1/8 by 2 1/8 inches deep.

c. Depth of boxes: large enough to allow manufacturers' recommended conductor bend radii.

d. Outlet boxes for fiber optic telecommunication outlets: include a minimum 3/8 inch deep single or two gang plaster ring as shown and installed using a minimum one inch conduit system.

2.8 CABINETS, JUNCTION BOXES, AND PULL BOXES

UL 50; volume greater than 100 cubic inches, NEMA Type 1 enclosure; sheet steel, hot-dip, zinc-coated. Where exposed to wet, damp, or corrosive environments, NEMA Type as indicated.

2.9 WIRES AND CABLES

Provide wires and cables in accordance applicable requirements of NFPA 70 and UL for type of insulation, jacket, and conductor specified or indicated. Do not use wires and cables manufactured more than 24 months prior to date of delivery to site.

2.9.1 Conductors

Provide the following:

a. Provide copper conductors.

b. Conductors No. 8 AWG and larger diameter: stranded.

c. Conductors No. 10 AWG and smaller diameter: solid.

d. Conductors for remote control, alarm, and signal circuits, classes 1, 2, and 3: stranded unless specifically indicated otherwise.

2.9.1.1 Equipment Manufacturer Requirements

When manufacturer's equipment requires copper conductors at the terminations or requires copper conductors to be provided between components of equipment, provide copper conductors or splices, splice boxes, and other work required to satisfy manufacturer's requirements.

2.9.1.2 Minimum Conductor Sizes

Provide minimum conductor size in accordance with the following:

a. Branch circuits: No. 12 AWG.

b. Class 1 remote-control and signal circuits: No. 14 AWG.

c. Class 2 low-energy, remote-control and signal circuits: No. 16 AWG.

d. Class 3 low-energy, remote-control, alarm and signal circuits: No. 22 AWG.

e. Digital low voltage lighting control (DLVLC) system at 24 Volts or less: Category 5 UTP cables in accordance with DLVLC system manufacturer requirements.

2.9.2 Color Coding

Provide color coding for service, feeder, branch, control, and signaling

circuit conductors.

2.9.2.1 Ground and Neutral Conductors

Provide color coding of ground and neutral conductors as follows:

a. Grounding conductors: Green.

b. Neutral conductors: White.

c. Exception, where neutrals of more than one system are installed in same raceway or box, other neutrals color coding: white with a different colored (not green) stripe for each.

2.9.2.2 Ungrounded Conductors

Provide color coding of ungrounded conductors in different voltage systems as follows:

a. 208/120 volt, three-phase

(1) Phase A - black

(2) Phase B - red

(3) Phase C - blue

b. 480/277 volt, three-phase

(1) Phase A - brown

(2) Phase B - orange

(3) Phase C - yellow

c. 120/240 volt, single phase: Black and red

2.9.3 Insulation

Unless specified or indicated otherwise or required by NFPA 70, provide power and lighting wires rated for 600-volts, Type THWN/THHN conforming to UL 83 or Type XHHW-2 conforming to UL 44, except that grounding wire may be type TW conforming to UL 83; remote-control and signal circuits: Type TW or TF, conforming to UL 83. Where equipment or devices require 90-degree Centigrade (C) conductors, provide only conductors with 90-degree C insulation or better.

2.9.4 Bonding Conductors

ASTM B1, solid bare copper wire for sizes No. 8 AWG and smaller diameter; ASTM B8, Class B, stranded bare copper wire for sizes No. 6 AWG and larger diameter.

2.9.4.1 Telecommunications Bonding Backbone (TBB)

Provide a copper conductor TBB in accordance with TIA-607 with No. 6 AWG minimum size, and sized at 2 kcmil per linear foot of conductor length up to a maximum size of 750 kcmil. Provide insulated TBB with insulation as specified in the paragraph INSULATION and meeting the fire ratings of its

pathway.

2.9.4.2 Bonding Conductor for Telecommunications

Provide a copper conductor Bonding Conductor for Telecommunications between the telecommunications main grounding busbar (PBB) and the electrical service ground in accordance with TIA-607. Size the bonding conductor for telecommunications the same as the TBB.

2.9.5 Service Entrance Cables

Service Entrance (SE) and Underground Service Entrance (USE) Cables, UL 854.

2.10 SPLICES AND TERMINATION COMPONENTS

UL 486A-486B for wire connectors and UL 510 for insulating tapes. Connectors for No. 10 AWG and smaller diameter wires: insulated, pressure-type in accordance with UL 486A-486B or UL 486C (twist-on splicing connector). Provide solderless terminal lugs on stranded conductors.

2.11 DEVICE PLATES

Provide the following:

a. UL listed, one-piece device plates for outlets to suit the devices installed.

b. For plates on unfinished walls (TEF, electrical, fire riser): zinc-coated sheet steel or cast metal having round or beveled edges.

c. Plates on finished walls: nylon or lexan, minimum 0.03 inch wall thickness and same color as receptacle or toggle switch with which they are mounted.

d. Plates on finished walls (labs, offices, conference, restrooms): satin finish stainless steel or brushed-finish aluminum, minimum 0.03 inch thick.

e. Screws: machine-type with countersunk heads in color to match finish of plate.

f. Sectional type device plates are not be permitted.

g. Plates installed in wet locations: gasketed and UL listed for "wet locations."

2.12 SWITCHES

2.12.1 Toggle Switches

NEMA WD 1, UL 20, single pole, totally enclosed with bodies of thermoplastic or thermoset plastic and mounting strap with grounding screw. Include the following:

a. Handles: white thermoplastic for offices, labs, conference rooms, vestibule, and restrooms. Provide grey thermoplastic for TEF, electrical room, and fire riser room.

b. Wiring terminals: screw-type, side-wired.

c. Contacts: silver-cadmium and contact arm - one-piece copper alloy.

d. Switches: rated quiet-type ac only, 120/277 volts, with current rating and number of poles indicated.

2.12.2 Switch with Red Pilot Handle

NEMA WD 1. Provide the following:

a. Pilot lights that are integrally constructed as a part of the switch's handle.

b. Pilot light color: red and illuminate whenever the switch is closed or "on".

c. Pilot lighted switch: rated 20 amps and 120 volts or 277 volts as indicated.

d. The circuit's neutral conductor to each switch with a pilot light.

2.12.3 Breakers Used as Switches

For 120- and 277-Volt fluorescent fixtures, mark breakers "SWD" in accordance with UL 489.

2.12.4 Disconnect Switches

NEMA KS 1. Provide heavy duty-type switches where indicated, where switches are rated higher than 240 volts, and for double-throw switches. Utilize Class R fuseholders and fuses for fused switches, unless indicated otherwise. Provide horsepower rated for switches serving as the motor-disconnect means. Provide switches in NEMA, enclosure as indicated per NEMA ICS 6.

2.13 FUSES

NEMA FU 1. Provide complete set of fuses for each fusible switch. Coordinate time-current characteristics curves of fuses serving motors or connected in series with circuit breakers for proper operation. Submit coordination data for approval. Provide fuses with a voltage rating not less than circuit voltage.

2.13.1 Fuseholders

Provide in accordance with UL 4248-1.

2.13.2 Cartridge Fuses, Current Limiting Type (Class R)

UL 248-12, Class RK-1 time-delay type. Provide only Class R associated fuseholders in accordance with UL 4248-12.

2.13.3 Cartridge Fuses, High-Interrupting Capacity, Current Limiting Type (Classes J, L, and CC)

UL 248-8, UL 248-10, UL 248-4, Class J for zero to 600 amperes, Class L for 601 to 6,000 amperes, and Class CC for zero to 30 amperes.

2.13.4 Cartridge Fuses, Current Limiting Type (Class T)

UL 248-15, Class T for zero to 1,200 amperes, 300 volts; and zero to 800 amperes, 600 volts.

2.14 RECEPTACLES

Provide the following:

a. UL 498, general purpose specification grade, grounding-type. Residential grade receptacles are not acceptable.

b. Ratings and configurations: as indicated.

c. Bodies: NEMA WD 1. Provide white for offices, labs, conferences rooms, vestibule and restrooms. Provide grey thermoplastic for TEF, electrical room and fire riser room)

d. Face and body: thermoplastic supported on a metal mounting strap.

e. Dimensional requirements: per NEMA WD 6.

f. Screw-type, side-wired wiring terminals or of the solderless pressure type having suitable conductor-release arrangement.

g. Grounding pole connected to mounting strap.

h. The receptacle: containing triple-wipe power contacts and double or triple-wipe ground contacts.

2.14.1 Weatherproof Receptacles

Provide receptacles, UL listed for use in "wet locations" with integral GFCI protection. Include cast metal box with gasketed, hinged, lockable and weatherproof while-in-use, die-cast metal/aluminum extra-duty rated hood.

2.14.2 Ground-Fault Circuit Interrupter Receptacles

UL 943, duplex type for mounting in standard outlet box. Provide device capable of detecting current leak when the current to ground is 6 milliamperes or higher, and tripping per requirements of UL 943 for Class A ground-fault circuit interrupter devices. Provide screw-type, side-wired wiring terminals or pre-wired (pigtail) leads.

2.14.3 Special Purpose Receptacles

Provide in ratings indicated. Furnish one matching plug with each receptacle.

2.14.4 Plugs

Provide heavy-duty, rubber-covered three-, four-, or five-wire cord of required size, install plugs thereon, and attach to equipment. Provide UL listed plugs with receptacles, complete with grounding blades. Where equipment is not available, turn over plugs and cord assemblies to the Government.

2.15 PANELBOARDS

Provide panelboards in accordance with the following:

a. Panelboards for use as service disconnecting means: additionally conform to UL 869A.

b. Panelboards: circuit breaker-equipped.

c. Designed such that individual breakers can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as means of obtaining clearances as required by UL.

d. "Specific breaker placement" is required in panelboards to match the breaker placement indicated in the panelboard schedule on the design drawings. If it is not possible to match "specific breaker placement" during construction, obtain Government approval prior to device installation.

e. Use of "Subfeed Breakers" is not acceptable.

f. Main breaker: "separately" mounted "above" or "below" branch breakers.

g. Where "space only" is indicated, make provisions for future installation of breakers.

h. Directories: indicate load served by each circuit in panelboard.

i. Directories: indicate source of service to panelboard (e.g., Panel PA served from Panel MDP).

j. Type directories and mount in holder behind transparent protective covering.

k. Panelboards: listed and labeled for their intended use.

l. Panelboard nameplates: provided in accordance with paragraph FIELD FABRICATED NAMEPLATES.

2.15.1 Enclosure

Provide panelboard enclosure in accordance with the following:

a. UL 50.

b. Cabinets mounted outdoors or flush-mounted: hot-dipped galvanized after fabrication or fiberglass enclosure.

c. Cabinets: painted in accordance with paragraph FIELD APPLIED PAINTING.

d. Outdoor cabinets: NEMA 3R raintight with a removable steel plate 1/4 inch thick in the bottom for field drilling for conduit connections.

e. Front edges of cabinets: form-flanged or fitted with structural shapes welded or riveted to the sheet steel, for supporting the panelboard front.

f. All cabinets: fabricated such that no part of any surface on the

finished cabinet deviates from a true plane by more than 1/8 inch.

g. Holes: provided in the back of indoor surface-mounted cabinets, with outside spacers and inside stiffeners, for mounting the cabinets with a 1/2 inch clear space between the back of the cabinet and the wall surface.

h. Flush doors: mounted on hinges that expose only the hinge roll to view when the door is closed.

i. Each door: fitted with a combined catch and lock latch.

j. Keys: two provided with each lock, with all locks keyed alike.

k. Finished-head cap screws: provided for mounting the panelboard fronts on the cabinets.

2.15.2 Panelboard Buses

Support bus bars on bases independent of circuit breakers. Design main buses and back pans so that breakers may be changed without machining, drilling, or tapping. Provide isolated neutral bus in each panel for connection of circuit neutral conductors. Provide separate ground bus identified as equipment grounding bus per UL 67 for connecting grounding conductors; bond to steel cabinet.

2.15.3 Circuit Breakers

UL 489, thermal magnetic-type having a minimum short-circuit current rating equal to the short-circuit current rating of the panelboard in which the circuit breaker will be mounted. Breaker terminals: UL listed as suitable for type of conductor provided. Where indicated on the drawings, provide circuit breakers with shunt trip devices. Series rated circuit breakers and plug-in circuit breakers are unacceptable.

2.15.3.1 Multipole Breakers

Provide common trip-type with single operating handle. Design breaker such that overload in one pole automatically causes all poles to open. Maintain phase sequence throughout each panel so that any three adjacent breaker poles are connected to Phases A, B, and C, respectively.

2.15.3.2 Circuit Breaker With Ground-Fault Circuit Interrupter

UL 943 and NFPA 70. Provide with auto-monitoring (self-test) and lockout features, "push-to-test" button, visible indication of tripped condition, and ability to detect and trip when current imbalance is 6 milliamperes or higher per requirements of UL 943 for Class A ground-fault circuit interrupter devices.

2.16 ENCLOSED CIRCUIT BREAKERS

UL 489. Individual molded case circuit breakers with voltage and continuous current ratings, number of poles, overload trip setting, and short circuit current interrupting rating as indicated. Enclosure type as indicated.

2.17 MOTOR SHORT-CIRCUIT PROTECTOR (MSCP)

Motor short-circuit protectors, also called motor circuit protectors (MCPs): UL 508 and UL 489, and provided as shown. Provide MSCPs that consist of an adjustable instantaneous trip circuit breaker used only in conjunction with a combination motor controller which provides coordinated motor branch-circuit overload and short-circuit protection. Rate MSCPs in accordance with the requirements of NFPA 70.

2.18 TRANSFORMERS

Provide transformers in accordance with the following:

a. NEMA ST 20, general purpose, dry-type, self-cooled, ventilated.

b. Provide transformers in NEMA 1 enclosure.

c. Taps for transformers 15 kVA and larger: Two 2.5 percent taps Full Capacity Above Nominal (FCAN) and four 2.5 percent taps Full Capacity Below Nominal (FCBN).

d. Transformer insulation system:

   (1) 220 degrees C insulation system for transformers 15 kVA and greater, with temperature rise not exceeding 80 degrees C under full-rated load in maximum ambient of 40 degrees C.

   (2) 180 degrees C insulation for transformers rated 10 kVA and less, with temperature rise not exceeding 80 degrees C under full-rated load in maximum ambient of 40 degrees C.

e. Transformer of 150 degrees C temperature rise is not acceptable.

f. Transformer of 115 degrees C temperature rise: capable of carrying continuously 115 percent of nameplate kVA without exceeding insulation rating.

g. Transformers: quiet type with maximum sound level at least 3 decibels less than NEMA standard level for transformer ratings indicated.

2.18.1 Specified Transformer Efficiency

Transformers, indicated and specified with: 480V primary, 80 degrees C or 115 degrees C temperature rise, kVA ratings of 37.5 to 100 for single phase or 30 to 500 for three phase, energy efficient type. The transformer is not acceptable if the calculated transformer efficiency is less than the efficiency indicated in 10 CFR 431, Subpart K.

2.18.2 K-Rated Transformers

Provide K-rated transformers for non-linear loads in accordance with the following:

a. Transformer insulation: UL recognized 220 degrees C system. Neither the primary nor the secondary temperature is allowed to exceed 220 degrees C at any point in the coils while carrying their full rating of non-sinusoidal load.

b. Transformers are to be UL listed and labeled for K-13 in accordance with UL 1561.

c. Transformers evaluated by the UL K-Factor evaluation: listed for 115 degrees C average temperature rise only.

d. Transformers with K-Factor ratings with temperature rise of 150 degrees C rise are not acceptable.

e. K-Factor rated transformers impedance: allowed range of 3 percent to 5 percent, with a minimum reactance of 2 percent to prevent excessive neutral current when supplying loads with large amounts of third harmonic.

2.19 POWER DISTRIBUTION UNIT (PDU)

The PDU will provide harmonic mitigation, isolation, distribution, and control and monitoring of AC power. PDU shall conform to NEMA AB 1, NEMA PB 1, and NEMA ST 20. Provide a NEMA 1 enclosure with dead front construction. The input voltage of the PDU will be 480V ac, three-phase, three-wire plus ground. The output voltage of the PDU shall be 208VAC, three-phase, four-wire plus ground. The PDU shall accommodate both bottom and top feed cables. Rear access to the PDU shall not be required for normal maintenance unless required for the addition of sidecars. The total harmonic current distortion at the input of the PDU shall be less than 12 percent and the rise in total harmonic voltage distortion shall be less than 2.5 percent with 100 percent non-linear load over the entire load range. Basis of design, Mirus International Harmonic Mitigating Power Centers.

Provide a pedestal for the PDU that is designed to be used with a raised access floor. Each pedestal shall be designed for the weight of the PDU, designed in accordance with the manufacturer's recommendations and meet the seismic requirements provided in Section 26 05 48 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT.

2.19.1 Transformer

NEMA ST 20, dry-type, self-cooled, and ventilated. Transformer shall have 220 degrees C insulation system with temperature rise not exceeding 130 degrees C under full-rated load in maximum ambient of 40 degrees C. Transformers shall have at least two taps of plus or minus 2.5 percent.

Transformers shall have a K-factor up to 20 and be of energy efficient type. Transformer rating will be as shown on the drawings. Dual electrostatic shields for 120 dB common mode noise attenuation.

2.19.2 Panelboards

Panelboards shall conform to UL 67. Each panel shall be equipped with a main breaker and include 200 percent rated neutral buses. Design shall be such that individual breakers can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as means of obtaining clearances as required by UL. "Specific breaker placement" is required in panelboards to match the breaker placement indicated in the panelboard schedule on the drawings. Each PDU shall be equipped with the quantity of panelboards specified on the drawings and additional side cars to the PDU shall be provided as needed to house these panelboards. Panelboard bus rating, short-circuit rating, and circuit

breaker sizes and quantities as shown on the drawings. Each breaker within the panelboards shall be monitored by the PDU. Refer to the Monitoring paragraph for the parameters that are required for each breaker.

2.19.3 Monitoring

The PDU shall be equipped with a system power monitor for metering and providing a digital display of the systems electrical power parameters.

The system monitor shall be a multifunction, microprocessor based digital display, data acquisition and control device. The following overall system parameters shall be displayed on a minimum 175 mm touchscreen display.

a. Current (each phase and neutral).

b. Voltage (phase to phase and phase to neutral.

c. kW and kWh (three-phase total).

d. Current Demand (three-phase total and per phase).

e. kW peak.

f. Frequency.

g. Power Factor (three-phase total and per phase).

h. kVA, kVAh, kVAR, and kVARh per phase and total.

i. kW, kVA and kVAR demand.

j. Voltage THD per phase.

k. Current THD per phase.

The PDUs shall include monitoring for every feeder breaker that can be viewed using the 175 mm touchscreen display. The following parameters shall be available for each individual feeder breaker.

a. RMS Current and Max Current.

b. Voltage.

c. kW and kWh (including kWh/m and kWh/y).

d. VA.

e. PF.

All metered values shall be true RMS. The monitor shall include a keypad for selecting different values. The monitoring system shall also provide data outputs of the above information for remote monitoring via Ethernet TCP/IP.

2.19.4 Remote Emergency Power Off (EPO)

Each PDU shall be equipped with an EPO to shut down the respective unit

upon activation.

2.20 DOCKING STATION

The docking station will be located outdoors. See the Contract Documents for additional requirements. Short circuit withstand rating must be 65 kAIC minimum.

Provide factory installed phase rotation monitor device.

Provide UL 489 listed breakers where shown on Contract Documents. Interlocked permanent line breaker and temporary generator breaker. Provide necessary components, keys and coordination for interlocking with permanent generator.

2.20.1 Enclosure

NEMA 3R rain-tight, stainless steel enclosure. NEMA rain-tight integrity must be maintained while temporary cabling is connected during use. Pad-lockable front door shall include a hinged access plate at the bottom for entry of temporary cabling that prevents unauthorized tampering while in use. Front and Side shall be accessible for maintenance. Top, Side, and Bottom shall be accessible for permanent cabling.

2.20.2 Phase, Neutral and Ground Busbar

2.20.2.1 Material

Silver-plated Copper.

2.20.2.2 Equipment Ground Bus

Bonded to box.

2.20.2.3 Isolated Ground Bus

Insulated from box.

2.20.2.4 Ground Bus

50 percent of phase size.

2.20.2.5 Neutral Bus

Neutral bus rated 100 percent of phase bus.

2.20.3 Temporary Generator and Load Bank Connections

Camlok shall be 16 Series model and color coded according to system voltage requirements. Camlok connections shall be Bus Bar Style, Cabling or Double Set Screw is not acceptable. Camlok connection shall be protected against accidental contact while not in use.

Permanent Connection shall be factory installed broad range set-screw mechanical type, located behind a physical barrier.

2.20.4 Temporary Generator and Load Bank Connections

Provide a surge protection device, alarms, local metering, and a two wire

auto start for temporary generator.

2.21 METERING

2.21.1 Digital Meters

IEEE C37.90.1 for surge withstand. Provide true rms, plus/minus one percent accuracy, programmable, microprocessor-based meter enclosed in a sealed case with the following features.

2.21.2 Display Capability

Display capability Multi-Function Meter: Display a selected phase to neutral voltage, phase to phase voltage, percent phase to neutral voltage THD, percent phase to phase voltage THD; a selected phase current, neutral current, percent phase current THD, percent neutral current; selected total PF, kW, KVA, kVAR, FREQ, kVAh, kWh. Detected alarm conditions include over/under current, over/under voltage, over/under KVA, over/under frequency, over/under selected PF/kVAR, voltage phase reversal, voltage imbalance, reverse power, over percent THD. Include a Form C KYZ pulse output relay on the meter.

Design meters to accept input from standard 5A secondary instrument transformers and direct voltage monitoring range to 600 volts, phase to phase.

Provide programming via a front panel display and a communication interface accessible by a computer.

Provide password secured programming stored in non-volatile EEPROM memory.

Provide digital communications in a Modbus RTU protocol via a RS485 serial port.

Provide meter that calculates and stores average max/min demand values with time and date for all readings based on a user selectable sliding window averaging period.

Provide meter with programmable hi/low set limits with two Form C dry contact relays when exceeding alarm conditions.

Provide meter with a display of Total Harmonic Distortion (THD) measurement to a minimum of the thirty-first order.

Include historical trend logging capability with the ability to store up to 100,000 data points with intervals of 1 second to 180 minutes. Provide a unit that can store and time stamp up to 1000 programmable triggered conditions.

2.21.3 Submetering

ASHRAE 90.1 - IP. Provide submetering for for all loads as indicated in the drawings.

2.22 MOTORS

Provide motors in accordance with the following:

a. NEMA MG 1.

b. Hermetic-type sealed motor compressors: Also comply with UL 984.

c. Provide the size in terms of HP, or kVA, or full-load current, or a combination of these characteristics, and other characteristics, of each motor as indicated or specified.

d. Determine specific motor characteristics to ensure provision of correctly sized starters and overload heaters.

e. Rate motors for operation on 208-volt, 3-phase circuits with a terminal voltage rating of 200 volts, and those for operation on 480-volt, 3-phase circuits with a terminal voltage rating of 460 volts.

f. Use motors designed to operate at full capacity with voltage variation of plus or minus 10 percent of motor voltage rating.

g. Unless otherwise indicated, use continuous duty type motors if rated 1 HP and above.

h. Where fuse protection is specifically recommended by the equipment manufacturer, provide fused switches in lieu of non-fused switches indicated.

i. Use Inverter-Duty motors designed to operate with adjustable speed drive (ASD).

2.22.1 High Efficiency Single-Phase Motors

Single-phase fractional-horsepower alternating-current motors: high efficiency types are not acceptable. In exception, for special purpose motors and motor-driven equipment with a minimum seasonal or overall efficiency rating, such as a SEER rating, provide equipment with motor to meet the overall system rating indicated.

2.22.2 Premium Efficiency Polyphase and Single-Phase Motors

Select polyphase and continuous-duty single phase motors based on high efficiency characteristics relative to typical characteristics and applications as listed in NEMA MG 10 and NEMA MG 11. In addition, continuous rated, polyphase squirrel-cage medium induction motors must meet the requirements for premium efficiency electric motors in accordance with NEMA MG 1, including the NEMA full load efficiency ratings. In exception, for motor-driven equipment with a minimum seasonal or overall efficiency rating, such as a SEER rating, provide equipment with motor to meet the overall system rating indicated. Electronically Commutated Motors (ECM) to have an integrated controller that senses rotor position and electronically commutates the stator windings to provide synchronous rotation. The rotor must be of a permanent magnet type supported by ball bearings to increase motor efficiency and longevity. The motor must maintain 70 percent or greater efficiency for its design application. ECM motors to comply with UL 1004-1.

2.22.3 Motor Sizes

Provide size for duty to be performed, not exceeding the full-load nameplate current rating when driven equipment is operated at specified capacity under most severe conditions likely to be encountered. When

motor size provided differs from size indicated or specified, make adjustments to wiring, disconnect devices, and branch circuit protection to accommodate equipment actually provided. Provide controllers for motors rated 1-hp and above with electronic phase-voltage monitors designed to protect motors from phase-loss, undervoltage, and overvoltage. Provide protection for motors from immediate restart by a time adjustable restart relay.

2.22.4 Wiring and Conduit

Provide internal wiring for components of packaged equipment as an integral part of the equipment. Provide power wiring and conduit for field-installed equipment using adjustable speed drive (ASD) manufacturer required wiring type and length, and motor control equipment forming part of motor control centers or switchgear assemblies, the conduit and wiring connecting such centers, assemblies, or other power sources to equipment as specified herein. Power wiring and conduit: conform to the requirements specified herein. Control wiring: provided under, and conform to, the requirements of the section specifying the associated equipment.

2.23 MOTOR CONTROLLERS

Provide motor controllers in accordance with the following:

a. UL 508, NEMA ICS 1, and NEMA ICS 2.

b. Provide controllers with thermal overload protection in each phase, and one spare normally open auxiliary contact, and one spare normally closed auxiliary contact.

c. Provide controllers for motors rated 1-hp 746 watts and above with electronic phase-voltage monitors designed to protect motors from phase-loss, undervoltage, and overvoltage.

d. Provide protection for motors from immediate restart by a time adjustable restart relay.

e. When used with pressure, float, or similar automatic-type or maintained-contact switch, provide a hand/off/automatic selector switch with the controller.

f. Connections to selector switch: wired such that only normal automatic regulatory control devices are bypassed when switch is in "hand" position.

g. Safety control devices, such as low and high pressure cutouts, high temperature cutouts, and motor overload protective devices: connected in motor control circuit in "hand" and "automatic" positions.

h. Control circuit connections to hand/off/automatic selector switch or to more than one automatic regulatory control device: made in accordance with indicated or manufacturer's approved wiring diagram.

i. Provide selector switch with the means for locking in any position.

j. Provide a disconnecting means, capable of being locked in the open position, for the motor that is located in sight from the motor location and the driven machinery location. As an alternative,

provide a motor controller disconnect, capable of being locked in the open position, to serve as the disconnecting means for the motor if it is in sight from the motor location and the driven machinery location.

k. Overload protective devices: provide adequate protection to motor windings; be thermal inverse-time-limit type; and include manual reset-type pushbutton on outside of motor controller case.

l. Cover of combination motor controller and manual switch or circuit breaker: interlocked with operating handle of switch or circuit breaker so that cover cannot be opened unless handle of switch or circuit breaker is in "off" position.

m. Provide controllers in hazardous locations with classifications as indicated.

2.23.1 Control Wiring

Provide control wiring in accordance with the following:

a. All control wire: stranded tinned copper switchboard wire with 600-volt flame-retardant insulation Type SIS meeting UL 44, or Type MTW meeting UL 1063, and passing the VW-1 flame tests included in those standards.

b. Hinge wire: Class K stranding.

c. Current transformer secondary leads: not smaller than No. 10 AWG.

d. Control wire minimum size: No. 14 AWG.

e. Power wiring for 480-volt circuits and below: the same type as control wiring with No. 12 AWG minimum size.

f. Provide wiring and terminal arrangement on the terminal blocks to permit the individual conductors of each external cable to be terminated on adjacent terminal points.

2.23.2 Control Circuit Terminal Blocks

Provide control circuit terminal blocks in accordance with the following:

a. NEMA ICS 4.

b. Control circuit terminal blocks for control wiring: molded or fabricated type with barriers, rated not less than 600 volts.

c. Provide terminals with removable binding, fillister or washer head screw type, or of the stud type with contact and locking nuts.

d. Terminals: not less than No. 10 in size with sufficient length and space for connecting at least two indented terminals for 10 AWG conductors to each terminal.

e. Terminal arrangement: subject to the approval of the Contracting Officer with not less than four spare terminals or 10 percent, whichever is greater, provided on each block or group of blocks.

f. Modular, pull apart, terminal blocks are acceptable provided they are

of the channel or rail-mounted type.

g. Submit data showing that any proposed alternate will accommodate the specified number of wires, are of adequate current-carrying capacity, and are constructed to assure positive contact between current-carrying parts.

2.23.2.1 Types of Terminal Blocks

a. Short-Circuiting Type: Short-circuiting type terminal blocks: furnished for all current transformer secondary leads with provision for shorting together all leads from each current transformer without first opening any circuit. Terminal blocks: comply with the requirements of paragraph CONTROL CIRCUIT TERMINAL BLOCKS above.

b. Load Type: Load terminal blocks rated not less than 600 volts and of adequate capacity: provided for the conductors for NEMA Size 3 and smaller motor controllers and for other power circuits, except those for feeder tap units. Provide terminals of either the stud type with contact nuts and locking nuts or of the removable screw type, having length and space for at least two indented terminals of the size required on the conductors to be terminated. For conductors rated more than 50 amperes, provide screws with hexagonal heads. Conducting parts between connected terminals must have adequate contact surface and cross-section to operate without overheating. Provide each connected terminal with the circuit designation or wire number placed on or near the terminal in permanent contrasting color.

2.23.3 Control Circuits

Control circuits: maximum voltage of 120 volts derived from control transformer in same enclosure. Transformers: conform to UL 506, as applicable. Transformers, other than transformers in bridge circuits: provide primaries wound for voltage available and secondaries wound for correct control circuit voltage. Size transformers so that 80 percent of rated capacity equals connected load. Provide disconnect switch on primary side. Provide fuses in each ungrounded primary feeder. Provide one fused secondary lead with the other lead grounded. For designated systems, as indicated, provide backup power supply, including transformers connected to emergency power source. Provide for automatic switchover and alarm upon failure of primary control circuit.

2.23.4 Enclosures for Motor Controllers

NEMA ICS 6.

2.23.5 Multiple-Speed Motor Controllers and Reversible Motor Controllers

Across-the-line-type, electrically and mechanically interlocked. Multiple-speed controllers: include compelling relays and multiple-button, station-type with pilot lights for each speed.

2.23.6 Pushbutton Stations

Provide with "start/stop" momentary contacts having one normally open and one normally closed set of contacts, and red lights to indicate when motor is running. Stations: heavy duty, oil-tight design.

2.23.7 Pilot and Indicating Lights

Provide LED cluster lamps.

2.24 MANUAL MOTOR STARTERS (MOTOR RATED SWITCHES)

Single pole designed for surface mounting with overload protection and pilot lights.

2.24.1 Pilot Lights

Provide yoke-mounted, seven element LED cluster light module. Color: green.

2.25 LOCKOUT REQUIREMENTS

Provide circuit breakers, disconnecting means, and other devices that are electrical energy-isolating capable of being locked out for machines and other equipment to prevent unexpected startup or release of stored energy in accordance with 29 CFR 1910.147, NFPA 70E and 29 CFR 1910.303. Comply with requirements of Division 23, "Heating, Ventilating, and Air Conditioning (HVAC)" for mechanical isolation of machines and other equipment.

2.26 TELECOMMUNICATIONS SYSTEM

Provide system of telecommunications wire-supporting structures (pathway), including: outlet boxes, conduits with pull wires wireways, cable trays, and other accessories for telecommunications outlets and pathway in accordance with TIA-569 and as specified herein. Additional telecommunications requirements are specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

2.27 GROUNDING AND BONDING EQUIPMENT

2.27.1 Ground Rods

UL 467. Ground rods: cone pointed copper-clad steel, with minimum diameter of 3/4 inch and minimum length 10 feet. Sectional type rods may be used for rods 20 feet or longer.

2.27.2 Ground Bus

Copper ground bus: provided in the electrical equipment rooms as indicated.

2.28 MANUFACTURER'S NAMEPLATE

Provide on each item of equipment a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.29 FIELD FABRICATED NAMEPLATES

Provide field fabricated nameplates in accordance with the following:

a. ASTM D709.

b. Provide laminated plastic nameplates for each equipment enclosure,

relay, switch, and device; as specified or as indicated on the drawings.

c. Each nameplate inscription: identify the function and, when applicable, the position.

d. Nameplates: melamine plastic, 0.125 inch thick, white with black center core.

e. Surface: matte finish. Corners: square. Accurately align lettering and engrave into the core.

f. Minimum size of nameplates: one by 2.5 inches.

g. Lettering size and style: a minimum of 0.25 inch high normal block style.

2.30 WARNING SIGNS

Provide warning signs for flash protection in accordance with NFPA 70E and NEMA Z535.4 for switchboards, panelboards, industrial control panels, and motor control centers that are in other than dwelling occupancies and are likely to require examination, adjustment, servicing, or maintenance while energized. Provide field installed signs to warn qualified persons of potential electric arc flash hazards when warning signs are not provided by the manufacturer. Provide marking that is clearly visible to qualified persons before examination, adjustment, servicing, or maintenance of the equipment.

2.31 FIRESTOPPING MATERIALS

Provide firestopping around electrical penetrations in accordance with Section 07 84 00 FIRESTOPPING.

2.32 WIREWAYS

UL 870. Material: steel galvanized 16 gauge for heights and depths up to 6 by 6 inches, and 14 gauge for heights and depths up to 12 by 12 inches. Provide in length required for the application with screw-cover NEMA 12 enclosure per NEMA ICS 6.

2.33 SURGE PROTECTIVE DEVICES

Provide parallel type surge protective devices (SPD) which comply with UL 1449 at the service entrance, load centers , panelboards . Provide surge protectors in a NEMA 1 enclosure per NEMA ICS 6. Do not install SPD inside a panelboard or switchboard enclosure. However, SPD may be installed in a separate compartment of a switchgear provided that it is supplied by a dedicated circuit breaker. SPD must have the same short-circuit current rating as the protected equipment and must not be installed at a point of system where the available fault current is in excess of that rating. Use Type 1 or Type 2 SPD and connect on the load side of a dedicated circuit breaker. Submit performance and characteristic curves.

Provide the following modes of protection:

FOR SINGLE PHASE AND THREE PHASE WYE CONNECTED SYSTEMS-
Phase to phase (L-L)

Each phase to neutral (L-N)
Neutral to ground (N-G)
Phase to ground (L-G)

FOR DELTA CONNECTIONS-
Phase to phase (L-L)
Phase to ground (L-G)

SPDs at the service entrance: provide with a minimum surge current rating of 80,000 amperes for L-L mode minimum and 40,000 amperes for other modes (L-N, L-G, and N-G).

Provide SPDs per NFPA 780 for the lightning protection system.

Maximum L-N, and N-G Voltage Protection Rating:

1,200V for 480Y/277V, three phase system

Maximum L-G Protection Rating:
1,200V for 480Y/277V, three phase system

Maximum L-L Voltage Protection Rating:

1,800V for 480Y/277V, three phase system

The minimum MCOV (Maximum Continuous Operating Voltage) rating for L-N and L-G modes of operation: 120 percent of nominal voltage for 240 volts and below; 115 percent of nominal voltage above 240 volts to 480 volts.

2.34 FACTORY APPLIED FINISH

Provide factory-applied finish on electrical equipment in accordance with the following:

a. NEMA 250 corrosion-resistance test and the additional requirements as specified herein.

b. Interior and exterior steel surfaces of equipment enclosures: thoroughly cleaned followed by a rust-inhibitive phosphatizing or equivalent treatment prior to painting.

c. Exterior surfaces: free from holes, seams, dents, weld marks, loose scale or other imperfections.

d. Interior surfaces: receive not less than one coat of corrosion-resisting paint in accordance with the manufacturer's standard practice.

e. Exterior surfaces: primed, filled where necessary, and given not less than two coats baked enamel with semigloss finish.

f. Equipment located indoors: ANSI Light Gray, and equipment located outdoors: ANSI Light Gray.

g. Provide manufacturer's coatings for touch-up work and as specified in paragraph FIELD APPLIED PAINTING.

2.35 SOURCE QUALITY CONTROL

2.35.1 Transformer Factory Tests

Submittal: include routine NEMA ST 20 transformer test results on each transformer and also provide the results of NEMA "design" and "prototype" tests that were made on transformers electrically and mechanically equal to those specified.

2.36 COORDINATED POWER SYSTEM PROTECTION

Prepare analyses as specified in Section 26 05 73 POWER SYSTEM STUDIES.

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations, including weatherproof and hazardous locations and ducts, plenums and other air-handling spaces: conform to requirements of NFPA 70 and IEEE C2 and to requirements specified herein.

3.1.1 Underground Service

Underground service conductors and associated conduit: continuous from service entrance equipment to outdoor power system connection.

3.1.2 Service Entrance Identification

Service entrance disconnect devices, switches, and enclosures: labeled and identified as such.

3.1.2.1 Labels

Wherever work results in service entrance disconnect devices in more than one enclosure, as permitted by NFPA 70, label each enclosure, new and existing, as one of several enclosures containing service entrance disconnect devices. Label, at minimum: indicate number of service disconnect devices housed by enclosure and indicate total number of enclosures that contain service disconnect devices. Provide laminated plastic labels conforming to paragraph FIELD FABRICATED NAMEPLATES. Use lettering of at least 0.25 inch in height, and engrave on black-on-white matte finish. Service entrance disconnect devices in more than one enclosure: provided only as permitted by NFPA 70.

3.1.3 Wiring Methods

Provide insulated conductors installed in rigid steel conduit, IMC, rigid nonmetallic conduit, or EMT, except where specifically indicated or specified otherwise or required by NFPA 70 to be installed otherwise. Grounding conductor: separate from electrical system neutral conductor. Provide insulated green equipment grounding conductor for circuit(s) installed in conduit and raceways. Minimum conduit size: 1/2 inch in diameter for low voltage lighting and power circuits. Vertical distribution in multiple story buildings: made with metal conduit in fire-rated shafts, with metal conduit extending through shafts for minimum distance of 6 inches. Firestop conduit which penetrates fire-rated walls, fire-rated partitions, or fire-rated floors in accordance with Section 07 84 00 FIRESTOPPING.

3.1.3.1 Pull Wire

Install pull wires in empty conduits. Pull wire: plastic having minimum 200-pound force tensile strength. Leave minimum 36 inches of slack at each end of pull wire.

3.1.4 Conduit Installation

Unless indicated otherwise, conceal conduit under floor slabs and within finished walls, ceilings, and floors. Keep conduit minimum 6 inches away from parallel runs of flues and steam or hot water pipes. Install conduit parallel with or at right angles to ceilings, walls, and structural members where located above accessible ceilings and where conduit will be visible after completion of project.

3.1.4.1 Restrictions Applicable to EMT

a. Do not install underground.

b. Do not encase in concrete, mortar, grout, or other cementitious materials.

c. Do not use in areas subject to physical damage including but not limited to equipment rooms where moving or replacing equipment could physically damage the EMT.

d. Do not use in hazardous areas.

e. Do not use outdoors.

f. Do not use in fire pump rooms.

g. Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).

3.1.4.2 Restrictions Applicable to Nonmetallic Conduit

a. PVC Schedule 40.

(1) Do not use where subject to physical damage, including but not limited to, mechanical equipment rooms, electrical equipment rooms, fire pump rooms, and where restrictions are applying to both PVC Schedule 40 and PVC Schedule 80.

(2) Do not use above grade, except where allowed in this section for rising through floor slab or indicated otherwise.

b. PVC Schedule 80.

(1) Do not use where subject to physical damage, including but not limited to, hospitals, power plant, missile magazines, and other such areas.

(2) Do not use in hazardous (classified) areas.

(3) Do not use in penetrating fire-rated walls or partitions, or fire-rated floors.

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3.1.4.3 Restrictions Applicable to Flexible Conduit

Use only as specified in paragraph FLEXIBLE CONNECTIONS. Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).

3.1.4.4 Underground Conduit

Plastic-coated rigid steel; PVC, or Type EPC-40. Convert nonmetallic conduit, other than PVC Schedule 40 or 80, to plastic-coated rigid, steel conduit before rising through floor slab. Plastic coating: extend minimum 6 inches above floor.

3.1.4.5 Conduit for Circuits Rated Greater Than 600 Volts

Rigid metal conduit or IMC only.

3.1.4.6 Conduit Installed Under Floor Slabs

Conduit run under floor slab: located a minimum of 12 inches below the vapor barrier. Seal around conduits at penetrations thru vapor barrier. Use NECA NEIS 1 Table 2a (Minimum Raceway Spacing) to determine under floor slab conduit spacing unless greater spacing is required elsewhere in this section.

3.1.4.7 Conduit Through Floor Slabs

Where conduits rise through floor slabs, do not allow curved portion of bends to be visible above finished slab. Where conduit rises through slab-on grade, seal all electrical penetrations to address radon mitigation and prevent infiltration of air, insects, and vermin.

3.1.4.8 Stub-Ups

Provide conduits stubbed up through concrete floor for connection to free-standing equipment with adjustable top or coupling threaded inside for plugs, set flush with finished floor. Extend conductors to equipment in rigid steel conduit, except that flexible metal conduit may be used 6 inches above floor. Where no equipment connections are made, install screwdriver-operated threaded flush plugs in conduit end.

3.1.4.9 Conduit Support

Support conduit by pipe straps, wall brackets, threaded rod conduit hangers, or ceiling trapeze. Plastic cable ties are not acceptable. Fasten by wood screws to wood; by toggle bolts on hollow masonry units; by concrete inserts or expansion bolts on concrete or brick; and by machine screws, welded threaded studs, or spring-tension clamps on steel work. Threaded C-clamps may be used on rigid steel conduit only. Do not weld conduits or pipe straps to steel structures. Do not exceed one-fourth proof test load for load applied to fasteners. Provide vibration resistant and shock-resistant fasteners attached to concrete ceiling. Do not cut main reinforcing bars for any holes cut to depth of more than 1 1/2 inches in reinforced concrete beams or to depth of more than 3/4 inch in concrete joints. Fill unused holes. In partitions of light steel construction, use sheet metal screws. In suspended-ceiling construction, run conduit above ceiling. Do not support conduit by ceiling support system. Conduit and box systems: supported independently of both (a) tie wires supporting ceiling grid system, and (b) ceiling grid system into

which ceiling panels are placed. Do not share supporting means between electrical raceways and mechanical piping or ducts. Identify independent conduit support in both fire and non-fire rated assemblies per NFPA 70. Coordinate installation with above-ceiling mechanical systems to assure maximum accessibility to all systems. Spring-steel fasteners may be used for lighting branch circuit conduit supports in suspended ceilings in dry locations. Where conduit crosses building expansion joints, provide suitable expansion fitting that maintains conduit electrical continuity by bonding jumpers or other means. For conduits greater than 2 1/2 inches inside diameter, provide supports to resist forces of 0.5 times the equipment weight in any direction and 1.5 times the equipment weight in the downward direction.

3.1.4.10 Directional Changes in Conduit Runs

Make changes in direction of runs with symmetrical bends or cast-metal fittings. Make field-made bends and offsets with hickey or conduit-bending machine. Do not install crushed or deformed conduits. Avoid trapped conduits. Prevent plaster, dirt, or trash from lodging in conduits, boxes, fittings, and equipment during construction. Free clogged conduits of obstructions.

3.1.4.11 Locknuts and Bushings

Fasten conduits to sheet metal boxes and cabinets with two locknuts where required by NFPA 70, where insulated bushings are used, and where bushings cannot be brought into firm contact with the box; otherwise, use at least minimum single locknut and bushing. Provide locknuts with sharp edges for digging into wall of metal enclosures. Install bushings on ends of conduits, and provide insulating type where required by NFPA 70.

3.1.4.12 Flexible Connections

Provide flexible steel conduit between 3 and 6 feet in length for recessed and semirecessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for motors. Install flexible conduit to allow 20 percent slack. Minimum flexible steel conduit size: 1/2 inch diameter. Provide liquid tight flexible conduit in wet and damp locations for equipment subject to vibration, noise transmission, movement or motors. Provide separate ground conductor across flexible connections. Plastic cable ties are not acceptable as a support method.

3.1.4.13 Telecommunications and Signal System Pathway

Install telecommunications pathway in accordance with TIA-569.

a. Horizontal Pathway: Telecommunications pathways from the work area to the telecommunications room: installed and cabling length requirements in accordance with TIA-568.1. Size conduits, wireways in accordance with TIA-569 and as indicated.

b. Backbone Pathway: Telecommunication pathways from the telecommunications entrance facility to telecommunications rooms, and, telecommunications equipment rooms (backbone cabling): installed in accordance with TIA-569. Size conduits, wireways, and cable trays for telecommunications risers in accordance with TIA-569 and as indicated.

3.1.5 Busway Installation

Comply at minimum with NFPA 70. Install busways parallel with or at right angles to ceilings, walls, and structural members. Support busways at 5 foot maximum intervals, and brace to prevent lateral movement. Provide fixed type hinges on risers; spring-type are unacceptable. Provide flanges where busway makes penetrations through walls and floors, and seal to maintain smoke and fire ratings. Provide waterproof curb where busway riser passes through floor. Seal gaps with fire-rated foam and caulk. Provide expansion joints, but only where bus duct crosses building expansion joints. Provide supports to resist forces of 0.5 times the equipment weight in any direction and 1.5 times the equipment weight in the downward direction.

3.1.6 Telecommunications Cable Support Installation

Install open top and closed ring cable supports on 4 ft to 5 ft centers to adequately support and distribute the cable’s weight. Use these types of supports to support a maximum of 50 0.25 in diameter cables. Install suspended cables with at least 3 in of clear vertical space above the ceiling tiles and support channels (T-bars). Open top and closed ring cable supports: suspended from or attached to the structural ceiling or walls with hardware or other installation aids specifically designed to support their weight. Do not use open top or closed ring cable supports outside of telecommunications rooms.

3.1.7 Boxes, Outlets, and Supports

Provide boxes in wiring and raceway systems wherever required for pulling of wires, making connections, and mounting of devices or fixtures. Boxes for metallic raceways: cast-metal, hub-type when located in wet locations, when surface mounted on outside of exterior surfaces, when surface mounted on interior walls exposed up to 7 feet above floors and walkways, or when installed in hazardous areas and when specifically indicated. Boxes in other locations: sheet steel, except that aluminum boxes may be used with aluminum conduit, and nonmetallic boxes may be used with nonmetallic conduit system. Provide each box with volume required by NFPA 70 for number of conductors enclosed in box. Boxes for mounting lighting fixtures: minimum 4 inches square, or octagonal, except that smaller boxes may be installed as required by fixture configurations, as approved. Boxes for use in masonry-block or tile walls: square-cornered, tile-type, or standard boxes having square-cornered, tile-type covers. Provide gaskets for cast-metal boxes installed in wet locations and boxes installed flush with outside of exterior surfaces. Provide separate boxes for flush or recessed fixtures when required by fixture terminal operating temperature; provide readily removable fixtures for access to boxes unless ceiling access panels are provided. Support boxes and pendants for surface-mounted fixtures on suspended ceilings independently of ceiling supports. Fasten boxes and supports with wood screws on wood, with bolts and expansion shields on concrete or brick, with toggle bolts on hollow masonry units, and with machine screws or welded studs on steel. In open overhead spaces, cast boxes threaded to raceways need not be separately supported except where used for fixture support; support sheet metal boxes directly from building structure or by bar hangers. Where bar hangers are used, attach bar to raceways on opposite sides of box, and support raceway with approved-type fastener maximum 24 inches from box. When penetrating reinforced concrete members, avoid cutting reinforcing steel.

3.1.7.1 Boxes

Boxes for use with raceway systems: minimum 1 1/2 inches deep, except where shallower boxes required by structural conditions are approved. Boxes for other than lighting fixture outlets: minimum 4 inches square, except that 4 by 2 inch boxes may be used where only one raceway enters outlet.

3.1.7.1.1 Wall-Mounted Telecommunications Outlet Box

Provide double gang electrical boxes, minimum standard size 4-11/16 inches square and 2-1/8 inches deep with plaster ring for connection of single gang faceplate. Design outlet box for recess mounting with the faceplate flush with the wall surface, at the same height as the electrical outlets.

3.1.7.2 Pull Boxes

Construct of at least minimum size required by NFPA 70 of code-gauge aluminum or galvanized sheet steel, except where cast-metal boxes are required in locations specified herein. Provide boxes with screw-fastened covers. Where several feeders pass through common pull box, tag feeders to indicate clearly electrical characteristics, circuit number, and panel designation.

3.1.8 Mounting Heights

Mount panelboards, enclosed circuit breakers, and disconnecting switches so height of center of grip of the operating handle of the switch or circuit breaker at its highest position is maximum 79 inches above floor or working platform or as allowed in Section 404.8 per NFPA 70. Mount lighting switches and handicapped telecommunications stations 48 inches above finished floor. Mount receptacles and telecommunications outlets 18 inches above finished floor, unless otherwise indicated. Wall-mounted telecommunications outlets: mounted at height 60 inches above finished floor. Mount other devices as indicated.

3.1.9 Conductor Identification

Provide conductor identification within each enclosure where tap, splice, or termination is made. For conductors No. 6 AWG and smaller diameter, provide color coding by factory-applied, color-impregnated insulation. For conductors No. 4 AWG and larger diameter, provide color coding by plastic-coated, self-sticking markers; colored nylon cable ties and plates; or heat shrink-type sleeves. Identify control circuit terminations in accordance with Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC and manufacturer's recommendations. Provide telecommunications system conductor identification as specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEMS.

3.1.9.1 Marking Strips

Provide marking strips for identification of power distribution, control, data, and communications cables in accordance with the following:

a. Provide white or other light-colored plastic marking strips, fastened by screws to each terminal block, for wire designations.

b. Use permanent ink for the wire numbers

c. Provide reversible marking strips to permit marking both sides, or provide two marking strips with each block.

d. Size marking strips to accommodate the two sets of wire numbers.

e. Assign a device designation in accordance with NEMA ICS 1 to each device to which a connection is made. Mark each device terminal to which a connection is made with a distinct terminal marking corresponding to the wire designation used on the Contractor's schematic and connection diagrams.

f. The wire (terminal point) designations used on the Contractor's wiring diagrams and printed on terminal block marking strips may be according to the Contractor's standard practice; however, provide additional wire and cable designations for identification of remote (external) circuits for the Government's wire designations.

g. Prints of the marking strips drawings submitted for approval will be so marked and returned to the Contractor for addition of the designations to the terminal strips and tracings, along with any rearrangement of points required.

3.1.10 Splices

Make splices in accessible locations. Make splices in conductors No. 10 AWG and smaller diameter with insulated, pressure-type connector. Make splices in conductors No. 8 AWG and larger diameter with solderless connector, and cover with insulation material equivalent to conductor insulation.

3.1.11 Covers and Device Plates

Install with edges in continuous contact with finished wall surfaces without use of mats or similar devices. Plaster fillings are not permitted. Install plates with alignment tolerance of 1/16 inch. Use of sectional-type device plates are not permitted. Provide gasket for plates installed in wet locations.

3.1.12 Electrical Penetrations

Seal openings around electrical penetrations through fire resistance-rated walls, partitions, floors, or ceilings in accordance with Section 07 84 00 FIRESTOPPING.

3.1.13 Grounding and Bonding

Provide in accordance with NFPA 70 and NFPA 780. Ground exposed, non-current-carrying metallic parts of electrical equipment, metallic raceway systems, grounding conductor in metallic and nonmetallic raceways, telecommunications system grounds, and neutral conductor of wiring systems.

Make ground connection at main service equipment, and extend grounding conductor to point of entrance of metallic water service. Make connection to water pipe by suitable ground clamp or lug connection to plugged tee. If flanged pipes are encountered, make connection with lug bolted to street side of flanged connection. Supplement metallic water service grounding system with additional made electrode in compliance with NFPA 70.

Make ground connection to driven ground rods on exterior of building. Bond additional driven rods together with a minimum of 4 AWG soft bare copper wire buried to a depth of at least 12 inches. Interconnect all

grounding media in or on the structure to provide a common ground potential. This includes lightning protection, electrical service, telecommunications system grounds, as well as underground metallic piping systems. Make interconnection to the gas line on the customer's side of the meter. Use main size lightning conductors for interconnecting these grounding systems to the lightning protection system. In addition to the requirements specified herein, provide telecommunications grounding in accordance with TIA-607. Where ground fault protection is employed, ensure that connection of ground and neutral does not interfere with correct operation of fault protection.

3.1.13.1 Ground Rods

Provide ground rods and measure the resistance to ground using the fall-of-potential method described in IEEE 81. Do not exceed 10 ohms under normally dry conditions for the maximum resistance of a driven ground. If this resistance cannot be obtained with a single rod, provide additional rods, spaced on center. Spacing for additional rods must be a minimum of 10 feet, or if sectional type rods are used, additional sections may be coupled and driven with the first rod. If the resultant resistance exceeds 10 ohms measured not less than 48 hours after rainfall, notify the Contracting Officer who will decide on the number of ground rods to add.

3.1.13.2 Grounding Connections

Make grounding connections which are buried or otherwise normally inaccessible, by exothermic weld or high compression connector.

a. Make exothermic welds strictly in accordance with the weld manufacturer's written recommendations. Welds which are "puffed up" or which show convex surfaces indicating improper cleaning are not acceptable. Mechanical connectors are not required at exothermic welds.

b. Make high compression connections using a hydraulic or electric compression tool to provide the correct circumferential pressure. Provide tools and dies as recommended by the manufacturer. Use an embossing die code or other standard method to provide visible indication that a connector has been adequately compressed on the ground wire.

3.1.13.3 Ground Bus

Provide a copper ground bus in the electrical equipment rooms as indicated. Noncurrent-carrying metal parts of transformer neutrals and other electrical equipment: effectively grounded by bonding to the ground bus. Bond the ground bus to both the entrance ground, and to a ground rod or rods as specified above having the upper ends terminating approximately 4 inches above the floor. Make connections and splices of the brazed, welded, bolted, or pressure-connector type, except use pressure connectors or bolted connections for connections to removable equipment. For raised floor equipment rooms in computer and data processing centers, provide a minimum of four, one at each corner, ground buses connected to the building grounding system. Use bolted connections in lieu of thermoweld, so they can be changed as required by additions and alterations.

3.1.13.4 Resistance

Maximum resistance-to-ground of grounding system: do not exceed 5 ohms under dry conditions. Where resistance obtained exceeds 5 ohms, contact Contracting Officer for further instructions.

3.1.13.5 Telecommunications System

Provide telecommunications grounding in accordance with the following:

a. Telecommunications Grounding Busbars: Provide a Primary bonding busbar (PBB) in the telecommunications entrance facility. Install the PBB as close to the electrical service entrance grounding connection as practicable. Install Secondary bonding busbars to maintain clearances as required by NFPA 70 and insulated from its support. A minimum of 2 inches separation from the wall is recommended to allow access to the rear of the busbar and adjust the mounting height to accommodate overhead or underfloor cable routing.

b. Telecommunications Bonding Conductors: Provide main telecommunications service equipment ground consisting of separate bonding conductor for telecommunications, between the PBB and readily accessible grounding connection of the electrical service. Grounding and bonding conductors should not be placed in ferrous metallic conduit. If it is necessary to place grounding and bonding conductors in ferrous metallic conduit that exceeds 3 feet in length, bond the conductors to each end of the conduit using a grounding bushing or a No. 6 AWG conductor, minimum.

c. Telecommunications Grounding Connections: Telecommunications grounding connections to the PBB or SBB: utilize listed compression two-hole lugs, exothermic welding, suitable and equivalent one hole non-twisting lugs, or other irreversible compression type connections. Bond all metallic pathways, cabinets, and racks for telecommunications cabling and interconnecting hardware located within the same room or space as the PBB to the PBB. In a metal frame (structural steel) building, where the steel framework is readily accessible within the room; bond each PBB to the vertical steel metal frame using a minimum No. 6 AWG conductor. Where the metal frame is external to the room and readily accessible, bond the metal frame to the SBB or PBB with a minimum No. 6 AWG conductor. When practicable because of shorter distances and, where horizontal steel members are permanently electrically bonded to vertical column members, the SBB may be bonded to these horizontal members in lieu of the vertical column members. All connectors used for bonding to the metal frame of a building must be listed for the intended purpose.

3.1.14 Equipment Connections

Provide power wiring for the connection of motors and control equipment under this section of the specification. Except as otherwise specifically noted or specified, automatic control wiring, control devices, and protective devices within the control circuitry are not included in this section of the specifications and are provided under the section specifying the associated equipment.

3.1.15 Repair of Existing Work

Perform repair of existing work, demolition, and modification of existing

electrical distribution systems as follows:

3.1.15.1 Workmanship

Lay out work in advance. Exercise care where cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings, or other surfaces is necessary for proper installation, support, or anchorage of conduit, raceways, or other electrical work. Repair damage to buildings, piping, and equipment using skilled craftsmen of trades involved.

3.1.15.2 Existing Concealed Wiring to be Removed

Disconnect existing concealed wiring to be removed from its source. Remove conductors; cut conduit flush with floor, underside of floor, and through walls; and seal openings.

3.1.15.3 Removal of Existing Electrical Distribution System

Removal of existing electrical distribution system equipment includes equipment's associated wiring, including conductors, cables, exposed conduit, surface metal raceways, boxes, and fittings, as indicated.

3.1.15.4 Continuation of Service

Maintain continuity of existing circuits of equipment to remain. Maintain existing circuits of equipment energized. Restore circuits wiring and power which are to remain but were disturbed during demolition back to original condition.

3.1.16 Surge Protective Devices

Connect the surge protective devices in parallel to the power source, keeping the conductors as short and straight as practically possible. Maximum allowed lead length is 3 feet avoiding 90 degree bends. Do not locate surge protective devices inside a panelboard or switchboard enclosure.

3.1.17 Docking Station

a. Install anchor bolts to elevations required for proper attachment to Generator Docking Station.

b. Review and verify the installation of all components and verify the correct electrical flow as depicted on the one-line drawings.

c. Authorized technician will set the long time, short time, instantaneous and ground fault protection settings on the Generator Docking Station circuit breaker(s) in accordance with the engineers specifications or as provided as part of the coordination study.

d. Factory training for on-site personnel to educate them on how to connect the GDS to a portable generator.

e. The Manufacturer’s factory authorized technician shall, upon completion of the commissioning provide a written report to the electrical contractor and electrical engineer indicating the completion of the work.

f. Any issue that is found during the start-up that is determined at that

time to be a warranty issue will be covered by Manufacturer. Any issues that are specific to the scope for the electrical installing contractor are the sole responsibility of the installing contractor.

3.2 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets. Provide nameplate on all equipment in access controlled spaces and areas.

3.3 WARNING SIGN MOUNTING

Provide the number of signs required to be readable from each accessible side. Space the signs in accordance with NFPA 70E.

3.4 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria.

3.5 FIELD QUALITY CONTROL

Furnish test equipment and personnel and submit written copies of test results. Give Contracting Officer 5 working days notice prior to each test. Where applicable, test electrical equipment in accordance with NETA ATS.

3.5.1 Devices Subject to Manual Operation

Operate each device subject to manual operation at least five times, demonstrating satisfactory operation each time.

3.5.2 600-Volt Wiring Test

Test wiring rated 600 volt and less to verify that no short circuits or accidental grounds exist. Perform insulation resistance tests on wiring No. 6 AWG and larger diameter using instrument which applies voltage of 1,000 volts DC for 600 volt rated wiring and 500 volts DC for 300 volt rated wiring per NETA ATS to provide direct reading of resistance. All existing wiring to be reused must also be tested.

3.5.3 Transformer Tests

Perform the standard, not optional, tests in accordance with the Inspection and Test Procedures for transformers, dry type, air-cooled, 600 volt and below; as specified in NETA ATS. Measure primary and secondary voltages for proper tap settings. Tests need not be performed by a recognized independent testing firm or independent electrical consulting firm.

3.5.4 Ground-Fault Receptacle Test

Test ground-fault receptacles with a "load" (such as a plug in light) to verify that the "line" and "load" leads are not reversed. Press the TEST button and then the RESET button to verify by LED status that the device is a self-test model as specified in UL 943.

3.5.5 Grounding System Test

Test grounding system to ensure continuity, and that resistance to ground is not excessive. Test each ground rod for resistance to ground before making connections to rod; tie grounding system together and test for resistance to ground. Make resistance measurements in dry weather, not earlier than 48 hours after rainfall. Submit written results of each test to Contracting Officer, and indicate location of rods as well as resistance and soil conditions at time measurements were made.

3.5.6 Phase Rotation Test

Perform phase rotation test to ensure proper rotation of service power prior to operation of new or reinstalled equipment using a phase rotation meter. Follow the meter manual directions performing the test.

3.5.7 Docking Station

Third Party Tests and Inspections to include the following:

a. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

Prepare test and inspection reports, including a certified report that identifies Generator Docking Station and that describes scanning results. Include notation.

-- End of Section --

SECTION 26 27 13.10 30

ELECTRIC METERS
10/07, CHG 2: 08/18

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C2	(2023) National Electrical Safety Code
IEEE C37.90.1	(2023; ERTA) Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
IEEE C57.13	(2016) Standard Requirements for Instrument Transformers

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 61000-4-5	(2017) Electromagnetic Compatibility (EMC) - Part 4-5: Testing and Measurement Techniques - Surge Immunity Test
IEC 62053-22	(2020) Electricity Metering Equipment (A.C.) - Particular Requirements - Part 22: Static Meters for Active Energy (Classes 0,2 S and 0,5 S)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C12.18	(2006; R 2023) Protocol Specification for ANSI Type 2 Optical Port
ANSI C12.20	(2015; E 2018) Electricity Meters - 0.1, 0.2, and 0.5 Accuracy Classes
ANSI C62.61	(1993) American National Standard for Gas Tube Surge Arresters on Wire Line Telephone Circuits

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2026; TIA 26-1; ERTA 26-1; TIA 26-2; TIA 26-3; TIA 26-4; TIA 26-5; TIA 26-6; TIA 26-7; ERTA 26-2; ERTA 26-3) National Electrical Code

1.2 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in this specification and on the drawings are as defined in IEEE 100.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

a. Provide the following in the maintenance manual:
   1. Condensed description of how the equipment operates.
   2. Block diagram indicating major assemblies.
   3. Troubleshooting information
   4. Preventive maintenance.
   5. Spare parts information.

b. Provide operation and maintenance manuals required by submittal item "SD-10 Operation and Maintenance Data."

SD-02 Shop Drawings

SD-03 Product Data

Power Meters; G

Current Transformers; G

Potential Transformer; G

Communications Module; G

Protocol Modules; G

Data Recorder; G

Modem; G

Include manufacturer's information for each component, device, and accessory provided with the meter, protocol module or communications module.

SD-06 Test Reports

Acceptance Checks and Tests; G

SD-10 Operation and Maintenance Data

Power Meters; G

Communications Module; G

Protocol Modules; G

Data Recorder; G

Modem; G

SD-11 Closeout Submittals

System Function Verification; G

1.4 QUALITY ASSURANCE

1.4.1 Installation Drawings

Drawings indicate but are not limited to the following:

a. Elementary diagrams and wiring diagrams with terminals identified of kilowatt meter, current transformers, potential transformers, protocol modules, communications modules, and Ethernet connections. For each meter installation, provide a diagram identified by the building number.

b. One-line diagram, including meters, switch(es), current transformers, potential transformers, protocol modules, communications modules, Ethernet connections, and fuses. For each meter installation, provide a diagram identified by the building number.

1.4.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Provide products that have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period includes applications of equipment and materials under similar circumstances and of similar size. Provide product that has been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.4.3 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.4.4 Material and Equipment Manufacturing Data

Do not use products manufactured more than 2 years prior to date of delivery to site, unless specified otherwise.

1.5 WARRANTY

Provide equipment items supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.6 SYSTEM DESCRIPTION

1.6.1 System Requirements

The metering and reading system, consisting of commercial, off-the-shelf meters, protocol modules, communications modules, and communication channels, will be used to record the electricity consumption and other values as described in the sections that follow and as shown on the drawings.

1.6.2 Selection Criteria

Metering components are part of a system that includes the physical meter, data recorder function and communications (modem) method. Include sufficient metering components to measure the electrical parameters identified and to store and communicate the values as required in the following sections for every building site identified. Verify that the metering system installed on any building site is compatible with the facility-wide communication and meter-reading protocol system. Contractor must connect the metering system to the facility-wide energy and utility monitoring and control system.

PART 2 PRODUCTS

2.1 POWER METERS

Provide meter capable of connecting and communicating advanced metering infrastructure operating at 902 MHz to 928 MHz radio frequency and via ethernet. Provide meter socket compatible with this meter. Provide meter that is connected and communicating within the AF Cybersecurity protocols. All new meter installations for Department of Defense and Air Force Facilities must include the installation of new properly sized split or solid core current transformers (CTs). Provide connection from the meter to a RJ45 jack in the electrical room. Contractor is responsible for providing cables and pathways to meet these requirements.

Coordinate with Contracting Officer prior to ordering the smart electrical meter to ensure that the communications protocols being used currently on base are being provided as part of this meter.

2.1.1 Physical and Common Requirements

a. Install metering system components according to the Metering System Schedule shown in this specification and on the drawings.

b. Power meter must be socket-mount design.

c. Provide meter consisting of a Class 20, transformer rated design.

d. Provide meter that is rated for use at temperature from -40 degrees Centigrade to +70 degrees Centigrade.

e. Meter must have NEMA 3R enclosure for surface mounting.

f. Surge withstand must conform to IEEE C37.90.1.

g. Provide meter with a standard 4 -year warranty.

h. Provide meter in compliance with IEC 62053-22 (Part 21: Static Meter

for Active Energy, classes 0.2S and 0.5S), certified by a qualified third party test laboratory.

2.1.2 Voltage Requirements

a. Furnish meter that is capable of connection to the service voltage phases and magnitude being monitored. If the meter is not rated for the service voltage, provide suitable potential transformers to send an acceptable voltage to the meter.

b. Provide meter that is capable of connection to the service voltage indicated in the Metering System Schedule:

c. Provide meter that accepts independent voltage inputs from each phase and is auto-ranging over the full range of input voltages.

d. Optically isolate voltage input to 2500 volts DC from signal and communications outputs. Use components meeting or exceeding IEEE C37.90.1 (Surge Withstand Capability).

e. The Contractor is responsible for determining the actual voltage ratio of each potential transformer. Provide transformer conforming to IEEE C57.13 and the following requirements.

(1) Type: Dry type, of two-winding construction.

(2) Weather: Outdoor rated for the application.

(3) Frequency: Nominal 60Hz.

(4) Accuracy: Plus or minus 0.3% at 60Hz or 0.3% for those systems that operate at 50Hz.

2.1.3 Current Requirements

a. Accept independent current inputs from each phase. Install current transformer with a full load rating as shown in the schedule.

b. Provide single ratio current transformer with an Accuracy Class of 0.3 with a maximum error of +/- 0.3% at 5.0 amps.

c. Current transformer must have:

(1) Insulation Class: Provide 600 volt and below current transformers rated at 10 KV BIL. Provide current transformers for 2400 and 4160 volt service rated at 25 KV BIL.

(2) Frequency: Nominal 60Hz, 50Hz for bases that operate on 50Hz.

(3) Burden: Select burden class for the load.

(4) Phase Angle Range: 0 to 60 degrees.

d. Provide meter that accepts current input from standard instrument transformers (5A secondary current transformers.)

e. Current inputs must have a continuous rating in accordance with IEEE C57.13.

f. Provide multi-ratio current transformer where indicated with a top range equal to or greater than the actual load. The Contractor is responsible for determining the actual ratio of each transformer. Provide current transformer conforming to IEEE C57.13.

2.1.4 Electrical Measurements

Measure and report the following quantities:

a. Kilowatt-hours ("kWh" in Metering Systems Schedule) of consumption. Cumulative.

b. Kilowatts of demand ("kW" in Metering Systems Schedule). Peak average over a selectable demand interval between 5 and 60 minutes (typically 15 minutes).

c. Reactive power ("kVAR" in Metering Systems Schedule). Measured over the same interval as the peak kW reading.

d. Power factor ("PF" in Metering Systems Schedule). Measured over the same interval as the peak kW reading.

e. Time of use consumption ("TOU" in Metering Systems Schedule). Kilowatt-hours recorded separately for each period set by programming into the meter. Time periods must be capable of being changed without removal from service. The meter must internally record and store Time of Use data.

(1) Four (4) minimum TOU Rates (Registers)

(2) Twenty (20) Year Calendar

(3) Two (2) minimum seasons per year

f. Interval recording ("IR" in Metering Systems Schedule). Record kilowatt-hours for each 15 minute interval and accumulate for 30 days. Memory for recording the interval readings must be internal to the meter and ANSI C12.19 compliant. Provide time-stamped readings for every measured parameter.

g. Meter readings must be true RMS.

2.1.5 Meter Accuracy

Provide the following accuracies. Measure accuracies as percent of reading at standard meter test points.

a. Provide power meter meeting ANSI C12.20 for Class 0.2 and IEC 62053-22 accuracy requirements.

2.1.6 An on the Meter Display, Output and Reading Capabilities

Include the following output signals.

a. The meter will have a face display plate and will display every electrical parameter indicated to be recorded. Do not require meters to indicate interval data collected in a data logger with a communications output feature. Display peak values, instantaneous and cumulative values.

b. Include optical output port capable of 9600 bps communication with a hand-held reading device. Provide optical device that is compatible with ANSI C12.18

c. Provide meter with two form C, dry contact relay outputs for alarm or control.

2.1.7 Installation Methods

a. Panel mounted. ("PNL" in Metering Systems Schedule)

(1) Mount meter where directed. See detail on the drawings.

b. Common features.

(1) PTs (if required for proper voltage range) and physically connect CTs to the service entrance cables inside the service entrance disconnect enclosure.

2.1.8 Disconnecting Switches

a. Provide disconnecting wiring blocks between the current transformer and the meter. Build a shorting mechanism into the wiring block to allow the current transformer wiring to be changed without removing power to the transformer. Locate the wiring blocks where they are accessible without the necessity of disconnecting power to the transformer. For multi-ratio current transformers, provide a shorting block from each tap to the common lead.

b. Equip voltage-monitoring circuits with disconnect switches to isolate the meter base or socket from the voltage source.

2.1.9 Meter Programming

a. Provide power meter that is programmable by software supplied by the meter manufacturer.

b. Provide user-friendly software with Windows-compatible interface.

c. Operate software on Windows operating systems.

d. Provide software that allows the user to configure the meter, troubleshoot meter, query and display meter parameters and configuration data and stored values.

e. Provide meter firmware that is upgradeable through one of the communications ports without removing the unit from service.

2.2 COMMUNICATIONS

2.2.1 Communications Methods

2.2.1.1 Optical Port

Communicate with a hand-held reading device according to the following requirements.

a. Communications standards

(1) ANSI C12.18

(2) MV90 protocol

(3) ANSI C12.20

b. Read operations

(1) Current kWh values

(2) Demand (kW) values since last reset

(3) Last reset value

(4) Meter status

c. Write operations

(1) Meter setup

2.2.1.2 Serial Port

Provide serial port for connection to modem module where required in this specification.

2.2.1.3 Ethernet

For those meters using the Ethernet, send logged information using open standard Internet Protocols.

a. On-board Ethernet port support

(1) HTTP

(2) SMTP

(a) Modbus

b. Distribute stored data by

(1) FTP

2.2.2 Communications Protocols and Methods

Use communications protocols and methods that are native to the meter. Provide communications module(s) as required to accomplish the following.

a. Include an IR port ("IR" in Metering Systems Schedule) for communication to external devices such as handheld readers that support a minimum speed of 9600 baud.

b. Provide meter with a port that can be configured as a 10/100 Base-T Ethernet port ("BaseT" in Metering Systems Schedule)

2.2.3 Communications Channels Surge Protection

Protect communications equipment against surges induced on its communications channels. Protect communication interfaces to all field

equipment to meet the requirements of IEEE C37.90.1 or the requirements of IEC 61000-4-5, test level 4, while the equipment is operating. Do not use fuses for surge protection. For metallic cables and conductors which serve as communications channels between buildings, install surge protection at equipment rated for the application at each end, within 3 feet of the building cable entrance. Provide surge protectors meeting the requirements of the applicable extension of ANSI C62 (for example, ANSI C62.61).

2.3 METER DATA PROTOCOL

Provide power meters that have communicating data protocols native or provide in supplemental modules to communicate with the communications methods that follow.

2.3.1 Open Protocol

Support the following open protocols. Verify that the meter native protocol is consistent with the facility data recording and communication and data storage system. Provide additional converters and modules as required for a complete measurement, recording, communicating and data storage system.

a. Provide meter that is fully supported by MV-90 software system or existing AMR software that is MV-90 compatible.

b. For systems that use proprietary software, an alternative, competitive software system must be available.

Systems capable of using more than one brand of commercially available meters are expected. In addition, if proprietary meter reading software is used, meters are to be capable of being read by more than one manufacturer's software.

2.4 SPARE PARTS

2.4.1 Parts List

Two sets of spare fuses for the meter disconnect switch.

PART 3 EXECUTION

3.1 INSTALLATION

Perform electrical installations conforming to IEEE C2, NFPA 70, and to the requirements specified herein. Provide new equipment and materials unless indicated or specified otherwise.

3.1.1 Scheduling of Work and Outages

The Contract Clauses govern regarding permission for power outages, scheduling of work, coordination with Government personnel, and special working conditions.

3.2 FIELD APPLIED PAINTING

Where field painting of enclosures is required to correct damage to the manufacturer's factory-applied coatings, provide manufacturer's recommended coatings and apply in accordance with manufacturer's

instructions.

3.3 FIELD QUALITY CONTROL

3.3.1 Performance of Acceptance Checks and Tests

3.3.1.1 Meter Assembly

a. Visual and mechanical inspection

(1) Compare equipment nameplate data with specification and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method.

(4) Verify grounding of metering enclosure.

(5) Verify the presence of surge arresters.

(6) Verify that the CT ratio and the PT ratio are properly included in the meter multiplier or the programming of the meter.

b. Electrical tests

(1) Calibrate watthour meters according to manufacturer's published data.

(2) Verify that correct multiplier has been placed on face or meter where applicable.

(3) Prior to system acceptance, the Contractor will demonstrate and confirm the meter is properly wired and is displaying correct and accurate electrical information.

3.3.1.2 Current Transformers

a. Visual and mechanical inspection

(1) Compare equipment nameplate data with specification and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify correct connection.

(4) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method.

(5) Verify that required grounding and shorting connections provide good contact.

b. Electrical tests

(1) Perform resistance measurements through all bolted connections

with low-resistance ohmmeter, if applicable.

(2) Perform insulation-resistance test.

(3) Perform a polarity test.

(4) Perform a ratio-verification test.

3.3.1.3 Potential Transformers

a. Visual and mechanical inspection

(1) PT's are rigidly mounted.

(2) PT's are correct voltage.

(3) Verify that adequate clearances exist between primary and secondary circuit.

b. Electrical tests

(1) Perform a ratio-verification test.

3.3.2 Follow-Up System Function Verification

Upon completion of acceptance checks and tests, the show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. As an exception to requirements stated elsewhere in the contract, give the Contracting Officer 5 working days' advance notice of the dates and times of checking and testing.

3.3.3 Training

Conduct a training course for meter configuration, operation, and maintenance of the system as specified. Orient the training for all components and systems installed under this contract. Deliver training manuals for two trainees with two additional copies delivered for archiving at the project site. Furnish all audiovisual equipment and all other training materials and supplies. A training day is defined as eight hours of classroom instruction, including two 15-minute breaks and excluding lunchtime, Monday through Friday, during the daytime shift in effect at the training facility. For guidance in planning the required instruction, assume that attendees have a high school education or equivalent, and are familiar with utility systems. Obtain approval of the planned training schedule from the Government at least 30 days prior to the training.

a. Training: Teach the course at the project site within thirty days after completion of the installation for a period of one day(s). A maximum of 6 personnel will attend the course. The training includes:

(1) Physical layout of each piece of hardware.

(2) Meter configuration, troubleshooting and diagnostics procedures.

(3) Repair instructions.

(4) Preventive maintenance procedures and schedules.

(5) Testing and calibration procedures.

-- End of Section --

SECTION 26 29 23

ADJUSTABLE SPEED DRIVE (ASD) SYSTEMS UNDER 600 VOLTS
02/20, CHG 1: 05/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

EUROPEAN COMMITTEE FOR STANDARDIZATION (CEN/CENELEC)

EN 61800-3	(2017) Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 519	(2022) Standard for Harmonic Control in Electrical Power Systems
IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 61000-3-12	(2012) Electromagnetic Compatibility (EMC) - Part 3-12: Limits - Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current >16 A and </=75 A per phase

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 1	(2022) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 3.1	(2019) Guide for the Application, Handling, Storage, Installation and Maintenance of Medium-Voltage AC Contactors, Controllers and Control Centers
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA ICS 7	(2020) Adjustable-Speed Drives

NEMA ICS 7.2	(2015) Application Guide for AC Adjustable Speed Drive Systems
NEMA MG 1	(2021) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2026; TIA 26-1; ERTA 26-1; TIA 26-2; TIA 26-3; TIA 26-4; TIA 26-5; TIA 26-6; TIA 26-7; ERTA 26-2; ERTA 26-3) National Electrical Code

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 15	Radio Frequency Devices

UL SOLUTIONS (UL)

UL 489	(2025) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 61800-5-1	(2016) Adjustable Speed Electrical Power Drive Systems - Part 5-1: Safety Requirements - Electrical, Thermal and Energy

1.2 RELATED REQUIREMENTS

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM applies to this section with additions and modifications specified herein.

1.3 SYSTEM DESCRIPTION

1.3.1 Performance Requirements

1.3.1.1 Electromagnetic Interference Suppression

Computing devices, as defined by 47 CFR 15 and EN 61800-3 rules and regulations, must be certified to comply with the requirements for class A computing devices and labeled.

1.3.1.2 Electromechanical and Electrical Components

Ensure electrical and electromechanical components of the Adjustable Speed Drive (ASD) do not cause electromagnetic interference to adjacent electrical or electromechanical equipment while in operation.

1.3.2 Electrical Requirements

1.3.2.1 Power Line Surge Protection

IEEE C62.41.1 and IEEE C62.41.2, IEEE 519, IEC 61000-3-12 Control panel must have surge protection, included within the panel to protect the unit from damaging transient voltage surges. Surge protective device must be mounted near the incoming power source and properly wired to all three phases and ground. Fuses must not be used for surge protection.

1.3.2.2 Sensor and Control Wiring Surge Protection

I/O functions as specified must be protected against surges induced on control and sensor wiring installed outdoors and as shown. Test the inputs and outputs in both normal mode and common mode using the following two waveforms:

a. A 10 microsecond by 1000 microsecond waveform with a peak voltage of 1500 volts and a peak current of 60 amperes.

b. An 8 microsecond by 20 microsecond waveform with a peak voltage of 1000 volts and a peak current of 500 amperes.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Schematic Diagrams; G

Interconnecting Diagrams; G

Installation Drawings; G

As-Built Drawings; G

SD-03 Product Data

Adjustable Speed Drives; G

Wires and Cables

Equipment Schedule

SD-06 Test Reports

ASD Test

Performance Verification Tests

Endurance Test

SD-08 Manufacturer's Instructions

Installation instructions

SD-09 Manufacturer's Field Reports

ASD Test Plan; G

Standard Products

SD-10 Operation and Maintenance Data

Adjustable Speed Drives, Data Package 4

1.5 QUALITY ASSURANCE

1.5.1 Schematic Diagrams

Submit diagrams showing circuits and device elements for each replaceable module. Schematic diagrams of printed circuit boards are permitted to group functional assemblies as devices, provided that sufficient information is provided for government maintenance personnel to verify proper operation of the functional assemblies.

1.5.2 Interconnecting Diagrams

Show interconnections between equipment assemblies, and external interfaces, including power and signal conductors. Include for enclosures and external devices.

1.5.3 Installation Drawings

Show floor plan of each site, with ASD's and motors indicated. Indicate ventilation requirements, adequate clearances, and cable routes. Submit drawings for government approval prior to equipment construction or integration. Immediately record modifications to original drawings made during installation for inclusion into the as-built drawings.

1.5.4 Equipment Schedule

Provide schedule of equipment supplied. Schedule must provide a cross reference between manufacturer data and identifiers indicated in shop drawings. Schedule must include the total quantity of each item of equipment supplied and data indicating compatibility with motors being driven. For complete assemblies, such as ASD's, provide the serial numbers of each assembly, and a sub-schedule of components within the assembly. Provide recommended spare parts listing for each assembly or component.

1.5.5 Installation Instructions

Provide installation instructions issued by the manufacturer of the equipment, including notes and recommendations, prior to shipment to the site. Provide operation instructions prior to acceptance testing.

1.5.6 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship and:

a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.

b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.

c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.6 DELIVERY AND STORAGE

Store delivered equipment to protect from the weather, humidity and temperature variations, dirt and dust, or other contaminants.

1.7 WARRANTY

The complete system must be warranted by the manufacturer for a period of one year . Repair or replace any component failing to perform its function as specified and documented at no additional cost to the Government. Items repaired or replaced must be warranted for an additional period of at least one year from the date that it becomes functional again, as specified in FAR 52.246-21 Warranty of Construction.

1.8 MAINTENANCE

1.8.1 Spare Parts

Manufacturers provide spare parts in accordance with recommended spare parts list.

1.8.2 Operation and Maintenance Data

Provide in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Provide service and maintenance information including preventive maintenance, assembly, and disassembly procedures. Include electrical drawings from electrical general sections. Provide additional information necessary to provide complete operation, repair, and maintenance information, detailed to the smallest replaceable unit. Include copies of as-built submittals. Provide routine preventative maintenance instructions, and equipment required. Provide instructions on how to modify program settings, and modify the control program. Provide instructions on drive adjustment, trouble-shooting, and configuration. Provide instructions on process tuning and system calibration.

1.8.3 Maintenance Support

During the warranty period, provide on-site, on-call maintenance services by drive manufacturer's personnel on the following basis: The service must be on a per-call basis with 36 hour response. Contractor is responsible for the maintenance of all hardware and software of the system during the warranty period. Various personnel of different expertise must be sent on-site depending on the nature of the maintenance service required. Costs must include travel, local transportation, living expenses, and labor rates of the service personnel while responding to the service request. The provisions of this Section are not in lieu of, nor relieve the Contractor of, warranty responsibilities covered in this specification. Should the result of the service request be the uncovering of a system defect covered under the warranty provisions, all costs for the call, including the labor necessary to identify the defect, must be borne by the Contractor.

1.8.4 Technical Support

Provide the ASDs with manufacturer's technical telephone support in English, readily available during normal working hours.

PART 2 PRODUCTS

2.1 ADJUSTABLE SPEED DRIVES (ASD)

Provide adjustable speed drive to control the speed of induction motor(s). The ASD must include the following minimum functions, features and ratings.

a. Input circuit breaker per UL 489 with a minimum of 10,000 amps symmetrical interrupting capacity and door interlocked external operator.

b. A converter stage per UL 61800-5-1 must change fixed voltage, fixed frequency, ac line power to a fixed dc voltage. The converter must utilize a full wave bridge design incorporating diode rectifiers. Silicon Controlled Rectifiers (SCR) are not acceptable. The converter must be insensitive to three phase rotation of the ac line and must not cause displacement power factor of less than .95 lagging under any speed and load condition.

c. An inverter stage must change fixed dc voltage to variable frequency, variable ac voltage for application to a standard NEMA MG 1 Part 30 motor designed for use with adjustable frequency power supplies. Switch the inverter to produce a sine coded pulse width modulated (PWM) output waveform.

d. The ASD shall be capable of supplying 110 percent of rated full load current for one minute at maximum ambient temperature.

e. The ASD must be designed to operate from a 480 volt, plus or minus 10 percent, three phase, 60 Hz supply, and control motors with a corresponding voltage rating.

f. Acceleration and deceleration time must be independently adjustable from one second to 60 seconds.

Adjust decelerating time by providing an ASD with a regenerative braking designed to return some of braking energy from the motor to the AC power distribution system. Required deceleration time may be achieved using not only dynamic braking resistor but with other methods described in NEMA ICS 7.2-2015 paragraph 5.2.5.

g. Adjustable full-time current limiting must limit the current to a preset value which must not exceed 110 percent of the controller rated current. The current limiting action must maintain the V/Hz ratio constant so that variable torque can be maintained. Short time starting override must allow starting current to reach 175 percent of controller rated current to maximum starting torque.

h. The controllers must be capable of producing an output frequency over the range of 3 Hz to 60 Hz (20 to one speed range), without low speed cogging. Over frequency protection must be included such that a failure in the controller electronic circuitry must not cause frequency to exceed 110 percent of the maximum controller output frequency selected.

i. Minimum and maximum output frequency must be adjustable over the following ranges: 1) Minimum frequency 3 Hz to 50 percent of maximum selected frequency; 2) Maximum frequency 40 Hz to 60 Hz.

j. The controller efficiency at any speed must not be less than 96 percent.

k. The controllers must be capable of being restarted into a motor coasting in the forward direction without tripping.

l. Protection of power semiconductor components must be accomplished without the use of fast acting semiconductor output fuses. Subjecting the controllers to any of the following conditions must not result in component failure or the need for fuse replacement:

(1) Short circuit at controller output

(2) Ground fault at controller output

(3) Open circuit at controller output

(4) Input undervoltage

(5) Input overvoltage

(6) Loss of input phase

(7) AC line switching transients

(8) Instantaneous overload

(9) Sustained overload exceeding 115 percent of controller rated current

(10) Over temperature

(11) Phase reversal

m. Solid state motor overload protection must be included such that current exceeding an adjustable threshold must activate a 60 second timing circuit. Should current remain above the threshold continuously for the timing period, the controller will automatically shut down.

n. Include slip compensation circuit that will sense changing motor load conditions and adjust output frequency to provide speed regulation of NEMA MG 1 Part 30 designed for use with adjustable frequency power supplies motors to within plus or minus 0.5 percent of maximum speed without the necessity of a tachometer generator.

o. The ASD must be factory set for manual restart after the first protective circuit trip for malfunction (overcurrent, undervoltage, overvoltage or overtemperature) or an interruption of power. The ASD must be capable of being set for automatic restart after a selected time delay. If the drive faults again within a specified time period (adjustable 0-60 seconds), a manual restart will be required. Provide Bidirectional Autospeed Search capable of starting the ASD into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

p. The ASD must include external fault reset capability. All the

necessary logic to accept an external fault reset contact must be included.

q. Provide critical speed lockout circuitry to prevent operating at frequencies with critical harmonics that cause resonant vibrations. The ASD must have a minimum of three user selectable bandwidths.

r. Provide properly sized NEMA rated by-pass and isolation contactors to enable operation of motor in the event of ASD failure. Install mechanical and electrical interlocks between the by-pass and isolation contactors. Provide a selector switch and transfer delay timer. Motor overload and short circuit protective features must remain in use during the bypass mode.

s. Each individual ASD must meet the following Total Harmonic Distortion (THD) requirements at the input terminals to the factory assembly of the ASD or at the load disconnecting means serving the ASD and filter assembly. These measurements should be taken with the drive set at 90 percent frequency (rpms) and the motor under a minimum of 50 percent demand.

(1) The Voltage THD should not exceed 2.0 percent THD.

(2) The Current THD should not exceed 15.0 percent THD.

(3) If the standard factory ASD does not meet or exceed these requirements the factory must install appropriate equipment (Harmonic Traps, Filters, different Drive technology, etc.) to mitigate the distortion to assure performance of the VFD is within the limits.

(4) These tests should be performed at the Manufacturers Laboratory facilities and submitted as part of the Product Data Submittals, in order to prevent the necessity of adding mitigation equipment in the field. If the requirements listed above are met, IEEE 519 will also be met.

t. Minimum Operating Conditions. Designed and constructed ASD's to operate within the following service conditions:

(1) Ambient Temperature Rating: 0 to 120 degrees F.

(2) Non-condensing relative humidity rating: less than 95 percent.

(3) Ambient rating: Not exceed 3,300 feet.

2.1.1 ASD for HVAC Application

ASDs must have the following features:

a. A local operator control providing the following functions:

(1) Remote/Local operator selection with password access.

(2) Run/Stop and manual speed commands.

(3) All programming functions.

(4) Scrolling through all display functions.

b. A local operator control panel with the following data displayed:

(1) ASD status.

(2) Frequency.

(3) Motor RPM.

(4) Phase current.

(5) Scrolling through all display functions.

(6) Fault diagnostics in descriptive text.

(7) All programmed parameters.

c. Standard PI loop controller with input terminal for controlled variable and parameter settings.

d. User interface terminals for remote control of ASD speed, speed feedback, and an isolated form C SPDT relay, which energizes on a drive fault condition.

e. An isolated form C SPDT auxiliary relay which energizes on a run command.

f. An adjustable carrier frequency with 16 KHz minimum upper limit.

g. A built-in or external line reactor with 3 percent minimum impedance to protect the DC bus capacitors and rectifier section diodes, reduce power line transient voltage, line notching, DC bus over-voltage tripping and improve the inverter over-current and over-voltage conditions.

h. Historical logging information and displays:

(1) Real-time clock with current time and date.

(2) Running log of total power versus time.

(3) Total run time.

(4) Fault log, maintaining last four faults with time and data stamp for each.

(5) .

i. The ASD must be capable of automatic control by a remote 4-20 mA, 0 to 10 VDC signal, by BACnet network command, or manually by the ASD control panel.

j. ASDs must include the following operator programmable parameters:

(1) Upper and lower limit frequency.

(2) Acceleration and deceleration rate.

(3) Variable torque volts per Hertz curve.

(4) Starting voltage level.

(5) Starting frequency level.

(6) Display speed scaling.

(7) Enable/disable soft stall feature.

(8) Motor overload level.

(9) Motor stall level.

(10) Jump frequency and hysteresis band.

(11) PWM carrier frequency.

k. ASD must have the following protective features:

(1) An electronic adjustable inverse time current limit with consideration for additional heating of the motor at frequencies below 45Hz, for the protection of the motor.

(2) An electronic adjustable soft stall feature, allowing the ASD to lower the frequency to a point where the motor will not exceed the full-load amperage when an overload ASD will automatically return to the requested frequency when load conditions permit.

(3) A separate electronic stall at 110 percent ASD rated current, and a separate hardware trip at 190 percent current.

(4) The ability to shut down if inadvertently started into a rotating load without damaging the ASD or the motor.

(5) The ability to keep a log of a minimum of four previous fault conditions, indicating the fault type and time of occurrence in descriptive text.

(6) The ability to sustain 110 percent rated current for 60 seconds.

(7) The ability to shutdown safely or protect against and record the following fault conditions:

(a) Over current (and an indication if the over current was during acceleration, deceleration, or running).

(b) Over current internal to the drive.

(c) Motor overload at start-up.

(d) Over voltage from utility power.

(e) Motor running overload.

(f) Over voltage during deceleration.

(g) ASD over heat.

(h) Load and ground fault.

(i) Abnormal parameters or data in ASD EEPROM.

2.2 ENCLOSURES

Provide equipment enclosures conforming to NEMA 250, NEMA ICS 7, and NEMA ICS 6, with a heater if located outdoors. An HMCP device shall provide the disconnecting means. The operating handle shall protrude through the door, but the disconnect shall not be mounted on the door. The handle shall indicate ON, OFF, and tripped conditions. The handle shall have provisions to accommodate a minimum of three padlocks in the OFF position. Interlocks shall prevent unauthorized opening or closing of the ASD door with the disconnect handle in the ON position. The door handle interlock should have provisions to be defeated by qualified maintenance personnel.

2.3 WIRES AND CABLES

All wires and cables must conform to NEMA 250, NEMA ICS 7, NFPA 70.

2.4 NAMEPLATES

Nameplates external to NEMA enclosures must conform with the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide manufacturer's standard, permanent nameplates for internal areas of enclosures.

2.5 SOURCE QUALITY CONTROL

2.5.1 ASD Test Plan

To ensure quality, each ASD must be subject to a series of in-plant quality control inspections before approval for shipment from the manufacturer's facilities. Provide test plans.

2.5.2 ASD Test Report

To ensure quality, each ASD must be subject to a series of in-plant quality control inspections before approval for shipment from the manufacturer's facilities. Provide test reports.

PART 3 EXECUTION

3.1 INSTALLATION

Per NEMA ICS 3.1, install equipment in accordance with the approved manufacturer's printed installation drawings, instructions, wiring diagrams, and as indicated on project drawings and the approved shop drawings. A field representative of the drive manufacturer must supervise the installation of all equipment, and wiring.

3.2 GROUNDING

Per NEMA ICS 7.2, ASD must be solidly grounded to the main distribution.

3.3 FIELD QUALITY CONTROL

Specified products must be tested as a system for conformance to specification requirements prior to scheduling the acceptance tests. Conduct performance verification tests in the presence of Government

representative, observing and documenting complete compliance of the system to the specifications. Submit a signed copy of the test results, certifying proper system operation before scheduling tests.

3.3.1 ASD Test

A proposed test plan must be submitted to the contracting officer at least 28 calendar days prior to proposed testing for approval. The tests must conform to NEMA ICS 1, NEMA ICS 7, and all manufacturer's safety regulations. The Government reserves the right to witness all tests and review any documentation. Inform the Government at least 14 working days prior to the dates of testing. Perform the ASD test with the assistance of a factory-authorized service representative.

3.3.2 Performance Verification Tests

"Performance Verification Test" plan must provide the step by step procedure required to establish formal verification of the performance of the ASD. Compliance with the specification requirements must be verified by inspections, review of critical data, demonstrations, and tests. The Government reserves the right to witness all tests, review data, and request other such additional inspections and repeat tests as necessary to ensure that the system and provided services conform to the stated requirements. Inform the Government 14 calendar days prior to the date the test is to be conducted.

3.3.3 Endurance Test

Immediately upon completion of the performance verification test, the endurance test must commence. The system must be operated at varying rates for not less than 192 consecutive hours, at an average effectiveness level of 0.9998, to demonstrate proper functioning of the complete PCS. Continue the test on a day-to-day basis until performance standard is met. The contractor is not allowed in the building during the endurance test. The system must respond as designed.

3.4 DEMONSTRATION

3.4.1 Training

Coordinate training requirements with the Contracting Officer. Provide video tapes, if available, of all training provided to the Government for subsequent use in training new personnel. Provide all training aids, texts, and expendable support material for a self-sufficient presentation shall be provided, the amount of which to be determined by the contracting officer.

3.4.1.1 Instructions to Government Personnel

Provide the services of competent instructors with minimum two-year field experience with the operation and maintenance of similar ASDs who will give full instruction to designated personnel in operation, maintenance, calibration, configuration, and programming of the complete control system. Orient the training specifically to the system installed. Instructors must be thoroughly familiar with the subject matter they are to teach. The number of training days of instruction furnished must be as specified. A training day is defined as eight hours of instruction, including two 15-minute breaks and excluding lunch time; Monday through Friday. Provide a training manual for each student at each training phase

which describes in detail the material included in each training program. Provide one additional copy for archiving. Provide equipment and materials required for classroom training. Provide a list of additional related courses, and offers, noting any courses recommended. List each training course individually by name, including duration, approximate cost per person, and location of course. Unused copies of training manuals must be turned over to the Government at the end of last training session.

3.4.1.2 Operating Personnel Training Program

Provide one 2-hour training session at the site at a time and place mutually agreeable between the Contractor and the Government. Provide session to train 4 operation personnel in the functional operations of the system and the procedures that personnel will follow in system operation. This training shall include:

a. System overview

b. General theory of operation

c. System operation

d. Alarm formats

e. Failure recovery procedures

f. Troubleshooting

3.4.1.3 Engineering/Maintenance Personnel Training

Accomplish the training program as specified. Training must be conducted on site at a location designated by the Government. Provide a one-day training session to train four engineering personnel in the functional operations of the system. This training must include:

a. System overview

b. General theory of operation

c. System operation

d. System configuration

e. Alarm formats

f. Failure recovery procedures

g. Troubleshooting and repair

h. Maintenance and calibration

i. System programming and configuration

-- End of Section --

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SECTION 26 32 15

ENGINE-GENERATOR SET STATIONARY 15-2500 KW, WITH AUXILIARIES
05/24

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.1	(2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.3	(2021) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2024) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2022) Forged Fittings, Socket-Welding and Threaded
ASME B16.21	(2021) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B31.1	(2024) Power Piping
ASME B31.3	(2022; Errata 2023) Process Piping
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2024) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A106/A106M	(2019a) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A126	(2004; R 2023) Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings

ASTM A181/A181M	(2014; R 2020) Standard Specification for Carbon Steel Forgings, for General-Purpose Piping
ASTM A193/A193M	(2024a) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A194/A194M	(2024) Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A234/A234M	(2024) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM B395/B395M	(2018) Standard Specification for U-Bend Seamless Copper and Copper Alloy Heat Exchanger and Condenser Tubes
ASTM D975	(2020) Standard Specification for Diesel Fuel Oils

ELECTRICAL GENERATING SYSTEMS ASSOCIATION (EGSA)

EGSA 101P	(1995) Performance Standard for Engine Driven Generator Sets

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 1	(2000; R 2011) General Principles for Temperature Limits in the Rating of Electric Equipment and for the Evaluation of Electrical Insulation
IEEE 43	(2013) Recommended Practice for Testing Insulation Resistance of Rotating Machinery
IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE 115	(2019) Guide for Test Procedures for Synchronous Machines: Part I Acceptance and Performance Testing; Part II Test Procedures and Parameter Determination for Dynamic Analysis
IEEE 120	(2023) Master Test Guide for Electrical Measurements in Power Circuits
IEEE 484	(2019) Recommended Practice for Installation Design and Implementation of

	Vented Lead-Acid Batteries for Stationary Applications
IEEE 485	(2020) Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications
IEEE 519	(2022) Standard for Harmonic Control in Electrical Power Systems
IEEE C2	(2023) National Electrical Safety Code
IEEE C50.12	(2005; R 2010) Standard for Salient Pole 50 HZ and 60 Hz Synchronous Generators and Generation/Motors for Hydraulic Turbine Applications Rated 5 MVA and above
IEEE C57.13	(2016) Standard Requirements for Instrument Transformers
IEEE C57.13.1	(2006; R 2012) Guide for Field Testing of Relaying Current Transformers

INTERNATIONAL CODE COUNCIL (ICC)

ICC IBC	(2024) International Building Code

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 3046	(2002, 2006, 2009, 2001) Reciprocating Internal Combustion Engines - Performance--Part 1, 3, 4, 5, 6
ISO 8528	(1993; R 2018) Reciprocating Internal Combustion Engine Driven Alternating Current Generator Sets--Part 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-70	(2011) Gray Iron Gate Valves, Flanged and Threaded Ends
MSS SP-71	(2018) Gray Iron Swing Check Valves, Flanged and Threaded Ends
MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves

MSS SP-85	(2011) Gray Iron Globe & Angle Valves Flanged and Threaded Ends

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA MG 1	(2021) Motors and Generators
NEMA PB 1	(2011) Panelboards
NEMA PB 2	(2011) Deadfront Distribution Switchboards
NEMA/ANSI C12.11	(2006; R 2019) Instrument Transformers for Revenue Metering, 10 kV BIL through 350 kV BIL (0.6 kV NSV through 69 kV NSV)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 30	(2024; TIA 24-1) Flammable and Combustible Liquids Code
NFPA 37	(2024) Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
NFPA 54	(2024) National Fuel Gas Code
NFPA 58	(2024; TIA 24-2) Liquefied Petroleum Gas Code
NFPA 70	(2026; TIA 26-1; ERTA 26-1; TIA 26-2; TIA 26-3; TIA 26-4; TIA 26-5; TIA 26-6; TIA 26-7; ERTA 26-2; ERTA 26-3) National Electrical Code
NFPA 110	(2025) Standard for Emergency and Standby Power Systems

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE ARP892	(1965; R 1994) DC Starter-Generator, Engine
SAE J537	(2016) Storage Batteries

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-461	(2015; Rev G) Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
UFC 3-301-01	(2023; with Change 2, 2024) Structural Engineering

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

40 CFR 60	Standards of Performance for New Stationary Sources

UL SOLUTIONS (UL)

UL 142	(2006; Reprint Jan 2021) UL Standard for Safety Steel Aboveground Tanks for Flammable and Combustible Liquids
UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment
UL 489	(2025) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 1236	(2015; Reprint Feb 2021) UL Standard for Safety Battery Chargers for Charging Engine-Starter Batteries
UL 1437	(2006) Electrical Analog Instruments - Panel Board Types

1.2 RELATED MATERIALS

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, and Section 26 08 00 APPARATUS INSPECTION AND TESTING apply to this section, except as modified herein.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Engine-Generator Set and Auxiliary Equipment; G

Auxiliary Systems; G

Detailed Drawings; G

Acceptance; G

SD-03 Product Data

Harmonic Requirements; G

Engine-Generator Set Efficiencies; G

Emissions; G

filters; G

special tools; G

Remote Alarm Annunciator; G

Engine-Generator Parameter Schedule

Heat Exchanger

Generator

Manufacturer's Catalog

Site Welding

Spare Parts

Onsite Training

Vibration-Isolation

Posted Data and Instructions; G

Instructions; G

Experience

Field Engineer

General Installation

Exciter

Load Bank; G

SD-05 Design Data

Performance Criteria

Sound Limitations; G

Integral Main Fuel Storage Tank

Power Factor

Heat Exchanger

Time-Delay on Alarms

Cooling System

Vibration Isolation

Battery Charger

Capacity Calculations for Engine-Generator Set; G

Torsional Vibration Stress Analysis Computations; G

Capacity Calculations for Batteries; G

Turbocharger Load Calculations; G

SD-06 Test Reports

Performance Tests

Factory Inspection and Tests

Factory Tests

Onsite Inspection and Tests; G

Acceptance Checks and Tests; G

Functional Acceptance Tests; G

Maintenance Procedures; G

Operation and Maintenance Manuals; G

Inspections; G

Functional Acceptance Test Procedure; G

SD-07 Certificates

Cooling System

Vibration Isolation

Prototype Test

Reliability and Durability

Fuel System Certification; G

Start-Up Engineer; G

Instructor's Qualification Resume; G

Engine Emission Limits; G

Sound Limitations

Site Visit

Current Balance

Materials and Equipment

Factory Inspection and Tests

SD-09 Manufacturer's Field Reports

Engine Tests; G

Generator Tests; G

Assembled Engine-Generator Set Tests; G

SD-10 Operation and Maintenance Data

Preliminary Assembled Operation and Maintenance Manuals; G

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and the paragraph ASSEMBLED OPERATION AND MAINTENANCE MANUALS.

SD-11 Closeout Submittals

Posted Data and Instructions; G

Training Plan; G

1.4 QUALITY ASSURANCE

1.4.1 Conformance to Codes and Standards

Where equipment is specified to conform to requirements of any code or standard such as UL, NEMA, etc., the design, fabrication and installation must also conform to the code.

1.4.2 Site Welding

Weld structural members in accordance with Section 05 05 23.16 STRUCTURAL WELDING. For all other welding, qualify procedures and welders in accordance with ASME BPVC SEC IX.

a. Welding procedures qualified by others, and welders and welding operators qualified by a previously qualified employer may be accepted as permitted by ASME B31.1.

b. Submit a copy of qualifying procedures and a list of names and identification symbols of qualified welders and welding operators.

c. Submit a letter listing the welder qualifying procedures for each welder, complete with supporting data such as test procedures used, what was tested to, and a list of the names of all welders and their identification symbols.

d. Perform welder qualification tests for each welder whose qualifications are not in compliance with the referenced standards. Notify the Contracting Officer 24 hours in advance of qualification tests which must be performed at the work site, if practical.

e. The welder or welding operator must apply the personally assigned symbol near each weld made as a permanent record.

1.4.3 Vibration Limitation

Limit the maximum engine-generator set vibration in the horizontal, vertical, and axial directions to 6 mils (peak-peak RMS), with an overall velocity limit of 0.95 inches/second RMS, at rated speed for all loads through 110 percent of rated speed. The engine-generator set must be provided with vibration isolation in accordance with the manufacturer's standard recommendation. Where the vibration isolation system does not secure the base to the structure floor or unit foundation, provide seismic

restraints in accordance with the seismic parameters specified.

1.4.4 Torsional Analysis

Submit torsional analysis including prototype testing or calculations which certify and demonstrate that no damaging or dangerous torsional vibrations will occur when the prime mover is connected to the generator, at synchronous speeds, plus/minus 10 percent.

1.4.5 Performance Data

Submit vibration isolation system performance data for the range of frequencies generated by the engine-generator set during operation from no load to full load and the maximum vibration transmitted to the floor. Also submit a description of seismic qualification of the engine-generator mounting, base, and vibration isolation.

1.4.6 Seismic Requirements

Seismic requirements must be in accordance with UFC 3-301-01 and Section 26 05 48 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT.

1.4.7 Experience

Each component manufacturer must have a minimum of 3 years' experience in the manufacture, assembly and sale of components used with stationary engine-generator sets for commercial and industrial use. The engine-generator set manufacturer/assembler must have a minimum of 3 years' experience in the manufacture, assembly and sale of stationary engine-generator sets for commercial and industrial use. Submit a statement showing and verifying these requirements.

1.4.8 Field Engineer

The engine-generator set manufacturer or assembler must furnish a qualified field engineer to supervise the complete installation of the engine-generator set, assist in the performance of the onsite tests, and instruct personnel as to the operational and maintenance features of the equipment. The field engineer must have attended the engine generator manufacturer's training courses on installation and operation and maintenance of engine generator sets. Submit a letter listing the qualifications, schools, formal training, and experience of the field engineer.

1.4.9 Detailed Drawings

Submit detailed drawings showing the following:

a. Base-mounted equipment, complete with base and attachments, including anchor bolt template and recommended clearances for maintenance and operation.

b. Starting system.

c. Fuel system.

d. Cooling system.

e. Exhaust system.

f. Electric wiring of relays, breakers, programmable controllers, and switches including single line and wiring diagrams.

g. Lubrication system, including piping, pumps, strainers, filters, heat exchangers for lube oil and turbocharger cooling, electric heater, controls and wiring.

h. Location, type, and description of vibration isolation devices for all applications.

i. The safety system, including wiring schematics.

j. One-line schematic and wiring diagrams of the generator, exciter, regulator, governor, and instrumentation.

k. Panel layouts.

l. Mounting and support for each panel and major piece of electrical equipment.

m. Engine-generator set rigging points and lifting instructions.

1.4.10 Auxiliary Systems Engine-Generator Set and Auxiliary Equipment Drawing Requirements

Submit drawings pertaining to the engine-generator set and auxiliary equipment, including but not limited to the following:

a. Certified outline, general arrangement (setting plan), and anchor bolt details. Show total weight and center of gravity of assembled equipment on the steel sub-base.

b. Detailed elementary, schematic wiring, and interconnection diagrams of the engine starting system, jacket coolant heating system, engine protective devices, engine alarm devices, engine speed governor system, generator and excitation system, and other integral devices.

c. Detailed elementary, schematic wiring; and interconnection diagrams of the fuel system, starting battery system, engine-generator control panel, generator circuit breaker, and remote alarm annunciator.

d. Dimensional drawings or catalog cuts of exhaust silencers, radiator, fuel day tanks, fuel oil cooler, valves and pumps, intake filters, vibration isolators, and other auxiliary equipment not integral with the engine-generator set.

1.4.11 Auxiliary Systems Drawing Requirements

Submit drawings showing floor plan arrangement of exhaust, air intake, fuel oil cooler, and jacket coolant water systems including arrangement of piping and pipe sizes.

1.4.12 Vibration Isolation System Certification

Submit certification from the manufacturer that the vibration isolation system will reduce the vibration to the limits specified in the paragraph VIBRATION ISOLATION.

1.4.13 Fuel System Certification

When the fuel system requires a fuel oil cooler as described in the paragraph FUEL OIL COOLER, submit certification from the engine manufacturer that the fuel system design is satisfactory.

1.5 DELIVERY, STORAGE, AND HANDLING

Properly protect materials and equipment, in accordance with the manufacturers recommended storage procedures, before, during, and after installation. Protect stored items from the weather and contamination. During installation, cap piping and similar openings to keep out dirt and other foreign matter.

Deliver equipment on pallets or blocking wrapped in heavy-duty plastic, sealed to protect parts and assemblies from moisture and dirt. Protect and prepare batteries for shipment as recommended by the battery manufacturer. Store auxiliary equipment at the site in covered enclosures, protected from atmospheric moisture, dirt, and ground water.

1.6 EXTRA MATERIALS

Provide two sets of special tools and two sets of filters required for maintenance. Special tools are those that only the manufacturer provides, for special purposes, or to reach otherwise inaccessible parts. One handset must be provided for each electronic governor when required to indicate and/or change governor response settings. Furnish 4 liters one gallon of identical paint used on engine-generator set in manufacturer's sealed container with each engine-generator set.

Wrenches and tools specifically designed and required to work on the new equipment, which are not commercially available as standard mechanic's tools, must be furnished to the Contracting Officer.

Provide proposed operating instructions for the engine-generator set and auxiliary equipment laminated between matte-surface thermoplastic sheets and suitable for placement adjacent to corresponding equipment. After approval, install operating instructions where directed.

1.7 MAINTENANCE SERVICES

Submit the operation and maintenance manuals and have them approved prior to commencing onsite tests.

1.7.1 Operation Manual

Provide three copies of the manufacturers standard operation manual in 8-1/2 by 11 inch three-ring binders. Sections must be separated by heavy plastic dividers with tabs which identify the material in the section. Fold drawings with the title block visible, and placed in 8-1/2 by 11 inch plastic pockets with reinforced holes. The manual must include:

a. Step-by-step procedures for system startup, operation, and shutdown;

b. Drawings, diagrams, and single-line schematics to illustrate and define the electrical, mechanical, and hydraulic systems with their controls, alarms, and safety systems;

c. Procedures for interface and interaction with related systems to

include automatic transfer switches, fire alarm/suppression systems, load shedding systems, uninterruptible power supplies.

1.7.2 Maintenance Manual

Provide three copies of the maintenance manual containing the information described below in 8-1/2 x 11 inch three-ring binders. Separate each section by a heavy plastic divider with tabs. Fold drawings with the title block visible, and placed in plastic pockets with reinforced holes. The manual must include:

a. Procedures for each routine maintenance item. Procedures for troubleshooting. Factory-service, take-down overhaul, and repair service manuals, with parts lists.

b. The manufacturer's recommended maintenance schedule.

c. A component list which includes the manufacturer's name, address, type or style, model or serial number, rating, and catalog number for the major components.

d. A list of spare parts for each piece of equipment and a complete list of materials and supplies needed for operation.

1.7.3 Assembled Operation and Maintenance Manuals

The contents of the assembled operation and maintenance manuals must include the manufacturer's O&M information required by the paragraph SD-10, OPERATION AND MAINTENANCE DATA and the manufacturer's O&M information specified in Section 26 36 23 AUTOMATIC TRANSFER SWITCHES AND BY-PASS/ISOLATION SWITCH.

a. Manuals must be in separate books or volumes, assembled and bound securely in durable, hard covered, water resistant binder, and indexed by major assembly and components in sequential order.

b. A table of contents (index) must be made part of the assembled O&M. The manual must be assembled in the order noted in table of contents.

c. The cover sheet or binder on each volume of the manuals must be identified and marked with the words, "Operation and Maintenance Manual."

1.8 SITE CONDITIONS

Protect the components of the engine-generator set, including cooling system components, pumps, fans, and similar auxiliaries when not operating and provide components capable of the specified outputs in the following environment:

a. Site Location: Mansfield Lahm Air National Guard Base, OH

b. Site Elevation: 1250 feet above mean sea level.

c. Ambient Temperatures: Refer to mechanical specifications.

d. Seismic Zone: Zone II B as defined by ICC IBC.

PART 2 PRODUCTS

2.1 SYSTEM REQUIREMENTS

a. Provide and install each engine-generator set complete and totally functional, with all necessary ancillary equipment to include: air filtration; starting system; generator controls, protection, and isolation; instrumentation; lubrication; fuel system; cooling system; and engine exhaust system. Each engine-generator set must satisfy the requirements specified in the Engine-Generator Parameter Schedule. Submit certification that the engine-generator set and cooling system function properly in the ambient temperatures specified.

b. Provide each engine-generator set consisting of one engine, one generator, and one exciter mounted, assembled, and aligned on one base; and all other necessary ancillary equipment which may be mounted separately. Assemble sets having a capacity of 750 kW or smaller and attach to the base prior to shipping. Sets over 750 kW capacity may be shipped in sections. Provide set components that are environmentally suitable for the locations shown and that are the manufacturer's standard product offered in catalogs for commercial or industrial use. Provide a generator strip heater for moisture control when the generator is not operating. Identify any nonstandard products or components and the reason for their use.

2.1.1 Engine-Generator Parameter Schedule

Engine-Generator Set and Auxiliary Equipment Capacity Calculations for Engine-Generator Set

ENGINE-GENERATOR PARAMETER SCHEDULE	
Identification	Make/Model
Electrical Characteristics	
Power Rating	Gross bhp rating / Net brake power rating Refer to Contract Documents for kW rating 0.8 power factor
Governor Type	Type Make / Model Isochronous
Overload Capacity (Prime applications only)	110 percent of Service Load for 1 hour in 12 consecutive hours
Service Load	As noted in sizing calculations
Motor Starting kVA (Max.)	As noted in sizing calculations
Power Factor	0.8 lagging
Engine-Generator Applications	stand-alone

ENGINE-GENERATOR PARAMETER SCHEDULE	
Voltage Regulation (No Load to Full Load)(Stand-alone applications)	plus or minus 2 percent (maximum)
Voltage Bandwidth (steady state)	plus or minus 1 percent
Frequency	60 Hz
Voltage	480/277 volts
Phases	3 Phase, Wye
Minimum Generator Sub-transient Reactance	Manufacturer standard
Nonlinear Loads	As noted in sizing calculations
Max Step Load Increase	100 percent of Service Load at 0.8 PF
Transient Recovery Time with Step Load Increase (Voltage)	Manufacturer standard meeting frequency and voltage dip requirements
Transient Recovery	Manufacturer standard meeting frequency and voltage dip requirements
Time with Step Load Increase (Frequency)	
Maximum Voltage Deviation with Step Load Increase	30 percent of rated voltage
Maximum Frequency Deviation with Step Load Increase	5 percent of rated frequency
Max Step Load Decrease (without shutdown)	100 percent of Service Load at 0.8 PF
Frequency Bandwidth (steady state)	plus or minus 0.25 percent
Frequency Regulation (droop) (No Load to Full Load)	3 percent (maximum)
Frequency Bandwidth (steady state)	plus or minus 0.25 percent
Reactances	Synchronous reactance, Xd Transient reactance, X'd Sub-transient reactance, X"d Negative sequence reactance, X2 Zero sequence reactance, Xo

ENGINE-GENERATOR PARAMETER SCHEDULE	
Capacity Calculations for Batteries	
Calculation must verify that the engine starting battery capacity exceeds dc power requirements.	
Mechanical Characteristics	
Engine Description	Strokes/cycle Number of cylinders Bore and Stroke, inches
Engine Speed	1800 rpm
Piston Speed	Manufacturer standard
Heat Exchanger Type	fin-tube (radiator)
Engine Cooling Type	water/ethylene glycol
Intercooler Type	Air-to-Air / Jacket Water
Induction Method	Naturally Aspirated / Turbocharged
Turbocharger	Make / Model
Max Time to Start and be Ready to Assume Load	10 seconds
Engine-Generator Set Efficiencies	
Fuel Consumption	At 0.8 power factor, Gallons / hour for: 1 / 2 load 3 / 4 load Full Load
Generator Efficiency	At 0.8 power factor,(per cent) for: 1 / 2 load 3 / 4 load Full Load
Radiator Capacity	Coolant Type gpm coolant cfm air through radiator Btu per hr of heat exchange based on optimum coolant temperature to and from engine
Engine-Generator Set Emissions Data	
Exhaust Temperature	Degrees F at full load
Weight of Exhaust Gas	lb per hr at full load
Weight of Intake Air	lb per hr at full load

ENGINE-GENERATOR PARAMETER SCHEDULE	
Total Heat Rejected	Btu per hr, at full load to: Jacket Coolant System Fuel Oil Cooling System
Emissions	lb per hr, at full load Total Suspended Particulate Particulate Matter with an average aerodynamic diameter of 10 microns Sulfur Dioxides Nitrogen Oxides (as NO2) Carbon Monoxide Volatile Organic Compounds
Visible Emissions	Percent opacity at full load

Torsional Vibration Stress Analysis Computations

Torsional vibrational stresses in the crankshaft and generator shaft of assembled engine and driven generator must not exceed 5000 psi when engine is driving generator at rated speed while assembled unit is loaded to rated engine-generator set power. Computations must be based on a mathematical model of the assembled generator set provided or based on calculations using measured values from tests on a unit identical to the one provided. Calculations based on models of, or measured data from, the unassembled engine and generator will not be acceptable. Calculations must include:

a. A description of the system relating information pertinent to analysis such as operating speed range and identification plate data.

b. A mass elastic assembly drawing, showing the arrangement of the units in the generator set and dimensions of shafting, including minimum diameters (or section moduli) of shafting in the system.

c. A labeled line diagram of the mass elastic system indicating values of masses, stiffness, equivalent lengths, and equivalent diameters including basic assumptions and definition of terms.

d. Sample computations showing procedures used to obtain resulting stress values.

e. Computations indicating assembled engine-generator speed of 1800 rpm with assembly loaded to rated generator power and the resulting computed critical torsional stress values in the assembled engine crankshaft and generator shaft.

Turbocharger Load Calculations

ENGINE-GENERATOR PARAMETER SCHEDULE
NOTE: When the engine-generator set installation includes field installed exhaust system (i.e., the engine-generator set is installed internal to a building in lieu of in a self-contained outdoor enclosure), include the following paragraph. When the proposed exhaust system layout is different from that shown on the contract drawings, submit calculations showing that the external loads from the exhaust system such as weight and thermal expansion do not exceed the engine manufacturer's maximum allowed forces and moments on the turbocharger.

2.1.2 Rated Output Capacity

Provide each engine-generator-set with power equal to the sum of service load plus the machine's efficiency loss and associated ancillary equipment loads. Rated output capacity must also consider engine and/or generator oversizing required to meet requirements in paragraph Engine-Generator Parameter Schedule.

The engine must meet the specified maximum BMEP requirements at rated speed as calculated in accordance with the calculations in the engine-generator parameter schedule. The engine capacity must be based on the following:

a. Engine burning diesel fuel conforming to ASTM D975, Grade 2-D, at an ambient temperature of 85 degrees F. For stationary engines operated in the United States, diesel fuel requirements are found in 40 CFR 60 Subpart IIII.

b. Engine cooled by a radiator fan mechanically driven by the engine or remote with a motor driven fan.

c. Engine cooled by coolant mixture of water and ethylene glycol, 50 percent by volume of each.

Maximum BMEP, psi			
	Naturally Aspirated	Turbocharged	Turbocharged and Intercooled
Four-cycle engines	Manufacturer standard	Manufacturer standard	Manufacturer standard
Engine speed, rpm:	1800	1800	1800

2.1.2.1 Engine Emission Limits

Engine must be certified by the manufacturer to meet applicable EPA emission standards found in 40 CFR 60 Subpart IIII. In addition, engine must meet any applicable state or local emission requirements (ex: California SCAQMD).

2.1.2.2 Performance Class

The voltage and frequency behavior of the generator set must be in accordance with ISO 8528 operating limit values for performance Class G3.

2.1.3 Power Ratings

Power ratings must be in accordance with EGSA 101P.

2.1.4 Transient Response

The engine-generator set governor and voltage regulator must cause the engine-generator set to respond to the maximum step load changes such that output voltage and frequency recover to and stabilize within the operational bandwidth within the transient recovery time. The engine-generator set must respond to maximum step load changes such that the maximum voltage and frequency deviations from bandwidth are not exceeded.

2.1.5 Reliability and Durability

Each standby engine-generator set must have both an engine and a generator capable of delivering the specified power on a standby basis with an anticipated mean time between overhauls of no less than 5,000 hours operating with a load factor of 70 percent. Cite two like engines and two like generators that have performed satisfactorily in a stationary power plant, independent and separate from the physical location of the manufacturer's and assembler's facilities, for standby without any failure to start, including all periodic exercise. Provide like engines and generators that have had no failures resulting in downtime for repairs in excess of 72 hours during two consecutive years of service. Provide engines that are the same model, speed, bore, stroke, number and configuration of cylinders, and rated output capacity. Provide generators that are the same model, speed, pitch, cooling, exciter, voltage regulator and rated output capacity.

Submit a reliability and durability certification letter from the manufacturer and assembler to prove that existing facilities are and have been successfully utilizing the same components proposed to meet this specification, in similar service. Certification may be based on components, i.e. engines used with different models of generators and generators used with different engines, and does not exclude annual technological improvements made by a manufacturer in the basic standard-model component on which experience was obtained, provided parts interchangeability has not been substantially affected and the current standard model meets the performance requirements specified. Provide a list with the name of the installations, completion dates, and name and telephone number of a point of contact.

2.1.6 Engine-Generator Set Enclosure

Provide engine-generator set enclosures that are corrosion resistant and fully weather resistant. The enclosure must contain all set components and provide ventilation to permit operation at Service Load under secured conditions. Provide access doors to controls and equipment requiring periodic maintenance or adjustment. Provide removable panels for access to components requiring periodic replacement. The enclosure must be capable of being removed without disassembly of the engine-generator set or removal of components other than the exhaust system. The enclosure

must reduce the noise of the generator set to within the limits specified in the paragraph SOUND LIMITATIONS.

2.1.7 Vibration Isolation

Provide an engine-generator set with a vibration isolation system in accordance with the manufacturer's standard recommendation. Submit vibration isolation system performance data for the range of frequencies generated by the engine-generator set during operation from no load to full load and the maximum vibration transmitted to the floor plus description of seismic qualification of the engine-generator mounting, base, and vibration isolation. Submit torsional analysis including prototype testing or and calculations which certify and demonstrate that no damaging or dangerous torsional vibrations will occur when the prime mover is connected to the generator, at synchronous speeds, plus 10 percent. Design and qualify vibration isolation systems as an integral part of the base and mounting system in accordance with the seismic parameters specified. Where the vibration isolation system does not secure the base to the structure floor or unit foundation, provide seismic restraints in accordance with the seismic parameters specified.

2.1.8 Harmonic Requirements

Non-linear loads to be served by each engine-generator set are as indicated. The maximum linear load demand (kVA at PF) when non-linear loads will also be in use is as indicated.

2.1.9 Starting Time Requirements

Upon receipt of a signal to start, each engine generator set will start, reach rated frequency and voltage and be ready to assume load within the time specified. For standby sets used in emergency power applications, each engine generator set will start, reach rated frequency and voltage, and power will be supplied to the load terminals of the automatic transfer switch within the starting time specified.

2.2 NAMEPLATES

Provide the manufacturer's name, type or style, model or serial number and rating on a plate secured to the equipment for each major component of this specification. Provide plates and tags sized so that inscription is readily legible to operating or maintenance personnel and securely mounted to or attached in proximity of their identified controls or equipment. Lettering must be normal block lettering, a minimum of 0.25 inch high. As a minimum, provide nameplates for:

Engines	Relays
Generators	Transformers (CT & PT)
Regulators	Day tanks
Pumps and pump motors	Governors
Generator Breaker	Air Starting System

Economizers	Heat exchangers (other than base mounted)

Where the following equipment is not provided as a standard component by the engine generator set manufacturer, the nameplate information may be provided in the maintenance manual in lieu of nameplates.

Battery charger	Heaters
Switchboards	Exhaust mufflers
Switchgear	Silencers
Battery	Exciters

2.2.1 Materials

Construct ID plates and tags of 16 gage minimum thickness bronze or stainless steel sheet metal engraved or stamped with inscription. Construct plates and tags not exposed to the weather or high operational temperature of the engine of laminated plastic, 0.125 inch thick, matte white finish with black center core, with lettering accurately aligned and engraved into the core.

2.2.2 Control Devices and Operation Indicators

Provide ID plates or tags for control devices and operation indicators, including valves, off-on switches, visual alarm annunciators, gages and thermometers, that are required for operation and maintenance of provided mechanical systems. Plates or tags must be minimum of 0.5 inch high and 2 inches long and must indicate component system and component function.

2.2.3 Equipment

Provide ID plates of a minimum size of high and 5 inches long on provided equipment indicating the following information:

a. Manufacturer's name, address, type and model number, serial number, and certificate of compliance with applicable EPA mission standards;

b. Contract number and accepted date;

c. Capacity or size;

d. System in which installed; and

e. System which it controls.

2.3 SAFETY DEVICES

Exposed moving parts, parts that produce high operating temperatures, parts which may be electrically energized, and parts that may be a hazard to operating personnel must be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Install safety devices such that proper operation of the equipment is not impaired.

2.4 MATERIALS AND EQUIPMENT

Submit certification stating that where materials or equipment are specified to comply with requirements of UL, written proof of such compliance has been obtained. The label or listing of the specified agency, or a written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of the specified agency are acceptable as proof.

2.4.1 Circuit Breakers, Low Voltage

UL 489.

2.4.2 Filter Elements

Provide the manufacturer's standard fuel-oil, lubricating-oil, and combustion-air filter elements.

2.4.3 Instrument Transformers

NEMA/ANSI C12.11.

2.4.4 Revenue Metering

IEEE C57.13.

2.4.5 Pipe (Fuel/Lube-Oil, Compressed Air, Coolant, and Exhaust)

ASTM A53/A53M, or ASTM A106/A106M steel pipe. Pipe smaller than 2 inches must be Schedule 80. Pipe 2 inches and larger must be Schedule 40.

2.4.5.1 Flanges and Flanged Fittings

ASTM A181/A181M, Class 60, or ASME B16.5, Grade 1, Class 150.

2.4.5.2 Pipe Welding Fittings

ASTM A234/A234M, Grade WPB or WPC, Class 150 or ASME B16.11, 3000 lb.

2.4.5.3 Threaded Fittings

ASME B16.3, Class 150.

2.4.5.4 Valves

MSS SP-80, Class 150.

2.4.5.5 Gaskets

Manufacturer's standard.

2.4.6 Pipe Hangers

MSS SP-58.

2.4.7 Electrical Enclosures

NEMA ICS 6.

2.4.7.1 Switchboards

NEMA PB 2.

2.4.7.2 Panelboards

NEMA PB 1.

2.4.8 Electric Motors

Provide electric motors that conform to the requirements of NEMA MG 1. Motors must have sealed ball bearings and a maximum speed of 1800 rpm. Motors used indoors must have drip-proof frames; enclose those that are used outside. Alternating current motors larger than 1/2 Hp must be of the squirrel-cage induction type for operation on 208 volts or higher, 60 Hz, and three-phase power. Alternating current motors 1/2 Hp or smaller, must be suitable for operation on 120 volts, 60 Hz, and single-phase power. Direct current motors must be suitable for operation on 125 volts.

2.4.9 Motor Controllers

Provide motor controllers and starters that conform to the requirements of NFPA 70 and NEMA ICS 2.

2.5 ENGINE

Each engine must operate on No. 2-D diesel fuel conforming to ASTM D975, must be designed for stationary applications and must be complete with ancillaries. The engine must be a standard production model shown in the manufacturer's catalog describing and depicting each engine-generator set and all ancillary equipment in sufficient detail to demonstrate complete specification compliance. The engine must be naturally aspirated, supercharged, or turbocharged. The engine must be 2- or 4-stroke-cycle and compression-ignition type. The engine must be vertical in-line, V- or opposed-piston type, with a solid cast block or individually cast cylinders. The engine must have a minimum of two cylinders. Opposed-piston type engines must have more than four cylinders. Each block must have a coolant drain port. Equip each engine with an over-speed sensor.

ISO 3046. Diesel engines must be four-cycle naturally aspirated, or turbocharged, or turbocharged and intercooled; vertical in-line or vertical Vee type; designed for stationary service. Engines must be capable of immediate acceleration from rest to normal speed without intermediate idle/warm up period or pre-lubrication to provide essential electrical power. Two-cycle engines are not acceptable.

2.5.1 Sub-base Mounting

Mount each engine-generator set on a structural steel sub-base sized to support the engine, generator, and necessary accessories, auxiliaries and control equipment to produce a complete self-contained unit as standard with the manufacturer. Design the structural sub-base to properly support the equipment and maintain proper alignment of the engine-generator set in the specified seismic zone. In addition, provide sub-base with both lifting rings and jacking pads properly located to facilitate shipping and installation of the unit. Factory align engine and generator on the sub-base and securely bolt into place in accordance with the

manufacturer's standard practice. Crankshaft must have rigid coupling for connection to the generator.

2.5.2 Assembly

Completely shop assemble each engine-generator set on its structural steel sub-base. Paint entire unit with manufacturer's standard paints and colors. After factory tests and before shipping, thoroughly clean and retouch painting as necessary to provide complete protection.

2.5.3 Turbocharger

If required by the manufacturer to meet the engine-generator set rating, provide turbine type driven by exhaust gas from engine cylinders, and direct connected to the blower supplying air to the engine intake manifold.

2.5.4 Intercooler

Provide manufacturer's standard intercooler for engine size specified.

2.5.5 Crankcase Protection

2.5.6 Miscellaneous Engine Accessories

Provide the following engine accessories where the manufacturer's standard design permits:

a. Piping on engine to inlet and outlet connections, including nonstandard companion flanges.

b. Structural steel sub-base and vibration isolators, foundation bolts, nuts, and pipe sleeves.

c. Level jack screws or shims, as required.

d. Rails, chocks, and shims for installation of sub-base on the foundation.

e. Removable guard, around fan. Support guard, on engine sub-base, to suit manufacturer's standard.

2.5.7 Intercooler

Provide manufacturer's standard intercooler for engine size specified.

2.6 FUEL SYSTEM

Provide fuel system conforming to the requirements of NFPA 30 and NFPA 37 and containing the following elements.

2.6.1 Pumps

Fuel transfer pumps may be mounted on the day tank. Pump must be horizontal, positive displacement. Direct-connect pump to motor through a flexible coupling. Equip each pump with a bypass relief valve, if not provided with an internal relief valve. Provide motor and controller in accordance with the paragraphs ELECTRIC MOTORS and MOTOR CONTROLLERS, respectively.

2.6.1.1 Main Pump

Provide engines with an engine driven pump. The pump must supply fuel at a minimum rate sufficient to provide the amount of fuel required to meet the performance indicated within the parameter schedule. Base the fuel flow rate on meeting the load requirements and all necessary recirculation.

2.6.1.2 Auxiliary Fuel Pump

Provide auxiliary fuel pumps to maintain the required engine fuel pressure, if either required by the installation or indicated on the drawings. The auxiliary pump must be driven by a dc electric motor powered by the starting/station batteries. Automatically actuate the auxiliary pump by a pressure-detecting device.

2.6.2 Fuel Filter

Provide a minimum of one full-flow fuel filter for each engine. The filter must be readily accessible and capable of being changed without disconnecting the piping or disturbing other components. Mark the inlet and outlet connections of the filter.

Provide intake filter assemblies for each engine of the oil bath or dry type, as standard with the manufacturer. Filters must be capable of removing a minimum of 92 percent of dirt and abrasive 3 microns and larger from intake air. Size filters to suit engine requirements at 100 percent of rated full load. Design unit for field access for maintenance purposes.

2.6.3 Relief/Bypass Valve

Provide a relief/bypass valve to regulate pressure in the fuel supply line, return excess fuel to a return line and prevent the build-up of excessive pressure in the fuel system.

2.6.4 Integral Main Fuel Storage Tank

Provide each engine with an integral main fuel tank. Each tank must be factory installed and provided as an integral part of the generator manufacturer's product. Provide each tank with connections for fuel supply line, fuel return line, local fuel fill port, gauge, vent line, and float switch assembly. Provide a fuel return line cooler as recommended by the manufacturer and assembler. The temperature of the fuel returning to the tank must be below the flash point of the fuel. Mount the tank within the enclosure for each engine-generator set provided with weatherproof enclosures. The fuel fill line must be accessible without opening the enclosure.

a. All Tanks: UL 142. Provide free standing double wall (110 percent containment) fuel tanks with a minimum capacity of 24 hours of engine-generator set operation at full-rated load. Epoxy coat day tanks inside and prime and paint outside. Construct tanks of not less than 3/16 inch steel plate with welded joints and necessary stiffeners on exterior of tank. Provide a braced structural steel framework support. Weld tank top tight. Provide 4 1/2 inch square inspection port with a 2 inch NPT fill connection and spill box. Provide proper normal and emergency venting for the primary tank and emergency venting only for the secondary tank / containment basin in accordance with UL 142 requirements.

b. Float Switches for Day Tanks: Provide tank-top mounted or external float cage, single-pole, single-throw type designed for use on fuel oil tanks. Arrange high level float switches to close on rise of liquid level, and low level float switches to close on fall of liquid level. Mount float cage units with isolating and drain valves. Contacts must be suitable for the station battery voltage.

(1) Critical low level float switch which must activate at 5 percent of normal liquid level must shut engine off.

(2) Low-low level float switch which must activate alarm at 30 percent of normal liquid level.

(3) Low level float switch which must open the fuel oil solenoid valve and start the fuel transfer pump at 75 percent of normal liquid level.

(4) High level float switch which must close the fuel oil solenoid valve and stop the fuel transfer pump at 90 percent of normal liquid level.

(5) Critical high level float switch which must activate alarm at 95 percent of normal liquid level.

c. Leak Detector Switch for Tanks: Actuates when fuel is detected in containment basin, stops fuel transfer pump, and closes the fuel oil solenoid valve.

d. Tank Gages for All Tanks: Provide buoyant force type gages for fuel tanks with dial indicator not less than 4 inches in size and arranged for top mounting. Calibrate each reading dial or scale for its specific tank to read from empty to full, with intermediate points of 1/4, 1/2, and 3/4.

e. Integral Base Tanks Used as Primary Tank: Provide a 2 inch opening at the tank fill port, fitted an overfill prevention valve (OPV). Additionally, the fill opening must be perpendicular to the tank in order to allow operation of the OPV. Integral base tank must be sized and configured such that the filling and venting nozzles are outside the generator cabinet for ease of accessibility, inspection, and maintenance. Level gage must be in the line of sight from the fill port.

2.6.4.1 Fuel Transfer Pump

Fuel transfer pumps may be mounted on the day tank. Pump must be horizontal, positive displacement. Direct-connect pump to motor through a flexible coupling. Equip each pump with a bypass relief valve, if not provided with an internal relief valve. Provide motor and controller in accordance with the paragraphs ELECTRIC MOTORS and MOTOR CONTROLLERS, respectively.

2.6.4.2 Capacity

Each tank must have capacity to supply fuel to the engine for an uninterrupted 4-hour period at 100 percent rated load without being refilled.

2.6.4.3 Local Fuel Fill

Each local fuel fill port on the day tank must have a screw-on cap.

2.6.4.4 Fuel Level Controls

Provide tanks with a float-switch assembly to perform the following functions:

a. Activate the "Low Fuel Level" alarm at 70 percent of the rated tank capacity.

b. Activate the "Overfill Fuel Level" alarm at 95 percent of the rated tank capacity.

2.6.4.5 Arrangement

Integral tanks may allow gravity flow into the engine. Gravity flow tanks and any tank that allows a fuel level above the fuel injectors must have an internal or external factory installed valve located as near as possible to the shell of the tank. The valve must close when the engine is not operating. Provide integral day tanks with any necessary pumps to supply fuel to the engine as recommended by the generator set manufacturer. The fuel supply line from the tank to the manufacturer's standard engine connection must be welded pipe.

2.6.5 Fuel Oil Cooler

Provide an air cooled fuel oil cooler if the temperature of the fuel returned to the tank from the engine will cause overheating of the tank fuel above the maximum fuel temperature allowed by the engine manufacturer when operating at maximum rated generator power output and low fuel level in the tank. The fuel oil cooler must be furnished by the engine manufacturer for the application and the installation must be complete including piping and power requirements.

2.7 LUBRICATION

Provide engine with a separate lube-oil system conforming to NFPA 30 and NFPA 37. Pressurize each system by engine-driven pumps. Regulate system pressure as recommended by the engine manufacturer. Provide a pressure relief valve on the crankcase for closed systems. Vent the crankcase in accordance with the manufacturer's recommendation. Do not vent the crankcase to the engine exhaust system. Crankcase breathers, if provided on engines installed in buildings or enclosures, must be piped to vent to the outside. The system must be readily accessible for service such as draining, refilling, etc. Each system must permit addition of oil and have oil-level indication with the set operating. The system must utilize an oil cooler as recommended by the engine manufacturer.

2.7.1 Lube-Oil Filter

Provide one full-flow filter for each pump. The filter must be readily accessible and capable of being changed without disconnecting the piping or disturbing other components. Mark inlet and outlet connections.

2.7.2 Lube-Oil Sensors

Equip each engine with lube-oil pressure sensors located downstream of the filters and provide signals for required indication and alarms. Submit two complete sets of filters, required for maintenance, supplied in a suitable storage box. Provide these filters in addition to filters replaced after testing.

2.7.3 Precirculation Pump

Provide a motor-driven precirculation pump powered by the station battery, complete with motor starter, if recommended by the engine manufacturer.

2.8 COOLING SYSTEM

Provide each engine with its own cooling system to operate automatically while its engine is running. The cooling system coolant must use a combination of water and ethylene-glycol sufficient for freeze protection at the minimum winter outdoor temperature specified. The maximum temperature rise of the coolant across each engine must not exceed that recommended below. Submit a letter which certifies that the engine-generator set and cooling system function properly in the ambient temperature specified, stating the following values:

a. The maximum allowable inlet temperature of the coolant fluid.

b. The minimum allowable inlet temperature of the coolant fluid through the engine.

c. The maximum allowable temperature rise in the coolant fluid through the engine.

d. The minimum allowable inlet fuel temperature.

2.8.1 Coolant Pumps

Provide centrifugal coolant pumps. Each engine must have an engine-driven primary pump. Provide secondary pumps that are electric motor driven and have automatic controllers. Control raw-water circulating pump by manual-off-automatic controllers and must be engine driven.

2.8.2 Heat Exchanger

Provide heat exchanger with the size and capacity to limit the maximum allowable temperature rise in the coolant across the engine to that recommended and submitted for the maximum summer outdoor design temperature and site elevation. Submit manufacturer's data to quantify heat rejected to the space with the engine generator set at rated capacity. Provide heat exchangers that are corrosion resistant, suitable for service in ambient conditions of application.

2.8.2.1 Fin-Tube-Type Heat Exchanger (Radiator)

Heat exchanger may be factory coated with corrosion resistant film, provided that corrective measures are taken to restore the heat rejection capability of the radiator to the initial design requirement via over sizing, or other compensating methods. Provide internal surfaces that are compatible with liquid fluid coolant used. Materials and coolant are subject to approval by the Contracting Officer. Provide heat exchangers

that are pressure type incorporating a pressure valve, vacuum valve and a cap. Design caps for pressure relief prior to removal. Provide heat exchanger and cooling system that is capable of withstanding a minimum pressure of 7 psi and protect with a strong grille or screen guard. Provide heat exchanger with at least two tapped holes; equip one tapped hole with a drain cock, and plug the rest.

Provide for each engine-generator set, as standard with the manufacturer.

a. Design Conditions: Each radiator unit must have ample capacity to remove not less than the total Btu per hour of heat rejected by its respective engine at 100 percent full-rated load to the jacket water, fuel oil, and lubricating oil system, and intercooler. Radiator capacity must be rated at optimum temperature of coolant leaving the engine and intercooler as recommended by the engine manufacturer with an ambient dry bulb air temperature and the site elevation specified, and with the coolant mixture specified in the paragraph ENGINE CAPACITY. Pressure drop through the radiator must not exceed 6 psi when circulating the maximum required coolant flow. Radiator air velocity must be a maximum of 1500 feet per minute.

b. Engine Mounted Radiator Construction: Radiator fan must direct airflow from the engine outward through the radiator. Fan must be V-belt driven directly from the engine crankshaft. Radiator fan must have sufficient capacity to meet design conditions against a static restriction of 0.5 inch of water. Fan static capacity must be adjusted to suit the ductwork furnished. Cooling section must have a tube and fin-type core consisting of copper or copper base alloy tubes with nonferrous fins. Select engine-driven fans for quiet vibration-free operation. Make provision for coolant expansion either by self-contained expansion tanks or separately mounted expansion tanks, as standard with the manufacturer. Provide suitable guards for each fan and drive.

c. Remote Radiator Construction: Provide radiators as described above, except radiators must be remotely piped and provided with electric motor driven fan. Drive must be multiple V-belt or reduction gears. Expansion tanks must be separately mounted. Air flow must be vertical or horizontal as indicated. Interlock fan with engine operation such that fan must operate when engine operates when recommended by engine manufacturer. Provide motors and controllers in accordance with the paragraphs ELECTRIC MOTORS and MOTOR CONTROLLERS, respectively. Motors, controllers, contactors, and disconnects must conform to Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

d. Coolant solution must be a mixture of clean water and ethylene glycol, 50 percent by volume each. Provide an anti-freeze solution tester suitable for the mixture.

Field installed jacket coolant water piping must conform to the following:

a. Piping: Provide seamless steel pipe, Schedule 40, conforming to ASTM A53/A53M, Grade A.

b. Fittings and Flanges: Fittings, 1 1/2 inches or smaller, must be malleable iron conforming to ASME B16.3 for Class 300 threaded type. Fittings, 2 inches and larger, must be steel butt welding conforming to ASME B16.9. Utilize either ASME B16.1 or Class A of ASTM A126 for Class 125 cast-iron flanged fittings. Flanges must be Class 150

slip-on forged steel welding flanges in accordance with ASME B16.5, with material in accordance with ASTM A181/A181M, Grade I. Provide flat face flanges for connecting to Class 125 standard cast-iron valves, fittings, and equipment connections.

c. Valves

(1) Gate Valves: For valves, 1 1/2 inches and smaller, provide double disk, rising stem, inside screw, union bonnet type, Class 125 bronze material conforming to MSS SP-80. For valves, 2 inches and larger, provide double-disk, parallel seat type, hydraulic-rated, Class 125, outside screw and yoke type with flanged ends and bronze trim conforming to MSS SP-70. Provide stem packing of material compatible with the system coolant.

(2) Globe Valves: For valves, 1 1/2 inches and smaller, provide rising stem, inside screw, union bonnet type, Class 125 bronze valves conforming to MSS SP-80. For valves, 2 inches and larger, provide Class 125 cast iron, flanged ends, bronze trim globe valves conforming to MSS SP-85. Valves must have renewable composition or cast iron discs compatible with the system coolant.

(3) Check Valves: MSS SP-71 or MSS SP-80, swing check type.

d. Hangers and Supports: MSS SP-58.

e. Piping Sleeves: Provide where piping passes through masonry or concrete walls, floors, roofs, and partitions. Place sleeves during construction. Unless indicated otherwise, pipe sleeves must comply with following requirements: Sleeves in outside walls below and above grade, in floor, or in roof slabs, must be standard weight zinc coated steel pipe. Sleeves in partitions must be zinc coated sheet steel having a nominal weight of not less than 0.90 pound per square foot. Space between piping insulation and the sleeve must be not less than 0.25 inch. Sleeves must be held securely in proper position and location during construction. Sleeves must be of sufficient length to pass through entire thickness of walls, partitions, or slabs. Sleeves in floor slabs must extend 2 inches above the finished floor. Space between the pipe and the sleeve must be firmly packed with insulation and caulked at both ends of the sleeve with plastic waterproof cement.

2.8.2.2 Shell and U-Tube Type Heat Exchanger

Provide multiple pass shell, U-tube type heat exchanger. Exchanger must operate with low temperature water in the shell and high temperature water in the tubes. Provide exchangers that are constructed in accordance with ASME BPVC SEC VIII D1 and certified with ASME stamp secured to the unit. Provide U-tube bundles that are completely removable for cleaning and tube replacement and free to expand with the shell. Construct shells of seamless steel pipe or welded steel. Tubes must be cupronickel or inhibited admiralty, constructed in accordance with ASTM B395/B395M, suitable for the temperatures and pressures specified. Tubes less than 3/4 inch unless otherwise indicated are not acceptable. Design shell side and tube side for 150 psig working pressure and factory tested at 300 psig. Locate high and low temperature water and pressure relief connections in accordance with the manufacturers standard practice. Water connections larger than 3 inches must be ASME Class 150 flanged. Water pressure loss through clean tubes must be as recommended by the engine manufacturer. Minimum water velocity through tubes must be 1 fps and assure turbulent

flow. Provide one or more pressure relief valves for each heat exchanger in accordance with ASME BPVC SEC VIII D1. The aggregate relieving capacity of the relief valves must be not less than that required by the above code. Install discharge from the valves indicated. Install the relief valves on the heat exchanger shell. Install a drain connection with 3/4 inch hose bib at the lowest point in the system near the heat exchanger. Install additional drain connection with threaded cap or plug wherever required for thorough draining of the system.

2.8.3 Expansion Tank

The cooling system must include an air expansion tank which will accommodate the expanded water of the system generated within the normal operating temperature range, limiting the pressure increase at all components in the system to the maximum allowable pressure at those components. The tank must be suitable for operating temperature of 250 degrees F and a working pressure of 125 psi. Provide welded steel tank , tested and stamped in accordance with ASME BPVC SEC VIII D1 for the stated working pressure. Do not use a bladder type tank. Support the tank by steel legs or bases for vertical or steel saddles for horizontal installation.

2.8.4 Thermostatic Control Valve

Provide a modulating type, thermostatic control valve in the coolant system to maintain the coolant temperature range submitted in paragraph SUBMITTALS.

2.8.5 Ductwork

Provide ductwork in accordance with Section 23 30 00 HVAC AIR DISTRIBUTION, except use a flexible connection to connect the duct to the engine radiator. Material for the connection must be wire-reinforced glass. Provide airtight connection.

2.8.6 Temperature Sensors

Equip each engine with coolant temperature sensors. Provide temperature sensors with signals for pre-high and high indication and alarms.

2.9 SOUND LIMITATIONS

Submit sound power level data for the packaged unit operating at 100 percent load in a free field environment. The data should demonstrate compliance with the sound limitation requirements of this specification. Submit certification from the manufacturer stating that the sound emissions meet the specification. Do not exceed dBA when measured in a free field at a radial distance of 22.9 feet 7 meters at 45 degrees apart in all directions when operating at 100 percent load.

2.10 AIR INTAKE EQUIPMENT

Locate filters and silencers in locations that are convenient for servicing. Provide high-frequency filter type silencers and locate in the air intake system as recommended by the engine manufacturer. Provide silencer to reduce the noise level at the air intake so that the indicated pressure levels specified in paragraph SOUND LIMITATIONS will not be exceeded. A combined filter-silencer unit meeting requirements for the separate filter and silencer items may be provided. Provide copper

expansion elements in air-intake lines.

Provide intake filter assemblies for each engine of the oil bath or dry type, as standard with the manufacturer. Filters must be capable of removing a minimum of 92 percent of dirt and abrasive 3 microns and larger from intake air. Size filters to suit engine requirements at 100 percent of rated full load. Design unit for field access for maintenance purposes.

2.11 EXHAUST SYSTEM

Provide a separate and complete system for each engine. Support piping to minimize vibration. Where a V-type engine is provided, use a V-type connector, with necessary flexible sections and hardware, to connect the engine exhaust outlets.

2.11.1 Flexible Sections and Expansion Joints

Provide a flexible section at each engine and an expansion joint at each muffler. Provide flexible sections and expansion joints that have flanged connections. Provide flexible sections made of convoluted seamless tube without joints or packing. Provide bellows type expansion joints. Provide stainless steel expansion and flexible elements suitable for engine exhaust gas at the maximum exhaust temperature that is specified by the engine manufacturer. Provide expansion and flexible elements that are capable of absorbing vibration from the engine and compensation for thermal expansion and contraction.

2.11.2 Exhaust Muffler

Provide a chamber type exhaust muffler. Provide welded steel muffler. Provide eyebolts, lugs, flanges, or other items as necessary for support in the location and position indicated. Do not exceed the engine manufacturer's recommended pressure drop. Outside mufflers must be zinc coated or painted with high temperature 400 degrees F resisting paint. The muffler and exhaust piping together must reduce the noise level to less than the maximum acceptable level listed for sound limitations in paragraph SOUND LIMITATIONS. Provide muffler with a drain valve, nipple, and cap at the low-point of the muffler.

A silencer must be provided for each engine which will reduce the exhaust sound spectrum by the following listed values at a 75 foot radius from the outlet, with generator set loaded to rated capacity and clear weather. Inlet and outlet connections must be flanged.

Octave Band Center Frequency (Hertz)								
Minimum Silencer Attenuation Decibels	63	125	250	500	1000	2000	4000	8000
Critical Class	15	32	37	36	30	36	37	37

2.11.3 Exhaust Piping

Slope horizontal sections of exhaust piping downward away from the engine to a drip leg for collection of condensate with drain valve and cap. Changes in direction must be long radius. Insulate exhaust piping, mufflers and silencers installed inside any building in accordance with paragraph THERMAL INSULATION and covered to protect personnel. Provide

vertical exhaust piping with a hinged, gravity-operated, self-closing, rain cover.

Field installed exhaust piping must conform to the following:

a. Exhaust Piping: Provide flanges for connections to engines, exhaust mufflers, and flexible connections. Provide steel pipe conforming to ASTM A53/A53M for each engine complete with necessary fittings, flanges, gaskets, bolts, and nuts. Exhaust piping must be Schedule 40 pipe for 12 inches and smaller, standard weight for sizes 14 inches through 24 inches, and 0.25 inch wall thickness for sizes larger than 24 inches. Flanges must be Class 150 slip-on forged steel welding flanges in accordance with ASME B16.5, with material in accordance with ASTM A181/A181M, Grade I. Fittings must be butt welding conforming to ASTM A234/A234M, with wall thickness same as adjoining piping. Fittings must be of same material and wall thickness as pipe. Built-up miter welded fittings may be used. Miter angles of each individual section must not exceed 22.5 degrees total and not more than 11.25 degrees relative to the axis of the pipe at any one cut. Gaskets for exhaust piping must be of high temperature asbestos-free material suitable for the service and must be ASME B16.21, composition ring, 0.0625 inch thick. Bolting material for exhaust flanges must be alloy-steel bolt-studs conforming to ASTM A193/A193M, Grade B7 bolts and alloy-steel nuts conforming to ASTM A194/A194M, Grade 7. Bolts must be of sufficient length to obtain full bearing on the nuts and must project not more than two full threads beyond the nut. Provide stainless steel counterbalance type rain caps at termination of each exhaust pipe.

b. Expansion (Flexible) Joints: Provide sections of multiple corrugated stainless steel expansion joints in the engine exhaust piping for each engine to absorb expansion strains and vibration transmitted to the piping. Flexible joints must be suitable for operation at 200 degrees F above normal exhaust gas temperature at 100 percent load, 10,000 cycles, minimum. Joints must be flanged and located between engine exhaust manifold and exhaust piping, must be the same size as exhaust piping size, and must be designed and constructed for engine exhaust service.

c. Hangers and Supports: MSS SP-58.

d. Piping Sleeves: Provide where piping passes through masonry or concrete walls, floors, roofs, and partitions. Sleeves must be placed during construction. Unless indicated otherwise, pipe sleeves must comply with following requirements: sleeves in outside walls below and above grade, in floor, or in roof slabs, must be standard weight zinc coated steel pipe. Sleeves in partitions must be zinc coated sheet steel having a nominal weight of not less than 0.90 pound per square foot. Space between piping insulation and the sleeve must not be less than 0.25 inch. Sleeves must be held securely in proper position and location during construction. Sleeves must be sufficient length to pass through entire thickness of walls, partitions, or slabs. Sleeves in floor slabs must extend 2 inches above the finished floor. Space between the pipe and the sleeve must be firmly packed with insulation and caulked at both ends of the sleeve with plastic waterproof cement.

e. Piping Insulation: Provide exhaust piping insulation in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.12 PYROMETER

Provide a pyrometer, with calibrated leads to show the temperature in each engine cylinder and the combined exhaust . For a supercharged engine, provide additional points, thermocouples and leads to show the temperature in the turbocharger exhaust gas outlet and combustion air discharge passages. Graduated scale length less than 6 inches is not acceptable. Provide double pole selector switch with an "off" position, one set of points for each thermocouple, and suitable indicating dial. Calibrate the pyrometer, thermocouples, leads and compensating devices to show true exhaust temperature within plus or minus 1 percent above the highest temperature encountered at 110 percent load conditions.

2.13 EMISSIONS

The finished installation must comply with Federal, state, and local regulations and restrictions regarding the limits of emissions. Submit certification from the engine manufacturer stating that the engine exhaust emissions meet the federal, state, and local regulations and restrictions specified. At a minimum this certification must include emission factors for criteria pollutants including nitrogen oxides, carbon monoxide, particulate matter, sulfur dioxide, non-methane hydrocarbon, and for hazardous air pollutants (HAPs).

2.14 STARTING SYSTEM

Provide starting system for engine generator sets used in non-emergency applications as follows.

2.14.1 Controls

Provide an engine control switch with functions including: run/start (manual), off/reset, and, automatic mode. Provide start-stop logic for adjustable cycle cranking and cool-down operation. Arrange the logic for fully automatic starting in accordance with paragraph AUTOMATIC ENGINE-GENERATOR-SET SYSTEM OPERATION. Provide electrical starting systems with an adjustable cranking limit device to limit cranking periods from 1 second up to the maximum duration.

2.14.2 Capacity

Provide starting system with sufficient capacity, at the maximum outdoor summer temperature specified to crank the engine without damage or overheating. The system must provide a minimum of three cranking periods with 15 second intervals between cranks. Each cranking period must have a maximum duration of 15 seconds. Starting must be accomplished using an adequately sized dc starter system with a positive shift solenoid to engage the starter motor and to crank the engine continuously for 60 seconds without overheating.

2.14.3 Electrical Starting

Manufacturers recommended dc system, utilizing a negative circuit ground. Starting motors must be in accordance with SAE ARP892.

2.14.3.1 Battery

Provide a starting battery system including the battery, battery rack,

intercell connectors, spacers, automatic battery charger with overcurrent protection, metering and relaying. Provide battery in accordance with SAE J537. Size critical system components (rack, protection, etc.) to withstand the seismic acceleration forces specified. Provide lead-acid battery with sufficient capacity, at the minimum outdoor and maximum outdoor temperature specified, to provide the specified cranking periods. Valve-regulated lead-acid batteries are not acceptable.

Provide maintenance free, sealed, lead-acid, SAE Type D engine starting batteries. Batteries must have sufficient capacity to provide 60 seconds of continuous cranking of the engine in an ambient temperature above 50 degrees F.

2.14.3.2 Battery Charger

Provide a current-limiting battery charger, conforming to UL 1236, that automatically recharges the batteries. Submit battery charger sizing calculations. The charger must be capable of an equalize charging rate for recharging fully depleted batteries within 24 hours which is manually adjustable in a continuous range and a floating charge rate for maintaining the batteries at fully charged condition. Provide an ammeter to indicate charging rate. Provide a voltmeter to indicate charging voltage. Provide a timer for the equalize charging-rate setting. A battery is considered to be fully depleted when the output voltage falls to a value which will not operate the engine generator set and its components.

Provide 120 volt ac, enclosed, automatic equalizing, dual-rate, solid-state, constant voltage type battery charger with automatic ac line compensation. DC output must be voltage regulated and current limited. Charger must have two ranges, float and equalize, and must provide continuous taper charging. The charger must have a continuous output rating of not less than 10 amperes and must be sized to recharge the engine starting batteries in a minimum of 8 hours while providing the control power needs of the engine-generator set. Enclosure must be NEMA ICS 6, Type 3R. The following accessories must be included:

a. DC ammeter

b. DC voltmeter

c. Equalize light

d. AC on light

e. Low voltage light

f. High voltage light

g. Equalize test button/switch

h. AC circuit breaker

i. Low dc voltage alarm relay

j. High dc voltage alarm relay

k. Current failure relay

l. AC power failure relay

2.14.4 Storage Batteries

Provide storage batteries of suitable rating and capacity to supply and maintain power for the remote alarm annunciator for a period of 90 minutes minimum without the voltage applied falling below 87.5 percent of normal. Provide a 120 volt ac automatic battery charger.

2.14.5 Pneumatic

2.14.5.1 Air Driven Motors

Provide air driven motors complete with solenoid valve, strainer, and lubricator.

2.14.5.2 Cylinder Injection

Perform starting by admitting compressed air into two or more engine cylinders through a timing valve, or through a distributor into a sufficient number of cylinders to assure successful starting regardless of piston positions.

2.14.6 Starting Aids

Provide one or more of other following methods to assist engine starting.

2.14.6.1 Glow Plugs

Design glow plugs to provide sufficient heat for combustion of fuel within the cylinders to guarantee starting at an ambient temperature of -25 degrees F.

2.14.6.2 Jacket-Coolant Heaters

Mount a thermostatically controlled electric heater in the engine coolant jacketing to automatically maintain the coolant within plus or minus 3 degrees F of the control temperature. The heater must operate independently of engine operation so that starting times are minimized. Power for the heaters must be 120 volts ac. Include necessary equipment, piping, controls, wiring, and accessories.

2.14.6.2.1 Prime Rated Sets

The control temperature must be the higher of the manufacturer's recommended temperature or the minimum coolant inlet temperature of the engine recommended in paragraph SUBMITTALS.

2.14.6.2.2 Standby Rated Sets

The control temperature must be the temperature recommended by the engine manufacturer to meet the starting time specified at the minimum winter outdoor temperature.

2.14.6.3 Lubricating-Oil Heaters

Mount a thermostatically controlled electric heater in the engine lubricating-oil system to automatically maintain the oil temperature within plus or minus 3 degrees F of the control temperature. The heater

must operate independently of engine operation so that starting times are minimized. Power for the heaters must be 120 volts ac.

2.14.7 Exerciser

Provide exerciser in accordance with Section 26 36 23 AUTOMATIC TRANSFER SWITCH AND BY-PASS/ISOLATION SWITCH.

2.15 GOVERNOR

Provide a forward acting type engine speed governor system. Steady-state frequency band and frequency regulation (droop) must be in accordance with the operating limit values of the performance class specified in the paragraph PERFORMANCE CLASS.

Provide engine with a governor which maintains the frequency within a bandwidth of the rated frequency, over a steady-state load range of zero to 100 percent of rated output capacity. Configure the governor for safe manual adjustment of the speed/frequency during operation of the engine-generator set, without special tools, from 90 to 110 percent of the rated speed/frequency, over a steady state load range of 0 to 100 percent or rated capacity. Submit two complete sets of special tools required for maintenance (except for electronic governor handset). Special tools are those that only the manufacturer provides, for special purposes, or to reach otherwise inaccessible parts. Provide a suitable tool box for tools. Provide one handset for each electronic governor when required to indicate and/or change governor response settings.

2.16 GENERATOR

Provide synchronous type, one or two bearing, generator conforming to the performance criteria in NEMA MG 1, equipped with winding terminal housings in accordance with NEMA MG 1, equipped with an amortisseur winding, and directly connected to the engine. Submit calculations of the engine and generator output power capability, including efficiency and parasitic load data. Provide Class H insulation.

a. Select NEMA MG 1, Part 16, standby duty, and temperature rise of 130 degrees C for engine-generator sets which are expected to operate for less than 300 hours per year. Select NEMA MG 1, Part 22, continuous duty, and temperature rise of 105 degrees C for engine-generator sets expected to operate 300 hours or greater per year or rated 300 kW and above.

b. Select 2/3 pitch design option for engine-generator sets rated 300 kW and above.

c. Select 10-12 lead re-connectable for engine-generator sets rated 300 kW to 800 kW.

d. For applications requiring high SCR loading or in harsh environments laden with salts and chemicals, select vacuum pressure impregnation (VPI) insulated coils. When engine-generator sets are rated 800 kW and larger, also select form wound coils.

e. Provide salient-pole type, ac, brushless-excited, revolving field, air-cooled, self-ventilated, coupled type, synchronous generator conforming to NEMA MG 1, Part 16 and 22, and IEEE C50.12. Generator must be rated for standby duty at 100 percent of the power rating of

the engine-generator set as specified in paragraph ENGINE-GENERATOR SET RATINGS AND PERFORMANCE. Temperature rise of each of the various parts of the generator must not exceed 130 degrees C as measured by resistance, based on a maximum ambient temperature of 40 degrees C. Winding insulation must be Class H.

f. Stator: Stator windings must be 2/3 pitch design , 10-12 lead re-connectable .

g. Rotor: The rotor must have connected amortisseur windings.

h. Generator Space Heater: Provide 120 volt ac heaters. Heater capacity must be as recommended by the generator manufacturer to aid in keeping the generator insulation dry.

i. Grounding: Provide non-corrosive steel grounding pads located at two opposite mounting legs.

j. Filters: Provide manufacturer's standard generator cooling air filter assembly.

k. Design generator to protect against mechanical, electrical and thermal damage due to vibration, 25 percent overspeeds, or voltages and temperatures at a rated output capacity of 110 percent for prime applications and 100 percent for standby applications.

l. Provide generator ancillary equipment meeting the short circuit requirements of NEMA MG 1. Select drip-proof guarded option for generators without weatherproof enclosures.

m. Submit manufacturer's standard data for each generator (prototype data at the specified rating or above is acceptable), listing the following information:

(1) Direct-Axis sub-transient reactance (per unit).

(2) The generator kW rating and short circuit current capacity (both symmetric and asymmetric).

2.16.1 Current Balance

At 100 percent rated output capacity, and load impedance equal for each of the 3 phases, the permissible current difference between any 2 phases must not exceed 2 percent of the largest current on either of the 2 phases. Submit certification stating that the flywheel has been statically and dynamically balanced and is capable of being rotated at 125 percent of rated speed without vibration or damage.

2.16.2 Voltage Balance

At any balanced load between 75 and 100 percent of rated output capacity, the difference in line-to-neutral voltage among the 3 phases must not exceed 1 percent of the average line-to-neutral voltage. For a single phase load condition, consisting of 25 percent load at unity power factor placed between any phase and neutral with no load on the other 2 phases, the maximum simultaneous difference in line-to-neutral voltage between the phases must not exceed 3 percent of rated line to neutral voltage. The single-phase load requirement must be valid utilizing normal exciter and regulator control. The interpretation of the 25 percent load for single

phase load conditions means 25 percent of rated current at rated phase voltage and unity power factor.

2.16.3 Waveform

The deviation factor of the line-to-line voltage at zero load and at balanced rated output capacity must not exceed 10 percent. The RMS of all harmonics must be less than 5.0 percent and that of any one harmonic less than 3.0 percent of the fundamental at rated output capacity. Design and configure engine-generator to meet the total harmonic distortion limits of IEEE 519.

2.17 EXCITER

Provide brushless generator exciter. Provide semiconductor rectifiers that have a minimum safety factor of 300 percent for peak inverse voltage and forward current ratings for all operating conditions, including 110 percent generator output at 104 degrees F ambient. The exciter and regulator in combination must maintain generator-output voltage within the limits specified.

Provide a brushless excitation system consisting of an exciter and rotating rectifier assembly integral with the generator and a voltage regulator. Insulation class for parts integral with the generator must be as specified in paragraph GENERATOR. System must provide a minimum short circuit of 300 percent rated engine-generator set current for at least 10 seconds. Steady state voltage regulation must be in accordance with the operating limit values of the performance class specified in the paragraph PERFORMANCE CLASS.

a. Exciter and Rotating Rectifier Assembly: Rectifiers must be provided with surge voltage protection.

b. Permanent Magnet Generator: Provide a voltage spike suppression device for permanent magnet generator (PMG) excitation systems.

c. Voltage Regulator: Voltage regulator must be solid state or digital, automatic, three-phase sensing, volts per hertz type regulator. Regulator must receive its input power from a PMG. Voltage variation for any 40 degree C change over the operating temperature range must be less than plus or minus 1.0 percent. Operating temperature must be minus 40 degree C to plus 70 degree C. Voltage adjust range must be plus to minus 5.0 percent of nominal. Inherent regulator features must include over excitation shutdown.

2.17.1 Electromagnetic Interference (EMI) Suppression

Provide as an integral part of the generator and excitation system, EMI suppression complying with MIL-STD-461.

2.18 VOLTAGE REGULATOR

Provide a solid-state voltage regulator, separate from the exciter, for each generator. Maintain the voltage within a bandwidth of the rated voltage, over a steady-state load range of zero to 100 percent of rated output capacity. Configure regulator for safe manual adjustment of the engine-generator voltage output without special tools, during operation, from 90 to 110 percent of the rated voltage over the steady state load range of 0 to 100 percent of rated output capacity. Regulation drift

exceeding plus or minus 0.5 percent for an ambient temperature change of 68 degrees F is not acceptable. Reactive droop compensation or reactive differential compensation must load share the reactive load proportionally between sets during parallel operation. Provide voltage regulator with a maximum droop of 2 percent of rated voltage over a load range from 0 to 100 percent of rated output capacity and automatically maintain the generator output voltage within the specified operational bandwidth.

2.19 GENERATOR ISOLATION AND PROTECTION

Provide necessary devices for electrical protection and isolation of each engine-generator set and its ancillary equipment. The generator circuit breaker (IEEE Device 52) ratings must be consistent with the generator rated voltage and frequency, with continuous, short circuit withstand, and interrupting current ratings to match the generator capacity. Provide electrically operated generator circuit breaker. Mount a set of surge capacitors at the generator terminals. Provide monitoring and control devices as specified in paragraph GENERATOR PANEL.

The generator circuit breaker must comply with UL 489 requirements for molded case, adjustable thermal magnetic trip type circuit breaker. The circuit breaker continuous current rating must be adequate for the power rating of the engine-generator set and the circuit breaker must be rated to withstand the short circuit current provided by the generator set. Provide circuit breaker in a NEMA ICS 6, Type 3R enclosure mounted on the engine-generator set.

2.19.1 Devices

Provide switches, circuit breakers, switchgear, fuses, relays, and other protective devices as specified in Section 26 05 73 POWER SYSTEM STUDIES.

Furnish with respective pieces of equipment. Motors, controllers, contactors, and disconnects must conform to Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide electrical connections under Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide controllers and contactors with maximum of 120-volt control circuits, and auxiliary contacts for use with controls furnished. When motors and equipment furnished are larger than size indicated, the cost of providing additional electrical service and related work must be included under this section.

2.20 SAFETY SYSTEM

Provide and install devices, wiring, remote panels, and local panels, etc., as a complete system to automatically activate the appropriate signals and initiate the appropriate actions. Provide a safety system with a self-test method to verify its operability. Provide alarm signals that have manual acknowledgment and reset devices. The alarm signal systems must reactivate for new signals after acknowledgment is given to any signal. Configure the systems so that loss of any monitoring device will be dealt with as an alarm on that system element.

2.20.1 Audible Signal

Provide audible alarm signal sound at a frequency of 70 Hz at a volume of 75 dB at 10 feet. The sound must be continuously activated upon alarm and silenced upon acknowledgment. Locate signal devices as shown.

2.20.2 Visual Signal

The visual alarm signal must be a panel light. The light must be normally off, activated to be blinking upon alarm. The light must change to continuously lit upon acknowledgement. If automatic shutdown occurs, the display must maintain activated status to indicate the cause of failure and must not be reset until cause of alarm has been cleared and/or restored to normal condition. Shutdown alarms must be red; all other alarms must be amber.

2.20.3 Alarms and Action Logic

2.20.3.1 Shutdown

Accomplish simultaneous activation of the audible signal, activation of the visual signal, stopping the engine, and opening the generator main circuit breakers.

2.20.3.2 Problem

Accomplish activation of the visual signal.

2.20.4 Safety Indications and Shutdowns
Provide a local alarm panel with the following shutdown and alarm functions in accordance with NFPA 110 level 2 mounted either on or adjacent to the engine generator set.

A remote alarm panel is is not required for audible alarms, e.g., in the control room.

Indicator Function (at battery voltage)	NFPA 99 Level 1 CV S RA	NFPA 110 Level 1 CV S RA	NFPA 110 Level 2 CV S RA
Overcrank	X X X	X X X	X X O
Low water temperature	X NA X	X NA X	X NA O
High engine temperature pre-alarm	X NA X	X NA X	O NA NA
High engine temperature	X X X	X X X	X X O
Low lube oil pressure pre-alarm	X NA X	NA NA NA	NA NA NA
Low lube oil pressure	X X X	X X X	X X O
Overspeed	X X X	X X X	X X O
Low fuel main tank	X NA X	X NA X	O NA O
Low coolant level	X O X	X O X	X O X

Indicator Function (at battery voltage)	NFPA 99 Level 1 CV S RA	NFPA 110 Level 1 CV S RA	NFPA 110 Level 2 CV S RA
EPS supplying load	X NA NA	X NA NA	O NA NA
Control switch not in automatic position	X NA X	X NA X	X NA X
High battery voltage	X NA NA	X NA NA	O NA NA
Low cranking voltage	X NA X	X NA X	O NA NA
Low voltage in battery	X NA NA	X NA NA	O NA NA
Battery charger ac failure	X NA NA	X NA NA	O NA NA
Lamp test	X NA NA	X NA NA	X NA NA
Contacts for local and remote common alarm	X NA X	X NA X	X NA X
Audible alarm silencing switch	NA NA X	NA NA X	NA NA O
Low starting air pressure	X NA NA	X NA NA	O NA NA
Low starting hydraulic pressure	X NA NA	X NA NA	O NA NA
Air shutdown damper when used	X X X	X X X	X X O
Remote emergency stop	NA X NA	NA X NA	NA X NA

Symbology:
CV: Control panel-mounted visual.
S: Shutdown of EPS indication.
RA: Remote audible.
Symbology:
CV: Control panel-mounted visual.
S: Shutdown of EPS indication.
RA: Remote audible.
X: Required.
O: Optional.
NA: Not applicable.

2.20.5 Time-Delay on Alarms

For startup of the engine-generator set, install time-delay devices bypassing the low lubricating oil pressure alarm during cranking, and the coolant-fluid outlet temperature alarm. Submit the magnitude of monitored values which define alarm or action set points, and the tolerance (plus

and/or minus) at which the devices activate the alarm or action for items contained within the alarm panels. The lube-oil time-delay device must return its alarm to normal status after the engine starts. The coolant time-delay device must return its alarm to normal status 5 minutes after the engine starts.

2.21 SYNCHRONIZING PANEL

Provide panel as specified in paragraph PANELS and provide controls, gauges, meters, and displays to include:

a. Frequency meters, dial type, with a range of 90 to 110 percent of rated frequency. Do not use vibrating-reed type meters . One must monitor generator output frequency ("Generator Frequency Meter") and the other must monitor the frequency of the parallel source ("Bus Frequency Meter").

b. Voltmeters, ac, dial type, 3-phase, with 4-position selector switch for the generator output ("Generator Volt Meter") and for the parallel power source ("Bus volt meter").

c. Automatic synchronizer.

d. Manual synchronizing controls.

e. Indicating lights for supplementary indication of synchronization.

f. Synchroscope.

g. Wattmeter, indicating.

2.22 PANELS

Each panel must be of the type and kind necessary to provide specified functions. Mount panels on the engine-generator set base by vibration/shock absorbing type mountings. Mount instruments flush or semiflush. Provide convenient access to the back of panels to facilitate maintenance. Calibrate instruments using recognized industry calibration standards. Provide a panel identification plate identifying the panel function. Provide a plate identifying the device and its function for each instrument and device on the panel. Provide switch plates identifying the switch-position function.

2.22.1 Enclosures

Design enclosures for the application and environment, conforming to NEMA ICS 6. Locking mechanisms must be keyed alike.

Provide for each engine-generator set and fabricate from zinc coated or phosphatized and shop primed 16 gage minimum sheet steel in accordance with the manufacturer's standard design. Provide a complete, weatherproof enclosure for the engine, generator, and auxiliary systems and equipment. Support exhaust piping and silencer so that the turbocharger is not subjected to exhaust system weight or lateral forces generated in connecting piping that exceed the engine manufacturer's maximum allowed forces and moments. The housing must have sufficient louvered openings to allow entrance of outside air for engine and generator cooling at full load. Design louvered openings to exclude driving rain and snow. Provide properly arranged and sized, hinged panels in the enclosure to allow

convenient access to the engine, generator, and control equipment for maintenance and operational procedures. Provide hinged panels with spring type latches which must hold the panels closed securely and will not allow them to vibrate. Brace the housing internally to prevent excessive vibration when the set is in operation

2.22.2 Analog

Provide analog electrical indicating instruments in accordance with UL 1437 with semi-flush mounting. Switchboard, switchgear, and control-room panel-mounted instruments must have 250 degree scales with an accuracy of not less than 99 percent. Unit-mounted instruments must be the manufacturer's standard with an accuracy of not less than 98 percent. The instrument's operating temperature range must be minus 4 to plus 158 degrees F. Distorted generator output voltage waveform of a crest factor less than 5 must not affect metering accuracy for phase voltages, hertz and amps.

2.22.3 Electronic

Electronic indicating instruments must be true RMS indicating instruments, 100 percent solid state, state-of-the-art, microprocessor controlled to provide specified functions. Provide control, logic, and function devices that are compatible as a system, sealed, dust and water tight, and that utilize modular components with metal housings and digital instrumentation. Provide an interface module to decode serial link data from the electronic panel and translate alarm, fault and status conditions to set of relay contacts. Instrument accuracy less than 98 percent for unit mounted devices and 99 percent for control room, panel mounted devices, throughout a temperature range of minus 4 to 158 degrees F is not acceptable. Provide LED or back lit LCD data display. Additionally, the display must provide indication of cycle programming and diagnostic codes for troubleshooting. Numeral height must be 0.5 inch .

2.22.4 Parameter Display

Provide indication or readouts of the tachometer, lubricating-oil pressure, ac voltmeter, ac ammeter, frequency meter, and safety system parameters. Specify a momentary switch for other panels.

2.23 SURGE PROTECTION

Electrical and electronic components must be protected from, or designed to withstand the effects of surges from switching and lightning.

2.24 AUTOMATIC ENGINE-GENERATOR-SET SYSTEM OPERATION

Provide fully automatic operation for the following operations: engine-generator set starting and load transfer upon loss of normal source; retransfer upon restoration of the normal source; sequential starting; paralleling, and load-sharing for multiple engine-generator sets; and stopping of each engine-generator set after cool-down. Devices must automatically reset after termination of their function.

2.24.1 Automatic Transfer Switch

Provide automatic transfer switches in accordance with Section 26 36 23 AUTOMATIC TRANSFER SWITCH AND BY-PASS/ISOLATION SWITCH.

2.24.2 Monitoring and Transfer

Provide devices to monitor voltage and frequency for the normal power source and each engine-generator set, and control transfer from the normal source and retransfer upon restoration of the normal source. Describe functions, actuation, and time delays as described in Section 26 36 23 AUTOMATIC TRANSFER SWITCH AND BY-PASS/ISOLATION SWITCH.

2.25 MANUAL ENGINE-GENERATOR-SET SYSTEM OPERATION

Provide complete facilities for manual starting and testing of each set without load, loading and unloading of each set, and synchronization of each set with an energized bus.

2.26 STATION BATTERY SYSTEM

Provide a station battery system including the battery, battery rack, spacers, automatic battery charger and distribution panelboard with overcurrent protection, metering and relaying. Size components to withstand the seismic acceleration forces specified. Provide batteries that have a rated life of 20 years and a manufacturer's 5-year, no cost replacement guarantee.

2.26.1 Battery

Provide lead-acid battery sized in accordance with IEEE 485 and conforming to the requirements of IEEE 484. Valve-regulated lead-acid batteries are not acceptable. The battery must be rated as recommended by generator manufacturer.

2.26.2 Battery Capacity

Provide in accordance wth manufacturer's recommendations.

2.26.3 Battery Charger

Furnish a current-limiting, battery charger to automatically recharge the batteries. Provide a charger that is capable of an equalize charging rate for recharging fully depleted batteries within 8 hours which is continuously adjustable and a floating-charge rate for maintaining the batteries in a fully charged condition. Equip the charger with a low-voltage alarm relay, 0- to 24-hour equalizing timer, an ammeter to indicate charging rate, and necessary circuit breakers. The charger must conform to the requirements of UL 1236. A battery is considered to be fully depleted when the voltage falls to a level incapable of operating the equipment loads served by the battery.

2.27 BASE

Provide a steel base. Design the base to rigidly support the engine-generator set, ensure permanent alignment of rotating parts, be arranged to provide easy access to allow changing of lube-oil, and ensure that alignment is maintained during shipping and normal operation. The base must permit skidding in any direction during installation and must withstand and mitigate the affects of synchronous vibration of the engine and generator. Provide base with suitable holes for anchor bolts and jacking screws for leveling.

2.28 THERMAL INSULATION

Provide thermal insulation as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.29 PAINTING AND FINISHING

Clean, prime and paintthe engine-generator set in accordance with the manufacturer's standard color and practice.

2.30 FACTORY INSPECTION AND TESTS

Submit six complete reproducible copies of the factory inspection result on the checklist format specified below. Perform the factory tests on each engine-generator set. The component manufacturer's production line test is acceptable as noted. Run each engine-generator set for at least 1 hour at rated output capacity prior to inspections. Complete inspections and make all necessary repairs prior to testing. Use engine generator controls and protective devices that are provided by the generator set manufacturer as part of the standard package for factory tests. When controls and switchgear are not provided as part of the generator set manufacturer's standard package, the actual controls and protective devices provided for the project are not required to be used during the factory test. The Contracting Officer may provide one or more representatives to witness inspections and tests.

2.30.1 Factory Inspection

Perform inspections prior to beginning and after completion of testing of the assembled engine-generator set. Look for leaks, looseness, defects in components, proper assembly, etc. and note any item found to be in need of correction as a necessary repair. Use the following checklist for the inspection:

INSPECTION ITEM	GOOD	BAD	NOTES
Drive belts			
Governor and adjustments			
Engine timing mark			
Starting motor			
Starting aids			
Coolant type and concentration			
Radiator drains			
Block coolant drains			
Coolant fill level			
All coolant line connections			

INSPECTION ITEM	GOOD	BAD	NOTES
All coolant hoses			
Combustion air filter			
Combustion air silencer			
Lube oil type			
Lube oil sump drain			
Lube-oil filter			
Lube-oil-level indicator			
Lube-oil-fill level			
All lube-oil line connections			
All lube-oil lines			
Fuel type and amount			
All fuel-line connections			
All fuel lines			
Fuel filter			
Coupling and shaft alignment			
Voltage regulators			
Battery-charger connections			
All wiring connections			
Instrumentation			
Hazards to personnel			
Base			
Nameplates			
Paint			
Exhaust-heat recovery unit			

INSPECTION ITEM	GOOD	BAD	NOTES

2.30.2 Factory Tests

Submit a letter giving notice of the proposed dates of factory inspections and tests at least 14 days prior to beginning tests, including:

a. A detailed description of the manufacturer's procedures for factory tests at least 14 days prior to beginning tests.

b. Six copies of the Factory Test data described below in 8-1/2 by 11 inch binders having a minimum of 3 rings from which material may readily be removed and replaced, including a separate section for each test. Separate sections by heavy plastic dividers with tabs. Provide full size (8-1/2 by 11 inch minimum) data plots showing grid lines, with full resolution.

(1) A detailed description of the procedures for factory tests.

(2) A list of equipment used, with calibration certifications.

(3) A copy of measurements taken, with required plots and graphs.

(4) The date of testing.

(5) A list of the parameters verified.

(6) The condition specified for the parameter.

(7) The test results, signed and dated.

(8) A description of adjustments made.

On engine-generator set tests where the engine and generator are required to be connected and operated together, the load power factor must be the power factor specified in the engine generator set parameter schedule 0.8 power factor. Perform electrical measurements in accordance with IEEE 120. Temperature limits in the rating of electrical equipment and for the evaluation of electrical insulation must be in accordance with IEEE 1. In the following tests where measurements are to be recorded after stabilization of an engine-generator set parameter (voltage, frequency, current, temperature, etc.), stabilization is considered to have occurred when measurements are maintained within the specified bandwidths or tolerances, for a minimum of four consecutive readings. Tests specifically for the generator may be performed utilizing any prime mover.

a. Insulation Resistance for Stator and Exciter Test, IEEE 115 and IEEE 43, to the performance criteria in NEMA MG 1, Part 22. Generator manufacturer's production line test is acceptable.

b. High Potential Test, in accordance with IEEE 115 and NEMA MG 1, test voltage in accordance with NEMA MG 1. Generator manufacturer's production line test is acceptable.

c. Winding Resistance Test, Stator and Exciter, in accordance with IEEE 115. Generator manufacturer's production line test is acceptable.

d. Phase Balance Voltage Test, to the performance criteria specified in paragraph GENERATOR. This test can be performed with any prime mover. Generator manufacturer's production line test results are acceptable.

(1) Start and operate the generator at no load.

(2) Adjust a regulated phase voltage (line-to-neutral) to rated voltage.

(3) Read and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.

(4) Apply 75 percent rated load and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.

(5) Apply rated load and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.

(6) Calculate average line-neutral voltage and percent deviation of individual line-neutral voltages from average for each load condition.

e. Current Balance on Stator Winding Test, by measuring the current on each phase of the winding with the generator operating at 100 percent of Rated Output Capacity, with the load impedance equal for each of the three phases: to the performance criteria specified in paragraph GENERATOR.

f. Voltage Waveform Deviation and Distortion Test in accordance with IEEE 115 to the performance criteria specified in paragraph GENERATOR. Use high-speed recording instruments capable of recording voltage waveform deviation and all distortion, including harmonic distortion. Include appropriate scales to provide a means to measure and interpret results.

g. Voltage and Frequency Droop Test. Verify that the output voltage and frequency are within the specified parameters as follows:

(1) With the generator operating at no load, adjust voltage and frequency to rated voltage and frequency. Record the generator output frequency and line-line and line-neutral voltages.

(2) Increase load to Rated Output Capacity. Record the generator output frequency and line-line and line-neutral voltages.

(3) Calculate the percent droop for voltage and frequency with the following equations:

$$\text{Voltage droop percent} = \frac{\text{(No-Load Volts) - (Rated Capacity Volts)}}{\text{(Service-Load Volts)}} \times 100$$

$$\text{Frequency droop percent} = \frac{\text{(No-Load Hertz) - (Rated Capacity Hertz)}}{\text{(Service-Load Hertz)}} \times 100$$

(4) Repeat steps 1 through 3 two additional times without making any adjustments.

h. Frequency and Voltage Stability and Transient Response. Verify that the engine-generator set responds to addition and dropping of blocks of load in accordance with the transient response requirements. Document maximum voltage and frequency variation from bandwidth and verify that voltage and frequency return to and stabilize within the specified bandwidth, within the specified response time period. Document results in tabular form and with high resolution, high speed strip chart recorders or comparable digital recorders, as approved by the Contracting Officer. Include the following tabular data:

(1) Ambient temperature (at 15 minute intervals).

(2) Generator output current (before and after load changes).

(3) Generator output voltage (before and after load changes).

(4) Frequency (before and after load changes).

(5) Generator output power (before and after load changes).

(6) Graphic representations must include the actual instrument trace of voltage and frequency showing: charts marked at start of test; observed steady-state band; mean of observed band; momentary overshoot and undershoot (generator terminal voltage and frequency) and recovery time for each load change together with the voltage and frequency maximum and minimum trace excursions for each steady state load condition prior to and immediately following each load change. Generator terminal voltage and frequency transient recovery time for each step load increase and decrease.

(a) Perform and record engine manufacturer's recommended pre-starting checks and inspections.

(b) Start the engine, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period and no load. Verify stabilization of voltage and frequency within specified bandwidths.

(c) With the unit at no load, apply the Maximum Step Load Increase.

(d) Apply load in steps equal to the Maximum Step Load Increase until the addition of one more step increase will exceed the Service Load.

(e) Decrease load to the unit such that addition of the Maximum Step Load Increase will load the unit to 100 percent of Service Load.

(f) Apply the Maximum Step Load Increase.

(g) Decrease load to zero percent in steps equal to the Maximum Step Load Decrease.

(h) Repeat steps (c) through (g).

i. Test Voltage Unbalance with Unbalanced Load (Line-to-Neutral) to the performance criteria specified in paragraph GENERATOR. Prototype test data is acceptable in lieu of the actual test. Submit manufacturer's standard certification that prototype tests were performed for the generator model proposed. This test may be performed using any prime mover.

(1) Start and operate the generator set at rate voltage, no load, rated frequency, and under control of the voltage regulator. Read and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.

(2) Apply the specified load between terminals L_1-L_2, L_2-L_0, and L_3-L_0 in turn. Record all instrument readings at each line-neutral condition.

(3) Express the greatest difference between any two of the line-to-line voltages and any two of the line-to-neutral voltages as a percent of rated voltage.

(4) Compare the largest differences expressed in percent with the maximum allowable difference specified.

2.31 LOAD BANK

2.31.1 Ratings

a. The total capacity of the resistive and reactive load bank must be rated as shown on the drawings at 480V, three-phase, three-wire, 60 hertz, at a 0.8 Power Factor and 50kW minimum load step resolution.

b. The load bank must be designed for continuous duty cycle operation with no limitations. The load bank must operate in an ambient temperature of minus 40 degrees F to 120 degrees F.

c. The load bank equipment must be manufactured using UL listed components.

2.31.2 Material and Construction

a. The load bank must be outdoor construction housed in 40 foot ISO style container with vertical air flow suitable for permanent operation.

b. The ISO style load bank container must be fabricated from formed and welded steel, making a rigid, drip-proof structure. The container must be primed on the inside and out with catalyzed epoxy primer and catalyst. Finish must be two coats of ANSI 61 Gray urethane, Polane S. Total dry film thickness to be 4.8-6.2 mileage less spatter top coat if applied.

c. Primary load connection will be to copper load bus bars housed in a recessed lockable compartment (external access).

d. The main input load bus and load contractors must be located within a dedicated local load bank enclosure.

e. An integral low voltage enclosure must be provided to house control devices, fuses, fan starter/control relays and safety circuits. Thermostatically controlled heaters must be located within the control section to provide protection to the control devices from the effects of low temperature, moisture and condensation.

f. Airflow through the load bank resistor section must be vertical. Ambient intake cooling air must be drawing in at the bottom of the unit and heated air exhausted out of the top. Intake openings must be designed to prevent objects greater than 0.50 inch diameter from entering the unit.

g. The load bank exhaust hoods must be angled and include interior baffle plates to direct falling rain from the interior of the load bank.

h. Load elements must be contained in multiple resistor cases or trays. Each can be removed in its entirety as a unit for inspection or service.

2.31.3 Cooling

a. The load bank must be cooled by integral motors which are direct coupled to the cooling fan blade. Each fan motor must be electrically protected against overload using a motor overload device and short circuit protected using three current limiting fuses with an interrupting rating of 200kAIC.

b. The fan blade is to be an airfoil design constructed from aluminum or non-corroding material.

c. An integral control power transformer must be provided to supply 120V, single-phase, 60 hertz to the load bank controls. Transformer primary and secondary control circuits must be fuse protected.

2.31.4 Protective Devices

a. Current sensing switches are provided to sense current flow on each fan motor. These switches change state when current flow is sensed. This feedback is electrically interlocked with load application controls to prevent or remove load if current is not sensed or lost at each fan motor.

b. An over-temperature switch must be provided to sense the load bank exhaust in each vertical resistor case assembly. The switch must be electrically interlocked with the load application controls to remove load from being applied in the event of an over temperature condition.

c. The exterior of the load bank must have appropriate warning/caution statements on access panels.

2.31.5 Control Panel

a. The control panel must be a 19” rack mounted panel housed in a NEMA 4X type wall mount enclosure, securely fastened to the exterior of the load bank and completely pre-wired. The control panel must contain the

following manual controls:

(1) Power ON/OFF switch.

(2) Fan START/STOP pushbuttons.

(3) Master load ON/OFF switch.

(4) Load step switches for ON/OFF application of individual load steps.

(5) Control panel visual indicators must be as follows:

(a) Power ON indication light.

(b) Fan ON light.

(c) Fan/Air FAILURE light.

(d) OVERTEMPERATURE light.

b. The standard remote load dump circuit must be provided as part of the load bank control circuit. Provisions must be provide to remove the load bank off-line from the operation of a remote normally closet set of auxiliary contacts from a transfer switch or other device. In the event of the remote contact opening, all load is removed but power to the cooling fans is maintained until the low temperature fan cutoff setting has been reached.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the job, perform a Site Visit to verify the information shown on the drawings, before performing any work. Submit a letter stating the date the site was visited and listing discrepancies found. Notify the Contracting Officer in writing of any discrepancies.

3.2 GENERAL INSTALLATION

Provide clear space for operation and maintenance in accordance with NFPA 70 and IEEE C2. Submit a copy of the manufacturer's installation procedures and a detailed description of the manufacturer's recommended break-in procedure. Install pipe, duct, conduit, and ancillary equipment to facilitate easy removal and replacement of major components and parts of the engine-generator set.

3.3 PIPING INSTALLATION

Weld piping. Provide flanged valve connections. Provide flanged connections at equipment. Provide threaded connections to the engine if the manufacturers standard connection is threaded. Except where otherwise specified, use welded flanged fittings to allow for complete dismantling and removal of each piping system from the facility without disconnecting or removing any portion of any other system's equipment or piping. Make connections to equipment with vibration isolation-type flexible connectors. Support and align piping and tubing to prevent stressing of flexible hoses and connectors. Flash pipes extending through the roof.

Install piping clear of windows, doors and openings, to permit thermal expansion and contraction without damage to joints or hangers, and install a 1/2 inch drain valve with cap at each low point.

The installation of gas engines must conform to the requirements of NFPA 37 and its references therein, including NFPA 54, NFPA 58, and ASME B31.3.

3.3.1 Support

Provide hangers, inserts, and supports to accommodate any insulation and conforming to MSS SP-58. Space supports no more than 7 feet on center for pipes 2 inches in diameter or less, no more than 12 feet on center for pipes larger than 2 inches but smaller than 4 inches in diameter, and not more than 17 feet on center for pipes larger than 4 inches in diameter. Provide supports at pipe bends or change of direction.

3.3.1.1 Ceiling and Roof

Support exhaust piping with appropriately sized Type 41 single pipe roll and threaded rods; support all other piping with appropriately sized Type 1 clevis and threaded rods.

3.3.1.2 Wall

Make wall supports for pipe by suspending the pipe from appropriately sized Type 33 brackets with the appropriate ceiling and roof pipe supports.

3.3.2 Flanged Joints

Provide flanges that are Class 125 type, drilled, and of the proper size and configuration to match the equipment and engine connections. Provide gasketed flanged joints that are square and tight.

3.3.3 Cleaning

After fabrication and before assembly, piping interiors must be manually wiped clean of debris.

3.3.4 Pipe Sleeves

Fit pipes passing through construction such as ceilings, floors, or walls with sleeves. Extend each sleeve through and fasten in its respective structure and cut flush with each surface. Build the structure tightly to the sleeve. The inside diameter of each sleeve must be minimum 1/2 inch, and where pipes pass through combustible materials 1 inch larger than the outside diameter of the passing pipe or pipe insulation/covering.

3.4 ELECTRICAL INSTALLATION

Perform electrical installation in compliance with NFPA 70, IEEE C2, and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. For vibration isolation, provide flexible fittings for conduit, cable trays, and raceways attached to engine-generator sets; provide flexible stranded conductor for metallic conductor cables installed on the engine generator set and from the engine generator set to equipment not mounted on the engine generator set; and provide crimp-type terminals or lugs for terminations of conductors on the engine generator set.

3.5 FIELD PAINTING

Perform field painting as specified in Section 09 90 00 PAINTS AND COATINGS.

3.6 ONSITE INSPECTION AND TESTS

Perform and report on factory tests and inspections prior to shipment. Provide certified copies of manufacturer's test data and results. Test procedures must conform to ASME, IEEE, and ANSI standards, and to ISO requirements on testing, as appropriate and applicable. The manufacturer performing the tests must provide equipment, labor, and consumables necessary for tests and measuring and indicating devices must be certified to be within calibration. Tests must indicate satisfactory operation and attainment of specified performance. If satisfactory, equipment tested will be given a tentative approval. Equipment must not be shipped before approval of the factory test reports for the following tests.

Submit a letter giving notice of the proposed dates of onsite inspections and tests at least 14 days prior to beginning tests.

a. Submit a detailed description of the Contractor's procedures for onsite tests including the test plan and a listing of equipment necessary to perform the tests at least 14 days prior to beginning tests.

b. Submit six copies of the onsite test data described below in 8-1/2 by 11 inch binders having a minimum of 3 rings from which material may readily be removed and replaced, including a separate section for each test. Separate sections by heavy plastic dividers with tabs. Provide full size (8-1/2 by 11 inch minimum) data plots showing grid lines, with full resolution.

    (1) A detailed description of the procedures for onsite tests.

    (2) A list of equipment used, with calibration certifications.

    (3) A copy of measurements taken, with required plots and graphs.

    (4) The date of testing.

    (5) A list of the parameters verified.

    (6) The condition specified for the parameter.

    (7) The test results, signed and dated.

    (8) A description of adjustments made.

3.6.1 Test Conditions

3.6.1.1 Data

Make and record measurements of all parameters necessary to verify that each set meets specified parameters. If the results of any test step are not satisfactory, make adjustments, replacements, or repairs and repeat the step until satisfactory results are obtained. Unless otherwise indicated, record data in 15 minute intervals during engine-generator set operation and include: readings of all engine-generator set meters and

gauges for electrical and power parameters; oil pressure; ambient temperature; and engine temperatures available from meters and gauges supplied as permanent equipment on the engine-generator set. Perform electrical measurements in accordance with IEEE 120. Definitions of terms are in accordance with IEEE 100. Provide temperature limits in the rating of electrical equipment and for the evaluation of electrical insulations in accordance with IEEE 1.

3.6.1.2 Power Factor

Submit the generator capability curve showing generator kVA output capability (kW vs. kvar) for both leading and lagging power factors ranging from 0 to 1.0. For all engine-generator set operating tests the load power factor must be 0.8 power factor.

3.6.1.3 Contractor Supplied Items

Provide equipment and supplies required for inspections and tests including fuel, test instruments, and loadbanks at the specified power factors.

3.6.1.4 Instruments

Verify readings of panel gauges, meters, displays, and instruments provided as permanent equipment during test runs, using test instruments of greater precision and accuracy. Test instrument accuracy must be within the following: current plus or minus 1.5 percent, voltage plus or minus 1.5 percent, real power plus or minus 1.5 percent, reactive power plus or minus 1.5 percent, power factor plus or minus 3 percent, frequency plus or minus 0.5 percent. Calibrate test instruments by a recognized standards laboratory within 30 days prior to testing.

3.6.1.5 Sequence

Provide the sequence of testing as specified in the approved testing plan unless variance is authorized by the Contracting Officer. Perform field testing in the presence of the Contracting Officer. Schedule and sequence tests in order to optimize run-time periods; however, follow the general order of testing: Construction Tests; Inspections; Pre-operational Tests; Safety Run Tests; Performance Tests; and Final Inspection.

3.6.2 Construction Tests

Perform individual component and equipment functional tests for fuel piping, coolant piping, and lubricating-oil piping, electrical circuit continuity, insulation resistance, circuit protective devices, and equipment not provided by the engine-generator set manufacturer prior to connection to the engine-generator set.

3.6.2.1 Piping Test

a. Flush lube-oil and fuel-oil piping with the same type of fluid intended to flow through the piping, until the outflowing fluid has no obvious sediment or emulsion.

b. Test fuel piping which is external to the engine-generator set in accordance with NFPA 30. Pressure all remaining piping which is external to the engine-generator set with air pressure at 150 percent of the maximum anticipated working pressure, but not less than 150 psi,

for a period of 2 hours to prove the piping has no leaks. If piping is to be insulated, perform the test before the insulation is applied.

3.6.2.2 Electrical Equipment Tests

a. Perform low-voltage cable insulation integrity tests for cables connecting the generator breaker to the automatic transfer switch, panelboard, main disconnect switch, distribution bus. Test low-voltage cable, complete with splices, for insulation resistance after the cables are installed, in their final configuration, ready for connection to the equipment, and prior to energization. Apply a test voltage of 500 volts dc for one minute between each conductor and ground and between all possible combinations conductors in the same trench, duct, or cable, with all other conductors in the same trench, duct, or conduit. Provide the minimum value of insulation as follows:

(1) R in meg-ohms = (rated voltage in kV plus 1) x 304.8/(length of cable in meters)

(2) R in meg-ohms = (rated voltage in kV plus 1) x 1000/(length of cable in feet)

(3) Each cable failing this test must be repaired or replaced. The repair cable must be retested until failures have been eliminated.

b. Ground-Resistance Tests. Measure the resistance of each grounding electrode using the fall-of-potential method defined in IEEE 81. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. Take measurements in normally dry weather, not less than 48 hours after rainfall. Provide site diagram indicating location of test probes with associated distances, and provide a plot of resistance vs. distance. The combined resistance of separate systems may be used to meet the requirements resistance, but the specified number of electrodes must still be provided as follows:

(1) Multiple rod electrodes - 25 ohms.

c. Examine and test circuit breakers and switchgear in accordance with the manufacturer's published instructions for functional testing.

3.6.3 Inspections

Perform the following inspections jointly by the Contracting Officer and the Contractor, after complete installation of each engine-generator set and its associated equipment, and prior to startup of the engine-generator set. Submit a letter certifying that all facilities are complete and functional; that each system is fully functional; and that each item of equipment is complete, free from damage, adjusted, and ready for beneficial use. Perform checks applicable to the installation. Document and submit the results of those which are physical inspections (I) in accordance with paragraph SUBMITTALS. Present manufacturer's data for the inspections designated (D) at the time of inspection. Verify that equipment type, features, accessibility, installation and condition are in accordance with the contract specification. Provide manufacturer's statements to certify provision of features which cannot be verified visually.

Drive belts	I
Governor type and features	I
Engine timing mark	I
Starting motor	I
Starting aids	I
Coolant type and concentration	D
Radiator drains	I
Block coolant drains	I
Coolant fill level	I
Coolant line connections	I
Coolant hoses	I
Combustion air filter	I
Intake air silencer	I
Lube oil type	D
Lube oil sump drain	I
Lube-oil filter	I
Lube-oil level indicator	I
Lube-oil fill level	I
Lube-oil line connections	I
Lube-oil lines	I
Fuel type	D
Fuel level	I
Fuel-line connections	I
Fuel lines	I
Fuel filter	I
Access for maintenance	I
Voltage regulator	I

Battery-charger connections	I
Wiring and terminations	I
Instrumentation	I
Hazards to personnel	I
Base	I
Nameplates	I
Paint	I
Exhaust-heat system	I
Exhaust muffler	I
Switchboard	I
Switchgear	I
Access provided to controls	I
Enclosure is weather resistant	I
Engine and generator mounting bolts (application)	I

3.6.4 Engine Tests

Perform customary commercial factory tests in accordance with ISO 3046 on each engine and associated engine protective device, including, but not limited to the following:

a. Perform dynamometer test at rated power. Record horsepower at rated speed and nominal characteristics such as lubricating oil pressure, jacket water temperature, and ambient temperature.

b. Test and record the values that the low oil pressure alarm and protective shutdown devices actuate prior to assembly on the engine.

c. Test and record values that the high jacket water temperature alarm and protective shutdown devices actuate prior to assembly on the engine.

3.6.5 Generator Tests

Tests must be performed on the complete factory assembled generator prior to shipment. Conduct tests in accordance with IEEE 115 and NEMA MG 1.

3.6.5.1 Routine Tests

Perform the following routine tests on the generators and their exciters:

a. Resistance of armature and field windings.

b. Mechanical balance.

c. Phases sequence.

d. Open circuit saturation curve and phase (voltage) balance test.

e. Insulation resistance of armature and field windings.

f. High potential tes.t

3.6.5.2 Design Tests

Submit the following design tests made on prototype machines that are physically and electrically identical to the generators specified.

a. Temperature rise test

b. Short circuit saturation curve and current balance test

3.6.6 Assembled Engine-Generator Set Tests

Perform the following tests on the assembled engine-generator set.

3.6.6.1 Initial Stabilization Readings

Operate the engine-generator set and allow the set to stabilize at rated kW at rated power factor, rated voltage, and rated frequency. During this period record instrument readings for output power (kW), terminal voltage, line current, power factor, frequency (rpm) generator (exciter) field voltage and current, lubricating oil pressure, jacket water temperature, and ambient temperature at minimum intervals of 15 minutes. Adjust the load, voltage, and frequency to maintain rated load at rated voltage and frequency. Adjustments to load, voltage, or frequency controls must be recorded on the data sheet at the time of adjustment. Stabilization must be considered to have occurred when four consecutive voltage and current recorded readings of the generator (or exciter) field either remain unchanged or have only minor variations about an equilibrium condition with no evident continued increase or decrease in value after the last adjustment to the load, voltage, or frequency has been made.

3.6.6.2 Regulator Range Test

Remove load and record instrument readings (after transients have subsided). Adjust voltage to the maximum attainable value or to a value just prior to actuation of the overvoltage protection device. Apply rated load and adjust voltage to the minimum attainable value or a value just prior to activation of the under-voltage protection device. The data sheets must indicate the voltage regulation as a percent of rated voltage and the maximum and minimum voltages attainable. Voltage regulation must be defined as follows:

$$\text{Percent Regulation} = \frac{(\text{No-Load Voltage}) - (\text{Rated-Load Voltage})}{(\text{Rated-Load Voltage})} \times 100$$

3.6.6.3 Frequency Range Test

Adjust the engine-generator set frequency for the maximum attainable frequency at rated load. Record instrument readings. Adjust the engine-generator set frequency for the specified minimum attainable frequency at rated load. Record instrument readings. Reduce the load to zero and adjust the engine-generator set frequency for the maximum attainable frequency. Record instrument readings. Adjust the engine-generator set frequency for the minimum attainable frequency. Record instrument readings. The data sheet must show the maximum and minimum frequencies attained at rated load, and at no load.

3.6.6.4 Transient Response Test

Drop the load to no load and re-apply rated load three times to ensure that the no load and rated load voltage and frequency values are repeatable and that the frequency and voltage regulation is within the limits specified. Record generator terminal voltage and frequency using a high speed strip chart recorder. The data sheet must show the following results:

a. Frequency

(1) Stability bandwidth or deviation in percent of rated frequency.

(2) Recovery time.

(3) Overshoot and undershoot.

b. Voltage

(1) Stability bandwidth or deviation in percent of rated voltage.

(2) Recovery time.

(3) Overshoot and undershoot.

3.6.7 Pre-operational Tests

3.6.7.1 Protective Relays

Visually and mechanically inspect, adjust, test, and calibrate protective relays in accordance with the manufacturer's published instructions. Include pick-up, timing, contact action, restraint, and other aspects necessary to ensure proper calibration and operation. Implement relay settings in accordance with the installation coordination study. Manually or electrically operate relay contacts to verify that the proper breakers and alarms initiate. Field test relaying current transformers in accordance with IEEE C57.13.1.

3.6.7.2 Insulation Test

Test generator and exciter circuits insulation resistance in accordance with IEEE 43. Take stator readings including generator leads to distribution board at the circuit breaker. Record results of insulation resistance tests. Readings must be within limits specified by the manufacturer. Verify mechanical operation, insulation resistance, protective relay calibration and operation, and wiring continuity of distribution board assembly. Do not damage generator components during

test.

3.6.7.3 Engine-Generator Connection Coupling Test

When the generator provided is a two-bearing machine, inspect and check the engine-generator connection coupling by dial indicator to prove that no misalignment has occurred. Use the dial indicator to measure variation in radial positioning and axial clearance between the coupling halves. Take readings at four points, spaced 90 degrees apart. Align solid couplings and pin-type flexible couplings within a total indicator reading of 0.0005 to 0.001 inch for both parallel and angular misalignment. For gear-type or grid-type couplings, 0.002 inch will be acceptable.

3.6.8 Safety Run Test

For the following tests, repeat the associated safety tests if any parts are changed, or adjustments made to the generator set, its controls, or auxiliaries.

a. Perform and record engine manufacturer's recommended prestarting checks and inspections.

b. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period.

c. Activate the manual emergency stop switch and verify that the engine stops.

d. Remove the high and pre-high lubricating oil temperature sensing elements from the engine and temporarily install a temperature gauge in their normal locations on the engine (required for safety, not for recorded data). Where necessary provide temporary wiring harness to connect the sensing elements to their permanent electrical leads.

e. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period. Operate the engine-generator set at no load until the output voltage and frequency stabilize. Monitor the temporarily installed temperature gauges. If either temperature reading exceeds the value required for an alarm condition, activate the manual emergency stop switch.

f. Immerse the elements in a vessel containing controlled-temperature hot oil and record the temperature at which the pre-high alarm activates and the temperature at which the engine shuts down. Remove the temporary temperature gauges and reinstall the temperature sensors on the engine.

g. Remove the high and pre-high coolant temperature sensing elements from the engine and temporarily install a temperature gauge in their normal locations on the engine (required for safety, not for recorded data). Where necessary provide temporary wiring harness to connect the sensing elements to their permanent electrical leads.

h. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period. Operate the engine generator-set at no load until the output voltage and frequency stabilize.

i. Immerse the elements in a vessel containing controlled-temperature hot oil and record the temperature at which the pre-high alarm activates and the temperature at which the engine shuts down. Remove the temporary temperature gauges and reinstall the temperature sensors on the engine.

j. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period.

k. Operate the engine generator-set for at least 2 hours at 75 percent of Service Load.

l. Verify proper operation and set-points of gauges and instruments.

m. Verify proper operation of ancillary equipment.

n. Manually adjust the governor to increase engine speed past the over-speed limit. Record the RPM at which the engine shuts down.

o. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections and operate the engine generator-set for at least 15 minutes at 75 percent of Service Load.

p. Manually adjust the governor to increase engine speed to within 2 percent of the over-speed trip speed previously determined and operate at that point for 5 minutes. Manually adjust the governor to the rated frequency.

q. Manually fill the day tank to a level above the overfill limit. Record the level at which the overfill alarm sounds. Verify shutdown of the fuel transfer pump. Drain the day tank down below the overfill limit.

r. Shut down the engine. Remove the time-delay low lube oil pressure alarm bypass and try to start the engine.

s. Attach a manifold to the engine oil system (at the oil pressure sensor port) that contains a shutoff valve in series with a connection for the engine's oil pressure sensor followed by an oil pressure gauge ending with a bleed valve. Move the engine's oil pressure sensor from the engine to the manifold. Open the manifold shutoff valve and close the bleed valve.

t. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections and operate the engine generator-set for at least 15 minutes at 75 percent of Service Load.

u. Close the manifold shutoff valve. Slowly allow the pressure in the manifold to bleed off through the bleed valve while watching the pressure gauge. Record the pressure at which the engine shuts down. Catch oil spillage from the bleed valve in a container. Add the oil from the container back to the engine, remove the manifold, and reinstall the engine's oil pressure sensor on the engine.

v. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections and operate the

engine generator-set for at least 15 minutes at 100 percent of Service Load. Record the maximum sound level in each frequency band at a distance of 75 feet from the end of the exhaust and air intake piping directly along the path of intake and discharge for horizontal piping; or at a radius of 75 feet from the engine at 45 degrees apart in all directions for vertical piping. If a sound limiting enclosure is provided, modify or replace the enclosure, the muffler, and intake silencer must be modified or replaced as required to meet the sound requirements contained within this specification.

w. Manually drain off fuel slowly from the day tank to empty it to below the low fuel level limit and record the level at which the audible alarm sounds. Add fuel back to the day tank to fill it above low level alarm limits.

3.6.9 Performance Tests

In the following tests, where measurements are to be recorded after stabilization of an engine-generator set parameter (voltage, frequency, current, temperature, etc.), stabilization is considered to have occurred when measurements are maintained within the specified bandwidths or tolerances, for a minimum of four consecutive readings. For the following tests, repeat the associated tests if any parts are changed, or adjustments made to the generator set, its controls, or auxiliaries.

3.6.9.1 Continuous Engine Load Run Test

Test the engine-generator set and ancillary systems at service load to demonstrate durability; verify that heat of extended operation does not adversely affect or cause failure in any part of the system; and check all parts of the system. If the engine load run test is interrupted for any reason, repeat the entire test. Accomplish the engine load run test during daylight hours. After each change in load in the following test, measure the vibration at the end bearings (front and back of engine, outboard end of generator) in the horizontal, vertical, and axial directions. Verify that the vibration is within the allowable range. Take data taken at 15 minute intervals and include the following:

Electrical: Output amperes, voltage, real and reactive power, power factor, frequency.

Pressure: Lube-oil.

Temperature: Coolant, Lube-oil, Exhaust, Ambient.

a. Perform and record engine manufacturer's recommended prestarting checks and inspections. Include as a minimum checking of coolant fluid, fuel, and lube-oil levels.

b. Start the engine, make and record engine manufacturer's after-starting checks and inspections during a reasonable warmup period.

c. Operate the engine generator-set for 2 hours at 75 percent of Service Load.

d. Increase load to 100 percent of Service Load and operate the engine generator-set for 4 hours.

e. Decrease load to 100 percent of Service Load and operate the engine

generator-set for 2 hours or until all temperatures have stabilized.

f. Remove load from the engine-generator set.

3.6.9.2 Frequency and Voltage Stability and Transient Response

Verify that the engine-generator set responds to addition and dropping of blocks of load in accordance with the transient response requirements. Document maximum voltage and frequency variation from bandwidth and verify that voltage and frequency return to and stabilize within the specified bandwidth, within the specified response time period. Document results in tabular form and with high resolution, high speed strip chart recorders or comparable digital recorders, as approved by the Contracting Officer. Include the following tabular data:

(1) Ambient temperature (at 15 minute intervals).

(2) Generator output current (before and after load changes).

(3) Generator output voltage (before and after load changes).

(4) Frequency (before and after load changes).

(5) Generator output power (before and after load changes.

(6) Include the actual instrument trace of voltage and frequency in graphic representations showing:

Charts marked at start of test; observed steady-state band; mean of observed band; momentary overshoot and undershoot (generator terminal voltage and frequency) and recovery time for each load change together with the voltage and frequency maximum and minimum trace excursions for each steady state load condition prior to and immediately following each load change. Generator terminal voltage and frequency transient recovery time for each step load increase and decrease.

a. Perform and record engine manufacturer's recommended prestarting checks and inspections.

b. Start the engine, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period and no load. Verify stabilization of voltage and frequency within specified bandwidths.

c. With the unit at no load, apply the Maximum Step Load Increase.

d. Apply load in steps equal to the Maximum Step Load Increase until the addition of one more step increase will exceed the Service Load.

e. Decrease load to the unit such that addition of the Maximum Step Load Increase will load the unit to 100 percent of Service Load.

f. Apply the Maximum Step Load Increase.

g. Decrease load to zero percent in steps equal to the Maximum Step Load Decrease.

h. Repeat steps c. through g.

3.6.10 Parallel Operation Test

Test the capability of each engine-generator set to parallel and share load with other generator sets, individually and in all combinations. This test must be performed with the voltage regulator and governor adjustment settings used for the Frequency and Voltage Stability and Transient Response test. If settings are changed during the performance of this test, a voltage and frequency stability and transient response test must be performed for each engine generator set using the setting utilized in this test. During operations record load-sharing characteristics of each set in parallel operation. Include the following data:

(1) Ambient temperature (at 15 minute intervals).

(2) Generator output current (before and after load changes).

(3) Generator output voltage (before and after load changes).

(4) Power division and exchange between generator sets.

(5) Real power (watts) and reactive power (vars) on each set.

3.6.10.1 Combinations

Connect each set, while operating at no load, parallel with one other set in the system, operating at service load, until all possible combinations have been achieved. Verify stabilization of voltage and frequency within specified bandwidths and proportional sharing of real and reactive loads. Document stabilization of voltage and frequency within specified bandwidth, the active power division, active power exchange, reactive power division, and voltage and frequency stability and transient response in the following steps for each combination.

a. Divide the load proportionally between the sets and operate in parallel for 15 minutes.

b. Increase the load, in steps equal to the Maximum Step Increase, until each set is loaded to its service load.

c. Decrease the load, in steps equal to the Maximum Step Decrease, until each set is loaded to approximately 25 percent of its service load.

d. Increase the load, in steps equal to the Maximum Step Increase, until each set is loaded to approximately 50 percent of its service load Verify stabilization of voltage and frequency within specified bandwidths and proportional sharing of real and reactive load.

e. Reduce the sum of the loads on both sets to the output rating of the smaller set.

f. Transfer a load equal to the output rating of the smaller of the 2 sets to and from each set. Verify stabilization of voltage and frequency within specified bandwidths and proportional sharing of real and reactive load.

g. Document the active power division, active power exchange, reactive power division, and voltage and frequency stability and transient response.

3.6.10.2 Multiple Combinations

Connect each set, while operating at no load, parallel with all multiple combinations of all other set in the system, while operating at service load, until all multiple combinations of parallel operations have been achieved.

3.7 GROUNDING

NFPA 70 and IEEE C2, except that grounding systems must have a resistance to solid earth ground not exceeding 5 ohms.

3.7.1 Grounding Electrodes

Provide driven ground rods as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Connect ground conductors to the upper end of ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors.

3.7.2 Engine-Generator Set Grounding

Provide separate copper grounding conductors and connect them to the ground system as indicated. When work in addition to that indicated or specified is required to obtain the specified ground resistance, the provision of the contract covering "Changes" must apply.

3.7.3 Connections

Make joints in grounding conductors by exothermic weld or compression connector. Exothermic welds and compression connectors must be installed as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION paragraph regarding GROUNDING.

3.7.4 Grounding and Bonding Equipment

UL 467, except as indicated or specified otherwise.

3.8 START-UP ENGINEER

Provide the services of a qualified factory trained start-up engineer, regularly employed by the engine-generator set manufacturer. The start-up services must include conducting preliminary operations and functional acceptance tests. The start-up engineer must be present at the engine generator set installation-site, full-time, while preliminary operations and functional acceptance tests are being conducted.

3.9 PREREQUISITES FOR FUNCTIONAL ACCEPTANCE TESTING

Completion of the following requirements is mandatory prior to scheduling functional acceptance tests for the engine-generator set and auxiliary equipment.

3.9.1 Performance of Acceptance Checks and Tests

The acceptance checks and tests must be accomplished by the testing organization as described in Section 26 08 00 APPARATUS INSPECTION AND TESTING.

3.9.2 Generator Sets

Complete as specified in the paragraph ACCEPTANCE CHECKS AND TESTS.

3.9.2.1 Automatic Transfer Switches

Complete acceptance checks and tests as specified in Section 26 36 23 AUTOMATIC TRANSFER SWITCHES AND BY-PASS/ISOLATION SWITCH.

3.9.3 Preliminary Operations

The start-up engineer must conduct manufacturer recommended start-up procedures and tests to verify that the engine-generator set and auxiliary equipment are ready for functional acceptance tests. Give the Contracting Officer 15 days' advance notice that preliminary operations will be conducted. After preliminary operation has been successfully conducted, the start-up engineer will notify the Contracting Officer in writing stating the engine-generator set and auxiliary equipment are ready for functional acceptance tests.

3.9.4 Preliminary Assembled Operation and Maintenance Manuals

Preliminary assembled operation and maintenance manuals must have been submitted to and approved by the Contracting Officer. Manuals must be prepared as specified in the paragraph ASSEMBLED OPERATION AND MAINTENANCE MANUALS.

3.9.5 Functional Acceptance Test Procedure

Test procedure must be prepared by the start-up engineer specifically for the engine-generator set and auxiliary equipment. The test agenda must cover the requirements specified in the paragraph FUNCTIONAL ACCEPTANCE TESTS. The test procedure must indicate in detail how tests are to be conducted. A statement of the tests that are to be performed without indicating how the tests are to be performed is not acceptable. Indicate what work is planned on each workday and identify the calendar dates of the planned workdays. Specify what additional technical support personnel is needed such as factory representatives for major equipment. Specify on which testing workday each technical support personnel is needed. Data recording forms to be used to document test results are to be submitted with the proposed test procedure. A list of test equipment and instruments must also be included in the test procedure.

3.9.6 Test Equipment

Test equipment and instruments must be on hand prior to scheduling field tests or, subject to Contracting Officer approval, evidence must be provided to show that arrangements have been made to have the necessary equipment and instruments on-site prior to field testing.

3.10 FIELD QUALITY CONTROL

Give Contracting Officer 30 days' notice of dates and times scheduled for tests which require the presence of the Contracting Officer. The Contracting Officer will coordinate with the using activity and schedule a time that will eliminate or minimize interruptions and interference with the activity operations. The Contractor must be responsible for costs associated with conducting tests outside of normal working hours and with incorporating special arrangements and procedures, including temporary

power conditions. The Contractor must provide labor, equipment, fuel, test load, and consumables required for the specified tests. The test load must be a cataloged product. Calibration of measuring devices and indicating devices must be certified. Refer to Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, for requirements for a cataloged product. Perform the following field tests.

3.10.1 Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations, and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.10.1.1 Circuit Breakers - Low Voltage Insulated Case/Molded Case

a. Visual and Mechanical Inspection

(1) Compare nameplate data with specifications and approved shop drawings.

(2) Inspect circuit breaker for correct mounting.

(3) Operate circuit breaker to ensure smooth operation.

(4) Inspect case for cracks or other defects.

(5) Verify tightness of accessible bolted connections and cable connections by calibrated torque-wrench method. Thermo-graphic survey is not required.

(6) Inspect mechanism contacts and arc chutes in unsealed units.

b. Electrical Tests

(1) Perform contact-resistance tests.

(2) Perform insulation-resistance tests.

(3) Adjust breaker(s) for final settings in accordance with engine-generator set manufacturer's requirements.

3.10.1.2 Current Transformers

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify correct connection.

(4) Verify that adequate clearances exist between primary and secondary circuit.

(5) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method. Thermo-graphic survey is not required.

(6) Verify that all required grounding and shorting connections provide good contact.

b. Electrical Tests

(1) Perform insulation-resistance tests.

(2) Perform polarity tests.

(3) Perform ratio-verification tests.

3.10.1.3 Metering and Instrumentation

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify tightness of electrical connections.

b. Electrical Tests

(1) Determine accuracy of meters at 25, 50, 75, and 100 percent of full scale.

(2) Calibrate watt-hour meters according to manufacturer's published data.

(3) Verify all instrument multipliers.

(4) Electrically confirm that current transformer secondary circuits are intact.

3.10.1.4 Battery Systems

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method. Thermo-graphic survey is not required.

(4) Measure electrolyte specific gravity and temperature and visually check fill level.

(5) Verify adequacy of battery support racks, mounting, anchorage, and clearances.

b. Electrical Tests

(1) Set charger float and equalizing voltage levels.

(2) Verify all charger functions and alarms.

(3) Measure each cell voltage and total battery voltage with charger energized and in float mode of operation.

(4) Perform a capacity load test.

3.10.1.5 Engine-Generator Set

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Inspect for correct anchorage and grounding.

b. Electrical and Mechanical Tests

(1) Perform an insulation-resistance test on generator winding with respect to ground. Calculate polarization index.

(2) Perform phase rotation test to determine compatibility with load requirements.

3.10.1.6 Grounding System

a. Visual and Mechanical Inspection

(1) Inspect ground system for compliance with contract plans and specifications.

b. Electrical Tests

(1) Perform ground-impedance measurements utilizing the fall-of-potential method defined in IEEE 81. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. Take measurements in normally dry weather, not less than 48 hours after rainfall. Provide site diagram indicating location of test probes with associated distances, and provide a plot of resistance vs. distance.

3.10.2 Functional Acceptance Tests

The tests must be performed by the start-up engineer. Upon successful test completion, the start-up engineer must provide the Contracting Officer with a written test report within 15 calendar days showing the tests performed and the results of each test. The report must include the completed approved test data forms and certification from the start-up engineer that the test results fall within the manufacturer's recommended limits and meet the specified requirements performance. The report must be dated and signed by the start-up engineer, and submitted for approval by the Contracting Officer. The Contracting Officer will witness final acceptance tests. Testing must include, but not be limited to, the following:

a. Verify proper functioning of each engine protective shutdown device and pre-shutdown alarm device. Testing of the devices must be accomplished by simulating device actuation and observing proper alarm

and engine shutdown operation.

b. Verify proper functioning of the engine over-speed trip device. Testing of the over-speed trip device must be accomplished by raising the speed of the engine-generator set until an over-speed trip is experienced.

c. Verify proper functioning of the crank cycle/terminate relay. Testing of the relay must be accomplished by engaging the starter motor with the engine being prevented from running. Observe the complete crank/rest cycle as described in the paragraph STARTING SYSTEM.

d. Verify proper functioning of the following automatic and manual operations. Testing must include, but not be limited to, the following:

(1) Loss of Utility: Initiate a normal power failure with connected test load of rated kW at 1.0 power factor. Record time delay on start, cranking time until engine starts and runs, time to come up to operating speed, voltage and frequency overshoot, and time to achieve steady state conditions with all switches transferred to emergency position.

(2) Return of Utility: Return normal power and record time delay on retransfer for each automatic transfer switch, and time delay on engine cool-down and shutdown.

(3) Manual starting.

(4) Emergency stop.

e. Operate the engine-generator set at rated current (amperes) until the jacket water temperature stabilizes. Stabilization will be considered to have occurred when three consecutive temperature readings remain unchanged. Continue to operate the generator set for an additional 2 hours. Record instrument readings for terminal voltage, line current, frequency (Hz), engine speed rpm, lubricating oil pressure, jacket water temperature, and ambient temperature at 5 minute intervals for first 15 minutes and at 15 minute intervals thereafter.

f. Emissions Tests. Provide on-site testing by a certified testing organization of each engine-generator set. Testing must be in accordance with an EPA approved method, 40 CFR 60, (Appendix, Method 7, 7A, 7B, 7C, 7D or 7E). Emissions at rated full load must be within the limits specified in the paragraph ENGINE EMISSIONS LIMITS.

3.11 DEMONSTRATION

Upon completion of the work and at a time approved by the Contracting Officer, the Contractor must provide instructions by a qualified instructor to the Government personnel in the proper operation and maintenance of the equipment. Government personnel must receive training comparable to the equipment manufacturer's factory training. The duration of instruction must be for not less than one 8 hour working day for instruction of operating personnel and not less than one 8 hour working day for instruction of maintenance personnel.

3.11.1 Instructor's Qualification Resume

Instructors must be regular employees of the engine-generator set manufacturer. The instruction personnel provided to satisfy the requirements above must be factory certified by the related equipment manufacturer to provide instruction services. Submit the name and qualification resume of instructor to the Contracting Officer for approval.

3.11.2 Training Plan

Submit training plan 30 calendar days prior to training sessions. Training plan must include scheduling, content, outline, and training material (handouts). Content must include, but not be limited to, the following:

3.11.2.1 Operating Personnel Training

This instruction includes operating the engine-generator set, auxiliary equipment including automatic transfer switches in all modes, and the use of all functions and features specified.

3.11.2.2 Maintenance Personnel Training

Training must include mechanical, hydraulic, electrical, and electronic instructions for the engine-generator set and auxiliary equipment including automatic transfer switches.

a. Mechanical Training: Must include at least the following:

(1) A review of mechanical diagrams and drawings.

(2) Component location and functions.

(3) Troubleshooting procedures and techniques.

(4) Repair procedures.

(5) Assembly/disassembly procedures.

(6) Adjustments (how, when, and where).

(7) Preventive maintenance procedures.

(8) Review of flow diagram.

(9) Valve locations and function.

(10) Valve and hydraulic equipment adjustment and maintenance procedures.

(11) Hydraulic system maintenance and servicing.

(12) Lubrication points, type, and recommended procedures and frequency.

b. Electrical and Electronic Maintenance Training: Must include at least the following:

(1) A review of electrical and electronic systems including wiring

diagrams and drawings.

(2) Troubleshooting procedures for the machine and control systems.

(3) Electrical and electronic equipment servicing and care.

(4) Use of diagnostics to locate the causes of malfunction.

(5) Procedures for adjustments (locating components, adjustments to be made, values to be measured, and equipment required for making adjustments).

(6) Maintenance and troubleshooting procedures for microprocessor or minicomputer where applicable.

(7) Circuit board repair procedures where applicable (with schematics provided).

(8) Use of diagnostic tapes.

(9) Recommended maintenance servicing and repair for motors, switches, relays, solenoids, and other auxiliary equipment and devices.

3.12 ONSITE TRAINING

Conduct a training course for the operating staff as designated by the Contracting Officer. The training period must consist of a total 8 hours of normal working time and must start after the system is functionally completed but prior to final acceptance.

a. Submit a letter giving the date proposed for conducting the onsite training course, the agenda of instruction, a description of the digital video recording to be provided. The course instructions must cover pertinent points involved in operating, starting, stopping, servicing the equipment, as well as major elements of the operation and maintenance manuals. Additionally, the course instructions must demonstrate routine maintenance procedures as described in the operation and maintenance manuals.

b. Submit a digital video recording of the manufacturers operating and maintenance training course.

c. One full size reproducible Mylar ach drawing must accompany the booklets. Mylars must be rolled and placed in a heavy cardboard tube with threaded caps on each end. The manual must include step-by-step procedures for system startup, operation, and shutdown; drawings, diagrams, and single-line schematics to illustrate and define the electrical, mechanical, and hydraulic systems together with their controls, alarms, and safety systems; the manufacturer's name, model number, and a description of equipment in the system. The instructions must include procedures for interface and interaction with related systems to include automatic transfer switches and uninterruptible power supplies. Each booklet must include a CD containing an ASCII file of the procedures.

d. Provide approved operation and maintenance manuals for the training course. Post approved instructions prior to the beginning date of the

training course. Coordinate the training course schedule with the using service's work schedule, and submit for approval 14 days prior to beginning date of proposed beginning date of training.

3.13 INSTALLATION

Installation must conform to the applicable requirements of IEEE C2, NFPA 30, NFPA 37, and NFPA 70.

3.14 FINAL TESTING AND INSPECTION

a. Start the engine, record the starting time, make and record all engine manufacturer's after-starting checks and inspections during a reasonable warm-up period.

b. Increase the load in steps no greater than the Maximum Step Load Increase to 100 percent of Service Load, and operate the engine-generator set for at least 30 minutes. Measure the vibration at the end bearings (front and back of engine, outboard end of generator) in the horizontal, vertical, and axial directions. Verify that the vibration is within the same range as previous measurements and is within the required range.

c. Remove load and shut down the engine-generator set after the recommended cool down period.

d. Remove the lube oil filter and have the oil and filter examined by the engine manufacturer for excessive metal, abrasive foreign particles, etc. Verify any corrective action for effectiveness by running the engine for 8 hours at Service Load, then re-examine the oil and filter.

e. Remove the fuel filter and examine the filter for trash, abrasive foreign particles, etc.

f. Visually inspect and check engine and generator mounting bolts for tightness and visible damage.

g. Replace air, oil, and fuel filters with new filters.

3.15 MANUFACTURER'S FIELD SERVICE

The engine generator-set manufacturer must furnish a qualified representative to supervise the installation of the engine generator-set, assist in the performance of the onsite tests, and instruct personnel as to the operational and maintenance features of the equipment.

3.16 POSTED DATA AND INSTRUCTIONS

Post Data and Instructions prior to field acceptance testing of the engine generator set. Provide two sets of instructions/data, typed and framed under weatherproof laminated plastic, and post side-by-side where directed. Include a one-line diagram, wiring and control diagrams and a complete layout of the system in the first set. Include the condensed operating instructions describing manufacturer's pre-start checklist and precautions; startup procedures for test-mode, manual-start mode, and automatic-start mode (as applicable); running checks, procedures, and precautions; and shutdown procedures, checks, and precautions in the second set. Submit posted data including wiring and control diagrams showing the key mechanical and electrical control elements, and a complete

layout of the entire system.

a. Include procedures for interrelated equipment (such as heat recovery systems, co-generation, load-shedding, and automatic transfer switches). Provide two sets of typed instructions/data in 8-1/2 x 11 inch format, laminated in weatherproof plastic, and placed in three-ring vinyl binders. Place the binders as directed by the Contracting Officer. Provide the instructions prior to acceptance of the engine generator set installation.

b. Include a one-line diagram, wiring and control diagrams and a complete layout of the system in the first set. Include the condensed operating instructions describing manufacturer's pre-start checklist and precautions; startup procedures for test-mode, manual-start mode, and automatic-start mode (as applicable); running checks, procedures, and precautions; and shutdown procedures, checks, and precautions in the second set. Include procedures for interrelated equipment (such as heat recovery systems, co-generation, load-shedding, and automatic transfer switches).

c. Submit instructions including: the manufacturers pre-start checklist and precautions; startup procedures for test-mode, manual-start mode, and automatic-start mode (as applicable); running checks, procedures, and precautions; and shutdown procedures, checks, and precautions. Include procedures for interrelated equipment (such as heat recovery systems, co-generation, load-shedding, and automatic transfer switches). Provide weatherproof instructions, laminated in plastic, and post where directed.

3.17 ACCEPTANCE

Submit drawings which accurately depict the as-built configuration of the installation, upon acceptance of the engine-generator set installation. Revise layout drawings to reflect the as-built conditions and submit them with the as-built drawings. Final acceptance of the engine-generator set will not be given until the Contractor has successfully completed all tests and all defects in installation material or operation have been corrected.

-- End of Section --

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SECTION 26 33 53

STATIC UNINTERRUPTIBLE POWER SUPPLY (UPS)
05/19

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE 450	(2020) Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications
IEEE 485	(2020) Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications
IEEE C2	(2023) National Electrical Safety Code
IEEE C62.41	(1991; R 1995) Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits
IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 9001	(2015) Quality Management Systems-Requirements

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA PE 1	(2012; R 2017) Uninterruptible Power Systems (UPS) - Specification and Performance Verification

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2026; TIA 26-1; ERTA 26-1; TIA 26-2; TIA 26-3; TIA 26-4; TIA 26-5; TIA 26-6; TIA 26-7; ERTA 26-2; ERTA 26-3) National Electrical Code
NFPA 70E	(2024) Standard for Electrical Safety in the Workplace

U.S. DEPARTMENT OF ENERGY (DOE)

Energy Star	(1992; R 2006) Energy Star Energy Efficiency Labeling System (FEMP)

U.S. FEDERAL COMMUNICATIONS COMMISSION (FCC)

FCC Part 15	Radio Frequency Devices (47 CFR 15)

UL SOLUTIONS (UL)

UL 1778	(2014; Reprint Apr 2023) UL Standard for Safety Uninterruptible Power Systems

1.2 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE 100.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

UPS Drawings; G

UPS Installation; G

SD-03 Product Data

UPS Module; G

Technical Requirements UPS System

Energy Star Label for Battery Charging Systems and AC-DC/AC-AC

Power Supply Products; S

Spare Parts; G

SD-06 Test Reports

Work Plan; G

Factory Test Plan; G

Factory Test Report; G

SD-09 Manufacturer's Field Reports

Initial Inspection and Tests; G

Performance Tests; G

Performance Test Plan; G

Performance Test Report; G

SD-10 Operation and Maintenance Data

UPS Operation and Maintenance, Data Package 5; G

Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and as specified herein.

SD-11 Closeout Submittals

Installation

1.4 OPERATION AND MAINTENANCE MANUALS

1.4.1 Additions to UPS Operation and Maintenance Manuals

In addition to requirements of SD-10 Data Package 5, include the followings on the actual UPS system provided:

a. An outline drawing, front, top, and side views.

b. Prices for spare parts and supply list.

c. Routine and field acceptance test reports.

d. Date of Purchase.

e. Corrective maintenance procedures.

1.4.2 Spare Parts

Furnish the following spare parts, of the same material and workmanship, meeting the same requirements, and interchangeable with the corresponding original parts.

a. Fuses: Two of each type and rating.

b. Circuit boards: One circuit board for each critical circuit.

c. Air Filters: One set of filters, when used on the UPS unit.

d. Special tools, calibration devices, and instruments required for operation, calibration, and maintenance of the equipment: One complete set.

1.5 QUALITY ASSURANCE

The manufacturer must have a documented quality assurance program including:

a. Inspections of incoming parts, modular assemblies and final product.

b. Final test procedure for the product including proof of performance specifications.

c. The on-site test procedure includes an inspection of controls and indicators after installation of the equipment.

d. ISO 9001 quality certification.

1.5.1 UPS Drawings

Drawings are to include the following: Detail drawings consisting of a complete list of equipment and materials, manufacturer's descriptive and technical literature, battery sizing calculations per IEEE 485, installation instructions, single-line diagrams, elevations, layout drawings, and details required to demonstrate that the system has been coordinated and will function properly as a unit.

a. One-line diagram.

b. Outline drawings including front elevation, section views, footprints, and overall dimensions.

c. Manufacturer's descriptive and technical literature.

d. Markings and NEMA nameplate data.

e. Battery sizing calculations per IEEE 485.

f. Wiring and control diagrams with terminals identified, and indicating prewired interconnections between items of equipment and interconnection between the items.

g. Complete list of materials and equipment covering major components. Ensure the bill of material and the schematic have a direct correlation between items in order to easily identify the various components.

h. Details required to demonstrate that the system has been coordinated and will function properly as a unit.

1.5.2 UPS Installation

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a

coordinated installation. Wiring diagrams are to identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings are to indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. Submittals include the nameplate data, size, and capacity. Submittals also include applicable federal, military, industry, and technical society publication references.

1.5.3 Work Plan

Submit schedules of dates for factory tests, installation, field tests, and operator training for the UPS system. Furnish a list of instrumentation equipment for factory and field test reports.

1.5.4 Factory Test Plan

Submit factory test plans and procedures at least 21 calendar days prior to the tests being conducted. Provide detailed description of test procedures, including test equipment and setups, to be used to ensure the UPS meets the performance specification and explain the test methods to be used. Provide test procedures that include the test required under the paragraph entitled "Factory Testing."

1.5.5 Factory Test Report

Submit a factory test report within 21 calendar days after completion of tests. Receive approval of test prior to shipping unit. Factory test reports are to be signed by an official authorized to certify on behalf of the UPS manufacturer of that the system meets specified requirements in accordance with the requirements set forth in paragraph entitled "Factory Testing". Provide test reports in booklet form tabulating factory tests and measurements performed, upon completion and testing of the installed system. Reports are to state the Contractor's name and address, the name of the project and location, and list the specific requirements which are being certified.

1.5.6 Performance Test Plan

Submit test plans and procedures at least 15 calendar days prior to the start of field tests. Provide detailed description and dates and times scheduled for performance of tests, and detailed description of test procedures, including test equipment (list make and model and provide functional description of the test instruments and accessories) and setups of the tests to be conducted to ensure the UPS meets the performance specification. Explain the test methods to be used. Provide test procedures that include the tests required under the paragraph entitled "Performance Tests."

1.5.7 Performance Test Report

Submit report of test results as specified by paragraph entitled "Performance Tests" within 15 calendar days after completion of tests. Field test reports are to be signed by an official authorized to certify on behalf of the UPS manufacturer that the system meets specified requirements in accordance with the requirements set forth in paragraph entitled "Performance Tests". Provide test reports in in booklet form tabulating factory tests and measurements performed, upon completion and testing of the installed system. Reports are to state the Contractor's name and address, the name of the project and location, and list the

specific requirements which are being certified.

1.5.8 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Provide equipment, materials, installation, and workmanship in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.5.8.1 Reference Standard Compliance

Where equipment or materials are specified to conform to industry and technical society reference standards of the organizations such as American National Standards Institute (ANSI), American Society for Testing and Materials (ASTM), National Electrical Manufacturers Association (NEMA), Underwriters Laboratories (UL), and Association of Edison Illuminating Companies (AEIC), submit proof of such compliance. The label or listing by the specified organization will be acceptable evidence of compliance.

1.5.8.2 Independent Testing Organization Certificate

In lieu of the label or listing, submit a certificate from an independent testing organization, competent to perform testing, and approved by the Contracting Officer. The certificate is to state that the item has been tested in accordance with the specified organization's test methods and that the item complies with the specified organization's reference standard.

1.5.9 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship and:

a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.

b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.

c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

d. The service organization is to be, in the opinion of the Contracting Officer, reasonably convenient to the site.

e. Provide new parts and materials comprising the UPS system from the current manufacture, of a high grade and free of defects and imperfections, and has not been in prior service except as required during aging and factory testing.

1.5.9.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.9.2 Material and Equipment Manufacturing Date

Products manufactured more than 6 months prior to date of delivery to site are not acceptable.

1.6 INSPECTION

Inspection before shipment is required. The manufacturer must notify the Government at least 2 weeks before shipping date so that an inspection can be made.

1.7 DELIVERY AND STORAGE

Protect equipment placed in storage from humidity and temperature variations, moisture, water intrusion, dirt, airborne corrosives, or other contaminants. In harsh environments where temperatures exceed non-operational parameters established within this specification, provide an environmentally controlled equipment storage facility to ensure temperature parameters are within equipment specification. Provide documentation of same to the Government when storage is implemented.

1.8 PROJECT/SITE CONDITIONS

1.8.1 Verification of Dimensions

The Contractor is to become familiar with details of the work, verify dimensions in the field, and is to advise the Contracting Officer of any discrepancy before performing the work. Do not proceed until the discrepancy or unsatisfactory condition(s) have been corrected.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide continuous duty, three-phase, solid state, on-line double conversion reverse transfer static UPS(s). The UPS by means of solid state conversion techniques, must provide continuous regulated AC power to its output terminals, while operating from an input power source, cabinet or rack-mounted direct current (DC) storage battery or other approved means. The performance of the UPS must not be degraded when operating without a system battery, provided the input AC source is within tolerance. Provide an UPS system that conforms to UL 1778 and consists of UPS module, battery system, battery protective device, static bypass transfer switch, controls and monitoring, system protective devices, means of isolating the UPS system from the critical load, and remote monitoring interfaces. Connect input ac power the normal source ac input of the UPS module. Connect battery to the dc input of the UPS module through the battery protective device. The following configuration is used:

a. Non-Redundant.

(1) Single Module. On-line, single module UPS configuration capable

of supplying power to the total load, with bypass availability.

(2) Parallel Multi-Module. Two or more UPS modules, of the same size, on-line, operating in parallel, with enough capacity to supply the total load.

b. Scalable Units.

(1) Scalable Unit Non-Redundant. Non-redundant:scalable unit consists of a UPS system module with one or more power modules. The power modules provided are all required to handle the critical load.

(2) Scalable Unit Internal Redundant. Internal Redundant: scalable unit consists of a UPS system module with more than one power module. There is at least one additional power module that is not required to handle the load within the system. The additional power module or power modules can be sized to handle only part of the critical load or all the critical load. This is not a true parallel redundant system system since it still uses one UPS system module.

(3) Scalable Unit Redundant. Redundant:scalable unit consists of a UPS system module with one or more power modules. The number of power modules can be to just support the load or also have at least one extra power module to internal redundancy. This UPS system module is parallel with a matching scalable unit previously discussed under "Redundant System".

2.2 MODES OF OPERATION

2.2.1 Normal

The UPS module rectifier/charger must convert the incoming ac input power to dc power for the inverter and for float charging the battery. The inverter continuously coverts the dc power to ac power to supply the critical load. The inverter output must synchronize with the bypass ac power source, provided that the bypass ac power source is within the specified voltage and frequency range.

2.2.2 Battery - Emergency Operation (Loss or deviation of AC Input Power)

Whenever the ac input power source deviates from the specified tolerances including complete failure, the inverter must draw power from the battery system and supply AC power to the critical load without any interruption or switching transient. The battery system must supply power to the inverter for the specified protection time or until return of ac input source. Provide an audible alarm to indicate the UPS is on battery and provide provisions for a remote alarm signal to be sent via the communication network and a relay output, allowing startup of a secondary power source or orderly shutdown of the critical load.

2.2.3 Failure of AC Input Power to Return

If the ac input power fail to return before the battery voltage reaches the discharge limit, then the UPS system must disconnect from the critical load to safeguard the battery.

2.2.4 Recharge

Upon restoration of normal power to the UPS unit, the input converter and output inverter must simultaneously recharge the batteries and provide regulated power to the critical load.

2.2.5 Transfer to Static Bypass AC Power Source

When the UPS controller senses an overload, two or more inverter shutdown signals or degradation of the inverter output, the static bypass switch automatically transfers the critical load from the inverter output to the bypass ac power source without an interruption of power. If the static bypass ac power source is outside of specified tolerance limits, the UPS and the critical load shut down. Transfer to static bypass can also be done manually (requested bypass). Transfer to bypass does not take place under these conditions: 100% stepload; and, loss or return of input power, momentary sags, surges or spikes on the input to the UPS.

2.2.6 Transfer to Inverter

Provide a static bypass switch that is capable of automatically transferring the load back to the inverter output after the inverter overload condition has returned to normal conditions. Transfer only occurs once the two sources are synchronized. UPS system logic is to monitor the number of retransfer's within any one-hour period and is to allow 1 to 3 transfers in order to prevent cyclical transfers caused by overloads.

2.2.7 Maintenance Bypass

Provide the system with an external make-before-break maintenance bypass cabinet/panel to electrically isolate the UPS during routine maintenance and service. Manual transfer to the maintenance bypass circuit transfers the critical load from the inverter output to the bypass ac power source without disturbing the critical load bus.

2.2.8 Off-Battery (Battery Maintenance)

Provide a battery protective device which disconnects the battery from the rectifier/charger and inverter for maintenance. The device may be located external to the UPS cabinet. The UPS module continues to function and meet the performance criteria specified except for the battery back-up time function.

2.2.9 Component Performance

Do not exceed 75% of the working voltage and current ratings as established by the manufacturer on solid-state power components and electronic devices. Do not exceed 75% of the operating temperature of solid-state component sub-assemblies. Use computer grade electrolytic capacitors and operate at no more than 95% of the voltage rating at the rectifier charging voltage.

2.3 GENERAL UPS SYSTEM COMPONENTS AND FABRICATION

2.3.1 Semiconductor Fusing

Protect power semiconductors with fast-acting fuses to prevent cascaded or sequential semiconductor failures. Bolt fuses at both ends to bus bars to ensure mechanical and electrical integrity. Indicator lamp or display

panel denoting blown fuse conditions must be readily observable by the operator without removing panels or opening cabinet doors.

2.3.2 EMI/RFI Protection

Provide an UPS that complies with and is labeled compliant, with FCC Part 15, Subclass B, Class A.

2.3.3 Internal Wiring

Wiring practices, materials, and coding must be in accordance with the requirements of NFPA 70, OSHA, UL 1778, and other applicable standards. Protect wire runs in a manner which separates power and control wiring. Provide control cabling that is at least No. 16 AWG extra-flexible stranded copper. Logic-circuit wiring may be smaller. Provide ribbon cables that are at least minimum No. 22 AWG. Provide control wiring with permanently attached wire numbers.

2.3.4 Internal Assembly

The printed circuit board (PCB) subassemblies are to be mounted in pull-out swing-out trays where feasible. Provide cable connections to the trays that are sufficiently long to allow easy access to all components. Where not feasible to mount PCB subassemblies in pull-out or swing-out trays, then mount them firmly mounted inside the enclosure. Monitor every PCB subassembly. Include self-test and diagnostic circuitry in the logic circuits such that a fault can be isolated down to the PCB subassembly level. When used, control logic cards are to have test points or logic indicators on the front edge of the control logic card and be labeled.

2.3.5 Cable Lugs and Terminations

2.3.5.1 Cable Lugs

Provide appropriate compression type lugs or pre-drilled bus bars on all ac and dc power connections to the UPS system and battery as required. Aluminum or bare copper cable lugs are not suitable.

2.3.5.2 Terminations

Supply terminals for making power and control connections. Provide terminal block for field wiring terminals. Provide terminal blocks that are the heavy-duty, strap-screw type or screw terminals that are integrated into removable plugs. Locate terminal blocks for field wiring in one place in each module. Extend control wiring to the terminal block location. Any terminal point is limited to land a maximum of two wires. Where control wiring is attached to the same point as power wiring, Provide a separate terminal where control wiring is attached to the same point as power wiring. If bus duct is used, provide bus stubs where bus duct enters cabinets.

2.3.6 Cabinets

Install the UPS system in cabinets of heavy-duty structure meeting the NEMA PE 1 standards for floor mounting. Provide a structurally adequate UPS module that can be forklift handled and lifted. Provide removable lifting eyes on top of each cabinet. Provide the UPS module cabinet with hinged and key lockable doors on the front only and with assemblies and components accessible from the front. Provide dead-front construction

behind the door for those UPS module cabinets that are not lockable. Operating controls are to be located outside the locked doors. Install input, output, and battery cables through the top or bottom of the cabinet.

2.3.6.1 Cabinet Finish

Provide an equipment cabinet that is cleaned, primed and painted in the manufacturer's standard colors, in accordance with accepted industry standards. Cabinets are to be labeled in accordance with NFPA 70 and NFPA 70E.

2.3.6.2 Factory Applied Finish

Provide electrical equipment with a factory-applied painting systems which, as a minimum, meets the requirements of NEMA 250 corrosion-resistance test.

2.3.6.3 Drawout Assemblies

Provide a means of lifting, either and overhead device or a hoisting device for drawout assemblies weighing 50 lbs or more. Device can either be part of the UPS or a separate portable device that can be used to perform the lifting.

2.3.7 Manufacturer's Nameplates

Provide a nameplate for each item of equipment bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.3.8 Field Fabricated Nameplates

ASTM D709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified or as indicated on the drawings. Provide an inscription on each nameplate that identifies the name of the item, calculated short circuit rating with date, and source of power e.g. 'Panel A in Electrical Room 103'. Provide nameplates that are made of melamine plastic, 0.125 inch thick, white with black center core. Provide the nameplate with a surface that is matte finished and that has square corners.. Accurately align lettering and engrave into the core. Provide nameplates that are at least 1.0 by 2.5 inches with a minimum lettering size of 0.25 inch high normal block style.

2.3.9 Safety

Provide UPS with instruction plates including warnings and cautions, suitably located, and describing any special or important procedures to be followed in operating and servicing the equipment. Provide control panel displays, which also provide warning messages prior to performing a critical function.

2.3.9.1 Maintenance Isolation

All energized terminals, both AC and DC, and control voltage exposed points are to be insulated or enclosed to ensure the safety of maintenance personnel. Provide the system with the ability to isolate the static switch to enable repair when the UPS is bypassed.

2.3.9.2 Remote Emergency Power Off (REPO) Switch

Provide a remote emergency power off switch that is separate from the UPS. Provide a red, pushbutton with a cover with a label indicating "UPS Emergency Power Off". The switch disconnects all breakers or contactors including battery, input, output, and bypass breakers when activated.

2.4 TECHNICAL REQUIREMENTS UPS SYSTEM RATINGS

Unless stated otherwise, the parameters listed are under full output load over the range of 0.9 lagging power factor to 0.9 leading power factor, with batteries fully charged and floating on the dc bus and with nominal input voltage.

2.4.1 UPS SYSTEM LOAD PROFILE

Provide an UPS system that is compatible with the load characteristics defined in the LOAD PROFILE below and load configuration. The UPS system is to provide compensation for UPS/load interaction problems resulting from nonlinear loads or transformer and motor inrush.

LOAD PROFILE

Type of load:

Data processing equipment. Size of load: 240 kVA, 208Y/120 V voltage, approximately 0.9 power factor.

Load switching pattern: unswitched.

Steady-state characteristics: 0.9 lagging power factor.

2.4.2 System Requirements

The UPS is to support and maintain full battery charging under the following conditions: indicated environmental conditions, a.c input voltage range, air filters blocked up to 50 percent and a single failed fan. The UPS size and configuration is indicated below.

Single Module (non-redundant). Provide one UPS sized for 300 kVA.

2.4.3 Battery Capacity

Discharge time to end voltage: 7 minutes, at 77 degrees F. Provide a battery that is capable of delivering 125 percent of full rated UPS kW load at 0.9 power factor at initial start-up.

2.4.4 Static Switch

Continuous duty amperes as indicated on the Drawings.

2.4.5 Short Circuit Withstand Rating

Braced for at least 65,000 amperes symmetrical interrupting capacity.

2.4.6 AC Input

a. Voltage 480 volts line-to-line.

b. Number of phases: Three-phase + neutral + ground configuration.

c. Voltage Range: Plus 10 percent, minus 15 percent nominal (no battery discharge), without affecting battery float voltage or output voltage.

d. Frequency: 60 Hz, plus or minus 5 percent.

e. Power walk-in: 0 percent to 100 percent input current over 10 to 15 seconds with an adjustable setting that can be set from 5 seconds to 30 seconds.

f. Total harmonic current distortion (THD) reflected into the primary line: 5 percent maximum at full load.

g. Sub-cycle magnetizing inrush: 2 to 3 times full load current for modules without an isolation transformer.

h. Input surge protection: per IEEE C62.41.1 and IEEE C62.41.2, meeting IEEE C62.41 requirement of Category B3 6kV, 100k Hz ring wave and 6kV, combined wave.

i. Input power factor: Lagging from 1-100 percent load.

j. Transformer sub-cycle magnetizing inrush: 5 to 8 times full load current with optional isolation transformer and optional input filter.

2.4.7 AC Output

a. Voltage 480 volts line-to-line, 277 volts line-to-neutral.

b. Number of phases: Three-phase + neutral + ground configuration.

c. Voltage regulation:

(1) Balanced load: Plus or minus 1.0 percent.

(2) 50 percent load imbalance, phase-to-phase: Plus or minus 2 percent.

(3) 100 percent load imbalance, phase-to-phase Plus or minus 3 percent.

(4) Voltage drift: Plus or minus 1 percent over any 30 day interval (or length of test) at stated ambient conditions found in paragraph Environmental Conditions.

d. Voltage adjustment: Plus or minus 5 percent.

e. Frequency: 60 Hz.

f. Frequency regulation: Plus or minus 0.1 percent, when on internal oscillator. Internal oscillator is to be temperature compensated.

g. Frequency drift: Plus or minus 0.1 percent over any 24 hour interval (or length of test) at stated ambient conditions when on internal oscillator.

h. Harmonic content (RMS voltage): Provide a system that meets the following voltage THD levels: maximum of 4% RMS total,2 percent total with 100 percent on any single harmonic (linear load) and 5 percent

RMS total for up to 100 percent nonlinear load.

i. Load power factor operating range (without derating): 0.9 leading to 0.9 lagging.

j. Phase angle displacement/imbalance:

(1) Balanced load: 120 degrees plus or minus 0.5 degree of bypass input.

(2) 50 percent load imbalance phase-to-phase: 120 degrees plus or minus 3 degrees of input.

k. Inverter overload capability (at full voltage with plus or minus 2 percent regulation) (excluding battery):

(1) 125 percent load for 60 seconds.

(2) 150 percent load for 10 seconds.

(3) Fault clearing. Provide an UPS that is able to maintain output current during a fault condition for 20 cycles if bypass is unavailable or 1 cycle with bypass available. If the fault is not cleared and a bypass is available, the UPS is to transfer to bypass without interruption to clear the fault.

l. Load sharing of parallel modules: Plus or minus 5 percent at full rated system load.

m. Bypass Overload Capability.

(1) 0 percent load for 15 seconds.

2.4.8 Transient Response

2.4.8.1 Voltage Transients

a. 100 percent load step: Plus or minus 5 percent.

b. Loss or return of ac input: Plus or minus 1 percent.

c. Automatic transfer of load from UPS to bypass: Plus or minus 1 percent.

d. Manual retransfer of load from bypass to UPS: Plus or minus 5 percent.

e. Response time: Recovery to 1 percent of nominal within 20 milliseconds where there was a maximum deviation from nominal system output of volts plus or minus 5 percent.

2.4.8.2 Frequency

a. Transients: Plus or minus 0.6 Hz maximum.

b. Slew Rate: under all conditions of operation, 0.25 to 0.8 Hz per second.

2.4.9 Efficiency

a. Minimum Single-Module Efficiency: 94 percent at full load kW and 92 percent at 50 percent load.

b. Minimum System Efficiency: 93 percent at full system load kW.

c. Provide Energy Star labeled battery charging systems and AC-DC/AC-AC power supplies. Provide proof of Energy Star label for battery charging systems and AC-DC/AC-AC power supply products.

2.4.10 Energy Saving Mode

Provide the UPS with an energy saving mode that operates by having the inverter charged and batteries on at all times, while the main power to the output is through the static bypass switch. When a power problem is sensed, the system is to operate in double-conversion mode and revert to energy saving mode after a pre-set period of time. Maximum transition time is 2 miliseconds.

2.5 UPS MODULE

2.5.1 General Description

UPS module consists of an input converter, output converter, with associated transformers, synchronizing equipment, protective devices, surge suppression, and accessories as required for operation.

2.5.1.1 Interchangeability

The subassemblies in one UPS module are to be interchangeable with the corresponding modules within the same UPS, and from one UPS system to another of identical systems.

2.5.1.2 Rectifier/Charger Unit

Scalable, expandable modular input converts for the system are to be housed within removable power modules. Input converters control the power from the mains input of the system, provide the necessary UPS power for precise regulation of the DC bus voltage, battery charging, and main inverter regulated output power.

2.5.1.2.1 Input Protective Device

Provide the rectifier/charger unit with an input protective device. Size the protective device to accept simultaneously the full-rated load and the battery recharge current. Provide a protective device that is capable of shunt tripping and has an amperes symmetrical interrupting rating of 65,000. Provide the protective device with an under-voltage release to open automatically when the control voltage is lost.

2.5.1.2.2 Power Walk-In

Input convert is to have an adjustable soft-start (either by manufacturer or owner), capable of limiting the input current form 0 percent to 100 percent of the input over a default 10 second period when returning to ac input bus from battery operation. The change in current over time is to be done in a linear manner.

2.5.1.2.3 Sizing

Size the rectifier/charger unit for the following two simultaneous operating conditions:

a. Supplying the full rated load current to the inverter.

b. Recharging a fully-discharged battery to 90 percent of rated ampere-hour capacity within ten times the discharge time after normal ac power is restored.

2.5.1.2.4 AC Input Current Limiting

Provide a circuit to the input converter that controls and limits the current draw form utility to 130 percent of the rated UPS output. During conditions where input current limit is active, the UPS system is to be able to support 100 percent of the load, charge the batteries at 10 percent of the UPS output rating, and provide voltage regulation with mains deviation of +15/-5 percent.

2.5.1.2.5 Battery Charging Current

a. Primary current limiting: Battery-charging current is to be voltage regulated and current limited. Provide a separately adjustable battery-charging current limit that is adjustable from 1 percent to 20 percent of the maximum discharge current. Set the limit at the factory to 10 percent. After the battery is recharged, the rectifier/charger unit maintains the battery at full float charge until the next operation under input power failure. Battery charger is capable of providing equalizing charge to the battery.

2.5.1.2.6 DC Ripple (Output Filter)

Rectifier/charger unit is to minimize ripple current and voltage supplied to the battery; the ripple voltage into the battery is not to exceed 1 percent RMS of the float voltage. Ensure the AC ripple voltage of the rectifier DC output does not exceed 0.5 percent of the float voltage.

2.5.1.2.7 Battery Isolation Protective Device

Provide the module or external battery system with a dc protective device to isolate the module from the battery system. The protective device size and interrupting rating are as required by system capacity and is to incorporate the trip required by circuit design. Provide the protective device with a provision for locking in the "off" position.

2.5.1.2.8 Battery Equalize Charge

Equalize charge timer is to provide an equalizing charge automatically to the battery after a 30 second or longer utility outage. The equalize charging time is to be adjustable form 0-72 hours. Provide a manual override for the automatic equalize circuit.

2.5.2 Inverter Unit

Provide a solid-state inverter with sinusoidal output deriving its power from the dc bus (rectifier or battery source) and providing ac power within specified limits to the critical load. Inverter is to utilize microprocessor controlled solid state Pulse Width Modulation (PWM)

controlled insulated gate bipolar transistor (IGBT) power transistor technology to shape the ac output.
Provide an output converter that constantly develops the UPS output voltage waveform by converting the dc voltage to ac voltage through a set of semiconductor power converters. In both normal operation and battery operation, the output inverters are creating and output voltage independent of the mains input voltage. Input anomalies such as brown-outs, spikes, surges, sags and outages do not affect the amplitude or sinusoidal nature of the output voltage sine wave of the inverters.

2.5.2.1 Output Overload

Provide an inverter that is able to sustain an overload as specified across its output terminals. The inverter is to remain on and continue to operate within rated parameters, with inverse-time overload shutdown protection. If the overload condition persists beyond the rated parameters of the inverter, the load is to be transferred to the bypass source where the inverter disconnects automatically from the critical load bus. If the bypass source is not available and the overload/fault condition continues, the inverter is to current limit for the time as determined by the manufacturer and then shut down to protect the internal components.
Provide the output inverter with overload capabilities that allows steady state overload conditions of up to 150 percent of system capacity to be sustained by for 30 seconds in normal and battery operation. If the overload condition persists beyond the rated parameters of the inverter, the load is to be transferred to the bypass source where the inverter disconnects automatically from the critical load bus.

2.5.2.2 Output Protective Device

Provide an output protective device that is capable of opening on an applied control signal and has the proper frame size and trip rating to supply overload current as specified. Provide the external output protective device with provision for locking in the "off" position. The inverter output protective device works in conjunction with the bypass protective device for both manual and automatic load transfers to and from bypass power.

2.5.3 External Protection

Provide the UPS module with built-in self-protection against undervoltage, overvoltage, overcurrent and surges introduced on the ac input source and/or the bypass source. Provide the UPS with built-in self-protection against overvoltage and voltage surges introduced at the output terminals by paralleled sources, load switching, or circuit breaker operation in the critical load distribution system.

2.5.4 Internal Protection

Provide the UPS module with the ability to be self-protected against overcurrent, sudden changes in output load and short circuits at the output terminals. Provide the UPS module with output reverse power detection which causes the module to be disconnected from the critical load bus when output reverse power is present. Provide the UPS module with built-in protection against permanent damage to itself and the connected load for predictable types of failure within itself and the connected load. At the end of battery discharge limit, the module shuts down without damage to internal components.

2.5.5 Battery Protection

Provide the inverter with monitoring and controls circuits to protect the battery system from damage due to excessive discharge. Inverter shutdown is be initiated when the battery has reached the end of discharge voltage. Manufacturer is to calculate the end-of-discharge voltage and automatically adjusted for partial load conditions to allow extended operation without damaging the battery. Automatic shutdown based on discharge time is not acceptable.

2.5.6 Modular Inverter Isolation

Provide each inverter in the UPS system with fault sensing and static isolation as well as an output protective device, to remove a faulted module from the system without affecting the critical load bus beyond the stated limits.

2.5.7 Parallel Operation

For parallel operation, ensure the protection system has control logic capable of isolating only the faulted module, and does not shut down the entire UPS system upon a fault in one module. Open protective devices are to be indicated by an alarm and indicator light.

2.6 STATIC BYPASS TRANSFER CIRCUIT

Provide the control logic with an automatic transfer circuit that senses the status of the inverter logic signals and alarm conditions and provides an uninterrupted transfer of the load to the static bypass ac power source, without exceeding the transient limits specified herein, during times when maintenance is required, when a malfunction occurs in the UPS or when an external overload condition occurs. The static bypass transfer circuit is to be used to connect the input bypass ac power source to the critical load when required. Provide the static bypass transfer circuit with the following features:

2.6.1 Construction

Provide a static with a continuous duty rating of at least 100 percent of the UPS output rating. Provide a static bypass transfer circuit as an integral part of the UPS that consists of a static switch, made up of two reverse-paralleled SCRs (silicon-controlled rectifiers) per phase conductor, and a bypass protective device, made up of a breaker and fuses. The bypass protective device is to be in series with the static switch. The inverter output protective device disconnects and isolates the inverter from the bypass transfer circuit.

2.6.2 Automatic Uninterrupted Transfer

The static bypass transfer switch automatically causes the bypass ac power source to assume the critical load without interruption when the bypass control logic senses one of the following conditions and the UPS inverter output is synchronized to the bypass ac power source:

a. Inverter overload exceeds unit's rating.

b. Battery protection period is expired and bypass is available.

c. System failure.

d. Inverter output undervoltage or overvoltage.

2.6.3 Interrupted Transfer

If an overload occurs and the UPS inverter output is not synchronized to the bypass ac power source, the UPS inverter output current-limits for 200 milliseconds minimum. The inverter then turns off and an interrupted transfer to the bypass ac power source is made.

If the bypass ac power source is beyond the conditions stated below, an interrupted transfer is made upon detection of a fault condition:

a. Bypass voltage greater than plus or minus 10 percent from the UPS rated output voltage.

b. Bypass frequency greater than plus or minus 0.5 Hz from the UPS rated output frequency.

c. Phase differential of ac bypass voltage to UPS output voltage greater than plus or minus 3 degrees.

2.6.4 Manual Load Transfer

It must be possible to make a manually-initiated static transfer from the system status and control panel by turning the UPS inverter off or by initiating it through the UPS display interface. The transfer is to make-before-break utilizing the UPS output and system bypass circuit breakers. Do not use the static switch for manual transfer unless there isn't a parallel by-pass circuit breaker or contactor.

2.6.5 Automatic Uninterrupted Forward Transfer

Automatic transfer of the load back to the inverter is to take place when the transfer was caused by an overload and only after the load has returned to a level within the inverter souse. Provide the ability to allow 1 to 3 transfers within any one-hour period to prevent cyclical transfers caused by overloads.

2.6.6 Forced Transfer

Provide control logic circuitry with the means of making a forced or reverse transfer of the static bypass transfer circuit on an interrupted basis. Minimum interruption is 200 milliseconds when the UPS inverter is not synchronized to the bypass ac power source.

2.6.7 Overload Ratings

The static bypass transfer switch is to withstand the following overload conditions:

a. 1000 percent of UPS output rating for one cycle.

b. 125 percent of UPS output rating for 1 minute.

c. 110 percent of UPS output continuously.

2.6.8 System Protection

Incorporate into the static bypass circuit back-feed protection per UL 1778. To achieve back-feed protection, provide a back-feed protection breaker/mechanical contactor upstream and in series with the bypass switch that is controlled by the UPS/static switch, to open immediately upon sensing a condition where back-feeding of the static switch by any source connected to the critical output bus of the system is occurring.

2.6.9 Static Bypass Switch Disconnect

Incorporate a static switch disconnect that can be used to isolate the static bypass transfer switch assembly so it can be removed for servicing. Equip the device with auxiliary contacts and provisions for padlocking in either the "on" or "off" position.

2.7 MAINTENANCE BYPASS CIRCUIT

2.7.1 General

Provide a maintenance bypass switch or arrangement of switch devices in a matching NEMA 250, type 1 cabinet adjacent to the UPS cabinet. Provide a maintenance bypass enclosure configured as indicated.

2.7.2 Interlock

Electrically and mechanically interlock the switch(es) to prevent interrupting power to the load when switching to bypass mode. Key interlock requires unlocking bypass/isolating switch before switching from normal position with key that is released only when the UPS is bypassed by the static bypass transfer switch. Lock is designed specifically for mechanical and electrical component interlocking. Provide auxiliary contacts for the purpose of relaying status information of each circuit breaker/switch actuator to the UPS and static bypass.

2.7.3 Load Transfer

The maintenance bypass switch provides the capability of transferring the critical load from the UPS static bypass transfer switch to maintenance bypass and then back to the UPS static bypass transfer switch with no interruption to the critical load.

2.8 DISPLAY,CONTROLS AND ALARMS

Provide the UPS module with a microprocessor-controlled display unit located on the hinged door on the front of the system. Provide a LCD color alphanumeric display that operated by touchscreen to access the various information. Controls, meters, alarms and indicators for operation of the UPS module are to be on this panel. Provide a menu driven graphical user interface for browsing the screens. All three-phases of three-phase parameters are to be displayed simultaneously.

2.8.1 Module Meters

2.8.1.1 Monitored Functions

Display the actual value along with the ability to show the peak, average and low values over various periods of time. Monitor and display the following functions:

a. Input voltage, phase-to-phase (all three phases).

b. Input current, all three phases.

c. Input frequency.

d. Bypass voltage, phase-to-phase and phase-to-neutral (all three phases).

e. Bypass frequency.

f. Battery voltage.

g. Battery current (charge/discharge).

h. Output voltage, phase-to-phase and phase-to-neutral (all three phases).

i. Output current, all three phases.

j. Output frequency.

k. Input power factor.

l. Maintenance bypass voltage, phase-to-phase and phase-to-ground (all three phases)

m. Output kilowatts or kilovoltamps.

n. Bypass voltage, phase-to-phase and phase-to-ground (all three phases).

2.8.1.2 Meter Construction

Display alphanumeric parameters based on true RMS metering with 2 percent accuracy at full scale(minimum 4 significant digits) at the display panel.

2.8.2 Module Controls

Provide a module or equivalent features via touchscreen with the following controls:

a. Silence audible alarm..

b. Display or set the date and time.

c. Adjust setpoints on various alarms.

d. Alarm test/reset pushbutton.

e. Battery protective device trip pushbutton, with guard.

f. Emergency off pushbutton, with guard. Provide a hard-wired pushbutton even if touchscreen system is provided.

g. DC voltage adjustment potentiometer, with locking guard or AC output voltage adjustment potentiometer. Provide potentiometer that is accessible only by authorized personnel.

h. Control power off switch.

i. Transfer load to and from static bypass circuit.

j. Display control pushbuttons: up, down, select.

k. Module input protective device trip pushbutton.

l. Module output protective device trip pushbutton.

2.8.3 Module or System Alarm Indicators

Provide the module with indicators for the following alarm items. Any one of these conditions is to turn on an audible alarm and the appropriate summary indicator. The system is to register each new alarm without affecting any previous alarm. Provide a processor that time-date stamps each event.

a. Input ac power source failure.

b. Input protective device open.

c. Input power out of tolerance.

d. Overload.

e. Overload shutdown.

f. DC overvoltage/shutdown.

g. DC ground fault.

h. Low battery.

i. Battery discharged.

j. Battery protective device open.

k. Blower fan failure or overtemperature.

l. Overtemperature shutdown.

m. Hardware shutdown.

n. Equipment overtemperature.

o. Fuse blown with annunciation..

p. Control power failure.

q. Charger off/problem.

r. Inverter fault/off.

s. Emergency power off.

t. External shutdown (Remote Emergency Power Off) activated.

u. Output protective device open.

v. Operating on internal oscillator

w. UPS on battery

x. Critical load on static bypass.

y. Static bypass transfer switch disabled/failure.

z. Inverter output overvoltage.

aa. Inverter output undervoltage.

ab. Inverter output overfrequency.

ac. Inverter output underfrequency.

ad. Bypass source overvoltage.

ae. Bypass source undervoltage.

af. Bypass source overfrequency.

ag. Bypass source underfrequency.

ah. Bypass source to inverter out of synchronization.

ai. Load no longer above alarm threshold.

aj. Intelligent module inserted or removed.

ak. Redundancy restored.

al. Need battery replacement.

am. Bad battery module.

an. Bad power module.

ao. Redundant intelligent module installed and failed.

ap. Load above alarm threshold.

2.8.4 Module Emergency OFF Button

Provide an emergency off pushbutton with a protective cover. Pressing the emergency off button causes the module input, output, and battery circuit breakers or contactors to open, completely isolating the UPS system from sources of power and transfer of the load to bypass.

System Mimic Panel

Provide a mimic panel in the format of a single-line diagram that graphically depicts whether the load is supplied from the inverter, bypass, or battery. Provide on status on the following:

a. Module on-line, one per UPS module.

b. UPS output protective device status, one for closed (red), one for open (green), and one for withdrawn (amber).

c. Static bypass protective device status, one for closed (red), one for open (green), and one for withdrawn (amber).

d. Static switch status, one for connected (red), and one for disconnected (green).

e. Status on the AC input circuit breaker, battery circuit breaker, and inverter circuit breaker. Connected (red) and disconnected (green).

2.9 SELF-DIAGNOSTIC CIRCUITS

Provide control logic with status indicators for trouble-shooting the control circuits. These indicators are mounted on the circuit card edge or face such that they will be visible without repositioning the card, and are labeled with the function name.

2.10 COMMUNICATIONS AND DATA ACQUISITION

Provide an RS 232, Internet Protocol (IP), RS 485 communications and data acquisition port as required. This port allows the system parameters, status, alarm indication and control panel functions specified to be remotely monitored and controlled.

Additionally, provide additional ports for use with the following:

a. Provide the following Form C contacts for remote indication:

(1) UPS on battery.

(2) UPS on-line.

(3) UPS load on bypass.

(4) UPS in alarm condition.

(5) UPS off (maintenance bypass closed).

b. Provide four spare Form C contacts rated at 120V, 0.5A.

c. Provide a SNMP (Simple Network Management Protocol) adapter to communicate UPS monitoring via a network or direct connection to BACnet.

d. Provide a standard Web Browser adapter to remotely view and monitor UPS functions over the Internet.

Provide communication ports and contacts that are capable of simultaneous communication.

2.10.1 Emergency Control Contacts

Provide normally open contacts to signal when power is supplied to the UPS from engine generators or alternate source. The signal connects to an automatic transfer switch.

2.11 TEMPERATURE CONTROL

2.11.1 General

Ensure cabinet and enclosure ventilation is adequate to operate the components within their ratings. Forced-air cooled rectifier, inverter, and control unit will be acceptable. If UPS input power is lost, then the cooling fans are to continue to operate. Provide redundancy that ensures failure of one fan or associated circuit breaker does not cause an overheat condition. Cooling air is to enter the lower front of the cabinets and exhaust at the top. Provide visual and audible alarms on the control panel that indicate blower power failure. Provide replaceable filters on air inlets, which may be located on the inside of the cabinet doors and are easily accessible for replacement.

2.11.2 Blower Power Source

Provide a blower power source that is internally derived from the output side of UPS module, with automatic transfer arrangement.

2.11.3 Temperature Sensors

Provide temperature sensors to monitor the air temperature. Provide a sensor or sensors to monitor the temperature of rectifier and inverter heat sinks. Provide critical equipment over-temperature indication that starts a timer that shuts down the UPS system if the temperature does not return below the setpoint level recommended by the UPS manufacturer.

2.12 BATTERY SYSTEM

2.12.1 General

Battery system contains the battery cells, cabinets, battery disconnect, and battery monitor. Provide a storage battery with sufficient ampere-hour rating to maintain UPS output at full capacity for the specified duration for each UPS module. Provide a battery that is heavy-duty, industrial design suitable for UPS service. Provide the cells with flame arrestor vents, intercell connectors and cables, cell-lifting straps, cell-numbering sets, and terminal grease. Size intercell connectors to maintain terminal voltage within voltage window limits when supplying full load under power failure conditions. Provide cell and connector hardware that is the type of stainless steel capable of resisting corrosion from the electrolyte used. The battery plant is to consist of the following:

a. Provide a lead calcium battery that is of the float-type, absorbed glass mat (AGM) valve-regulated, lead-acid, sealed, non-gassing, recombinant type (VRLA) that is rated for 10 years. Battery is factory assembled in a separate matching cabinet, complete with battery disconnect switch.

2.12.2 Battery Cabinet

Furnish the battery pack assembly in a battery cabinet matching the UPS cabinet. Design the battery cabinet to allow for checking the torque on the connections in the battery system and to provide adequate access for annual housekeeping chores. Provide an external wiring interface through the bottom or top of the assembly. Provide a high temperature alarm that annunciates detection of high temperature within the battery cabinet.

2.12.3 Cell-Terminal Covers

Provide acid-resistant transparent cell-terminal covers not exceeding 6 feet in length and with vent holes drilled on top where needed.

2.12.4 Battery Disconnect

Provide each battery string with a circuit breaker provided in a NEMA 250, type 1 enclosure, finished with acid-resistant paint and located in line with the assembly. Provide each switch with line side and load side bus bars for connection to battery cells. Rate each switch 500 V dc, ampere rating per manufacturer, 3-pole with interrupting rating as required by system capacity, and provide an external operator that is lockable in the "off" position. Provide a cabinet mounted disconnecting means for cabinet mounted batteries. Disconnect is allowed to be in the battery cabinet.

2.12.5 Modular Battery Enclosures

Provide battery enclosures that house draw-out battery cartridges. Battery cartridges are to interlock in place within the battery enclosure to ensure proper contact.

2.12.6 Battery Monitor

Provide a battery monitor for each battery string in the system. Monitor the following minimum parameters by the device:

a. Total system voltage.

b. Battery Detect.

c. Shunt Trip.

The monitor is to record the total accumulated discharge minutes and accumulated battery system discharge kW hours.

2.13 FACTORY TESTING

Factory test the UPS system to meet the requirements specified using a test battery (not the battery to be supplied with the system) or D.C. simulator. Factory load test the UPS module as an independent assembly with 3-phase ac input power and with battery power for a minimum of 8 hours, with meter readings taken every 30 minutes. Balance the load at rated kVA and rated power factor.

a. Submit a detailed description of proposed factory test and field test procedures, including proposed dates and steps outlining each test, how it is to be performed, what it accomplishes, and its duration, not later than 1 months prior to the date of each test.

b. Run the factory test for each UPS module under full load that is witnessed by the Government. Should a malfunction occur, correct the problem and repeat the test. As a minimum, the factory tests are to include the parameters described in paragraphs ac Input, ac Output, Transient Response and Efficiency. Tests are to encompass all aspects of operation, such as module failure, static bypass operation, battery failure, input power failure and overload ratings.

c. Notify the Government in writing at least 2 weeks before testing. Do not use factory-test time for system debugging and/or checkout. Perform such work prior to notifying the Government that the system is ready for testing. Perform factory tests during normal business hours. Interconnect and test the system for an additional 8 hours to ensure proper wiring and performance.

d. Submit factory and field test reports in booklet form tabulating factory and field tests and measurements performed, upon completion and testing of the installed system. An official authorized to certify on behalf of the manufacturer of the UPS system that the system meets specified requirements will sign the factory and field test reports. Date each report after the award of this contract, which states the Contractor's name and address, name the project and location, and list the specific requirements, which are being certified.

2.13.1 Transient Tests

Conduct transient tests using high-speed oscillograph type recorders to demonstrate the operation of the components to the satisfaction of the Government. These tests consist of 50 percent to 100 percent load changes, manual transfer, manual retransfer, low dc bus initiated transfer and low ac output bus transfer. Use a recording instrument equipped with an event marker.

2.13.2 Efficiency Tests

Perform testing for efficiency at zero output up to 100 percent of stated kW output in 25 percent steps with battery fully charged and floating on the dc bus, with nominal input voltage, and with module connected to represent actual operating conditions.

PART 3 EXECUTION

3.1 INSTALLATION

Conform electrical installations to IEEE C2, NFPA 70, and to requirements specified herein. Provide new equipment and materials unless indicated or specified otherwise. Set the UPS system in place that is wired and connected in accordance with the approved shop drawings and manufacturer's instructions.

3.1.1 Control Cable

Install UPS control wiring in individual separate rigid steel conduits, unless connections are made between side by side matching cabinets of UPS. Tag control wires with numeric identification tags corresponding to the terminal strip location to where the wires are connected. In addition to manufacturer's requirements, provide four additional spare conductors between UPS module and remote alarm panel in same conduit. When routing control cables inside UPS module, maintain a minimum 6 inches separation from power cables.

3.1.2 Grounding

3.1.2.1 Grounding Conductor Title

Provide a separate grounding conductor that is separate from the

electrical system neutral conductor in feeder and branch circuits. Ground battery racks and battery breaker cabinets with a separate equipment grounding conductor to the UPS cabinet.

3.1.2.2 Separately Derived

If not part of a listed power supply for a data-processing room, comply with NFPA 70 requirements for connecting to grounding electrodes and for bonding to metallic pipe.

3.1.3 UPS Output Conductors

Isolate the UPS output conductors from the UPS cabinet to the critical load panels and from other conductors by installing in separate conduit.

3.1.4 DC Power Conductors

When installed in conduits, place dc power conductors from the UPS cabinet to the battery circuit breaker such that each conduit contains an equal number of positive and negative conductors, for example, two positive and two negative conductors in each conduit. Size conductor for a maximum of 2 percent voltage drop at full discharge.

3.1.5 Conduit Entries

Ensure conduit entries use the available conduit areas shown on manufacturer's installation drawings. Do not make conduit entries through the front, side or rear panels of the UPS or Maintenance Bypass Cabinet or battery cabinet.

3.1.6 Battery Cabinet Assembly

Conform battery rack installation to the manufacturer's instructions.

3.1.7 Battery Installation

Conform battery cabinet installation to the manufacturer's instructions.

3.2 FIELD QUALITY CONTROL

Notify the Contracting Officer in writing at least 30 calendar days prior to completion of the UPS system installation. At this time the Contractor, will schedule the UPS manufacturer's technical representative to inspect the completed installation. Provide instruction for activity personnel by the UPS technical representative as specified in paragraph titled "DEMONSTRATION".

3.2.1 Installation Preparation

Completely install the following items by the Contractor and be operational prior to the arrival of the UPS representative for inspection, unit start-up and testing:

a. Ventilation equipment in the UPS and battery rooms.

b. Battery cabinets and cells.

c. Battery connections including cell-to-cell, tier-to-tier, and rack-to-rack connections, with correct polarity;

d. DC power and control connections between UPS and battery circuit breaker, with correct polarity;

e. DC power connection between battery circuit breaker and battery, with correct polarity;

f. Clockwise phase rotation of ac power connections;

g. AC power to rectifier input bus;

h. AC power to UPS bypass input bus;

i. AC power to UPS maintenance bypass circuit breaker;

j. AC power from UPS output to UPS maintenance bypass output circuit breaker;

k. Remote monitors and control wiring;

l. UPS system and battery system properly grounded;

m. Emergency shower and eye wash;

n. Control connections between UPS and emergency engine generator signal contacts;

o. Control connections between UPS module and UPS maintenance bypass cabinet;

p. Clean and vacuum UPS and battery room floors, battery cells, and UPS equipment, both inside and outside

q. Ensure that shipping members have been removed.

r. Provide IEEE 450 battery installation certification.

3.2.2 Initial Inspection and Tests

The UPS technical representative and the Contracting Officer, in the presence of the Contractor, will inspect the completed installation. The Contractor is responsible to correct construction or installation deficiencies as directed. Perform acceptance checks in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections, performed in accordance with NETA ATS.

a. UPS Unit visual and mechanical inspection

(1) Compare equipment nameplate data with drawings, specifications and approved shop drawings.

(2) Inspect physical and mechanical condition. Inspect doors, panels, and sections for paint, dents, scratches, fit, and missing hardware. Inspect the displays for scratches, dark pixels or uneven brightness.

(3) Inspect anchorage, alignment, grounding, and required clearances.

(4) Verify that fuse sizes and types correspond to drawings.

(5) Verify the unit is clean inside and out.

(6) Test all electrical and mechanical interlock systems for correct operation and sequencing.

(7) Inspect bolted electrical connections for high resistance using one of the following methods:

(a) Use a low-resistance ohmmeter.

(b) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method.

(c) Perform thermographic survey.

(8) Verify operation of forced ventilation.

(9) Verify that vents are clear and new clean filters are installed.

(10) Inspect batteries and chargers according to requirements in NETA ATS

b. UPS Batteries visual and mechanical inspection

(1) Compare equipment nameplate data with drawings, specifications and approved shop drawings.

(2) Inspect physical and mechanical condition. Inspect doors, panels, and sections for paint, dents, scratches, fit, and missing hardware. Inspect the displays for scratches, dark pixels or uneven brightness.

(3) Inspect anchorage, alignment, grounding, and required clearances.

(4) Verify that fuse sizes and types correspond to drawings.

(5) Verify the unit is clean inside and out.

(6) Verify the application of an oxide inhibitor on battery terminal connections.

(7) Inspect bolted electrical connections for high resistance using one of the following methods:

(a) Use a low-resistance ohmmeter.

(b) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method.

(c) Perform thermographic survey.

3.2.3 Performance Tests

Provide equipment, test instruments, power, load bank, materials and labor required for tests. Contracting Officer will witness all tests and the tests are subject to his approval. Perform tests in accordance with the manufacturer's recommendations and include the following electrical tests.

3.2.3.1 UPS Unit Performance Tests

Upon completion of battery activation procedures, Contractor is to connect load bank to UPS output. Size load bank to the full kW rating of the system.

Performance test is to be run under the supervision of the UPS technical representative. Operate UPS unit under full kW load for a minimum of one hour. Operation of the feeder and bypass power feeder breakers during testing of the UPS is the responsibility of the Contractor.

a. Electrical Tests

(1) Test static transfer from inverter to bypass and back. Use normal load, if possible.

(2) Test dc undervoltage trip level on inverter input breaker/relay. Set according to manufacturer's published data.

(3) Test alarm circuits.

(4) Verify synchronizing indicators for static switch and bypass switches.

(5) Perform electrical tests for UPS system breakers.

(6) Perform electrical tests for UPS system batteries.

(a) Measure negative post temperature.

(b) Measure charger float and equalizing voltages.

(c) Verify all charge functions and alarms.

b. Test Values

Verify bolt-torque levels.

c. Maintenance Bypass Panel/Cabinet

Verify interlocks (Kirk-Key or other means) operate properly. Verify that the breaker arrangement operates in the manner required for the number of possible combinations.

d. Load Test

Load test the installed system for a continuous 24 hour period by means of resistive load banks. Continuously test the system at 1/2 load for 8 hours, 3/4 load for 8 hours and full load for 8 hours. Provide variable load banks sized to the full kW load of system to facilitate startup under load conditions, and to conduct load tests described above. Record instrument readings every half hour for the following:

(1) Input voltage (all three phases).

(2) Input current (all three phases).

(3) Input frequency.

(4) Battery voltage.

(5) Output voltage (all three phases).

(6) Output current (all three phases).

(7) Output kilowatts.

(8) Output frequency.

e. Full Load Burn In Test

Provide an additional full load burn-in period of 24 continuous hours for the installed system. If a failure occurs during the burn-in period, repeat the tests. Record instrument readings every half hour as above. Perform the following tests during the burn-in period:

(1) With the UPS carrying maximum continuous design load and supplied from the normal source, switch 100 percent load on and off a minimum of three times within the burn-in period .

(2) (2) With the UPS carrying maximum continuous design load and supplied from the emergency source, repeat the switching operations described in step (1).

(3) With the UPS carrying maximum continuous design load and operating on battery power, repeat the switching operations described in step (1) above.

(4) Continue operation on battery power for 1 minute, then restore normal power.

Furnish a high-speed dual trace oscillograph to monitor ten or more cycles of the above tests at the ON and OFF transitions and two typical steady-state periods, one shortly after the load is energized (at 30 to 60 seconds) and one after operation has stabilized (at 8 to 10 minutes). Deliver four copies of the traces to the Contracting Officer.

f. Battery Discharge Test

Allow UPS 24 hrs to recharge batteries and an additional 24 hrs cool down prior to commencing this test, if other tests such as the full load test were performed. With the UPS carrying maximum continuous design load and the battery fully charged, the system is to undergo a complete battery discharge test to full depletion and a recharge to nominal conditions. Record instrument readings every minute during discharge for the following:

(1) Battery voltage.

(2) Battery current.

(3) Output voltage (all three phases).

(4) Output current (all three phases).

(5) Output kilowatts.

(6) Output frequency.

3.2.3.2 Generator Operation

Test UPS to observe operation with generator service. UPS technical representative is to verify UPS battery current limiting feature functions properly.

3.2.3.3 Battery Performance Test (Constant kW)

Furnish all labor, material and test equipment necessary to conduct performance test under the direction of UPS technical representative. Accomplish the following:

a. Install a calibrated voltmeter across the battery terminals to measure voltage, and provide current transformers to measure the current from each string.

b. Record temperature of pilot cells in battery immediately prior to start of discharge performance test.

c. Read and record total battery voltage and battery current at start of discharge and every minute during discharge test.

d. Record minutes and seconds when battery voltage drops below minimum discharge voltage. On initial discharge test, a battery may be expected to deliver 95 percent of its rated capacity. This will increase to 100 percent after several complete discharge cycles or after 12 months of float charge service.

e. Should battery fail to meet the requirements of the first discharge performance test, place battery on equalizing charge as defined by the specific battery manufacturer's recommendations. Measure and record time and battery voltage. Run a second discharge performance test.

3.3 DEMONSTRATION

3.3.1 Instructing Government Personnel

Furnish the services of competent instructors to give full instruction to designated Government personnel in the adjustment, operation, and maintenance of the specified systems and equipment, including pertinent safety requirements as required. Instructors are to be thoroughly familiar with all parts of the installation and be trained in operating theory as well as practical operation and maintenance work. Provide instruction during the first regular work week after the equipment or system has been accepted and turned over to the Government for regular operation. Provide 8 hours of instruction for personnel. Provide a factory training video or on-line training as part of the training materials.

3.4 FINAL ADJUSTMENTS

a. Remove load bank and reconnect system for normal operation.

b. Equalize battery per manufacturer instructions.

c. Bring electrolyte level of all cells up to the bottom of the high level line by adding original filling gravity electrolyte.

d. Resume charging battery at normal float voltage as defined by battery manufacturer recommendations.

e. Prior to charging, check battery connections are properly torque to manufacturer's specifications. Take and record, for cell-to-cell and terminal connections, detailed micro-ohm resistance readings. Remake connections having a resistance of more than 10 percent above the average.

f. Deliver all manufacturer's data and operation manuals, which are an integral part of, and shipped with UPS, to Contracting Officer.

3.5 NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.6 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting is to comply with Section 09 90 00 PAINTS AND COATINGS.

-- End of Section --

SECTION 26 36 23

AUTOMATIC TRANSFER SWITCHES AND BY-PASS/ISOLATION SWITCH
05/20, CHG 1: 08/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 602	(2007) Recommended Practice for Electric Systems in Health Care Facilities - White Book

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 4	(2015) Application Guideline for Terminal Blocks
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2026; TIA 26-1; ERTA 26-1; TIA 26-2; TIA 26-3; TIA 26-4; TIA 26-5; TIA 26-6; TIA 26-7; ERTA 26-2; ERTA 26-3) National Electrical Code
NFPA 99	(2024) Health Care Facilities Code
NFPA 110	(2025) Standard for Emergency and Standby

Power Systems

UL SOLUTIONS (UL)

UL 489	(2025) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 508	(2018; Reprint Jul 2021) UL Standard for Safety Industrial Control Equipment
UL 1008	(2022) UL Standard for Safety Transfer Switch Equipment
UL 1066	(2022) UL Standard for Safety Low-Voltage AC and DC Power Circuit Breakers Used in Enclosures
UL 1449	(2021; Reprint Oct 2025) UL Standard for Safety Surge Protective Devices

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Automatic Transfer Switch Drawings; G

SD-03 Product Data

Automatic Transfer Switches; G

By-Pass/Isolation Switch (BP/IS); G

Manual Transfer Switch (MTS)/Docking Station; G

SD-06 Test Reports

Acceptance Checks and Tests; G

Functional Acceptance Tests; G

Factory Testing; G

Factory Test Reports; G

SD-07 Certificates

Proof of Listing; G

SD-10 Operation and Maintenance Data

Operation and Maintenance Manual, Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA, Data Package 5; G

1.3 OPERATION AND MAINTENANCE MANUAL

Assemble and bind manuals in durable, hard-covered, water resistant binders. Assemble and index the manuals per the following table of contents:

a. Manufacturer's O&M per "SD-10 Operation and Maintenance Data".

b. Catalog data required by "SD-03 Product Data"

c. Drawings required by "SD-02 Shop Drawings".

1.3.1 Additions to Operation and Maintenance Manuals

In addition to requirements of SD-10 Data Package 5, include the followings on the actual equipment provided:

a. An outline drawing, front, top, and side views.

b. Prices for spare parts and supply list.

c. Date of Purchase.

d. Corrective maintenance procedures.

e. Operating manual outlining step-by-step procedures for system startup, operation, and shutdown.

f. Include simplified wiring and control diagrams in the manual for system as installed.

g. Provide typical contact voltage drop readings under specified conditions for use during periodic maintenance. Provide instructions for determination of contact integrity.

1.3.2 Spare Parts

Furnish the following the following minimum spare parts and any other spare parts required in one-year operation, of the same material and workmanship, meeting the same requirements, and interchangeable with the corresponding original parts.

a. Fuses: Two of each type and rating.

1.4 QUALITY ASSURANCE

1.4.1 Proof of Listing

Submit proof of listing by UL 1008.

1.4.2 Automatic Transfer Switch Drawings

Include the following as a minimum:

a. An outline drawing, including front, top, and side views.

b. Provide a nameplate of corrosion-resistant material with not less than 1/8 inch tall characters showing manufacturer's name and equipment ratings. Mount nameplate to front of enclosure and meet the nameplate

requirements of NEMA ICS 2.

c. Provide detail drawings that include manufacturer's name and catalog number, electrical ratings, total system transfer statement, reduced normal supply voltage at which transfer to the alternate supply is initiated, transfer delay times, short-circuit current rating, wiring diagram, description of interconnections, testing instructions, acceptable conductor type for terminals, tightening torque for each wire connector, and other required UL 1008 markings.

d. Submit interface equipment connection diagram showing conduit and wiring between ATS and related equipment. Provide diagrams showing interlocking provisions and cautionary notes, if any.

e. Drawings are to indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices.

1.4.3 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship must be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated

1.4.4 Standard Product

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship, and:

a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.

b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.

c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.4.4.1 Alternative Qualifications

Products having less than a 2-year field service record are acceptable if the manufacturer has been regularly engaged in the design and production of automatic transfer switches and if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.4.4.2 Material and Equipment Manufacturing Date

Products manufactured more than 1 years prior to date of delivery to site are not acceptable.

1.5 DELIVERY AND STORAGE

Protect equipment placed in storage from humidity and temperature variations, moisture, water intrusion, dirt, dust, or other contaminants. In harsh environments where temperatures exceed non-operational parameters established within this specification, provide an environmentally controlled equipment storage facility to ensure temperature parameters are within equipment specification. Provide documentation of same to the Government when storage is implemented.

1.6 ENVIRONMENTAL CONDITIONS

Provide an ATS that is suitable for prolonged performance under following service conditions:

a. Operating altitude: Sea level to 1,500 ft. (Systems applied at higher altitudes are to be derated in accordance with the manufacturer's instructions).

b. Operating ambient temperature range: 40 to 104 degrees F.

c. Operating relative humidity: 0 to 90 percent, without condensation.

1.7 SEISMIC REQUIREMENTS

Provide seismic details conforming to Section 26 05 48, SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT.

PART 2 PRODUCTS

2.1 AUTOMATIC TRANSFER SWITCHES

Each automatic transfer switch must be rated and marked for total system transfer and have the current and voltage ratings as indicated. Provide a switch operating mechanism that is electrically operated, have quick-make, quick-break, load break contacts, and be mechanically held in both positions. Provide an ATS that is UL listed. ATS must be manufactured and tested in accordance with applicable requirements of NEMA ICS 2, UL 1008 and UL 1066. ATS must conform to NFPA 110. Provide the ATS with the following characteristics:

a. Voltage: 480Y/277 volts ac.

b. Amperage: As specified in the Contract Documents. Provide an ATS with a continuous load current rating of the switch rating.

c. Number of Phases: Three.

d. Number of Wires: Four.

e. Frequency: 60 Hz.

f. Poles: Four switched. One of the poles is the neutral.

g. ATS Withstand Current Rating: ATS must be rated to close on and withstand the available RMS symmetrical short circuit current at the ATS terminals. The ATS must be listed in accordance with UL 1008 for 3 30 cycle close and withstand ratings. Minimum UL listed close and withstand ratings at 480 VAC must be as specified in the Contract

Documents.

h. Nonwelding Contacts: Provide contacts that are nonwelding at the available fault current rating. Contacts must be suitable for repetitive power transfer switching. Switches rated 800 amps and above must have segmented, blow-on construction for high withstand and close-on capability and be protected by separate arcing contacts.

i. Phase and Neutral Contacts: Provide contacts with silver alloy composition. Provide neutral contacts with the same continuous current rating as main or phase contacts.

j. Configuration. Provide an ATS for use in optional standby systems described in NFPA 70.

k. ATS Configuration. Provide an open transition ATS. Neutral is to break and make with the phase contacts.

l. Service Entrance Rated. Provide an integrated circuit breaker and automatic transfer switch. Provide a separate deadfront compartment for the circuit breaker on switches 600 amp and larger. Provide label indicating that the ATS is the service disconnect. Provide a circuit breaker that is rated for 100 percent of the switch contact current rating. All components, except as noted herein, are to have a continuous load rating.

m. Viewing Ports. Provide contacts that are viewable from the front of the device when the door is open. Comply with the requirements found in IEEE 602 and NFPA 99

2.1.1 Undervoltage Sensing - Normal/Preferred Source

Undervoltage Sensing - Normal Source. Provide undervoltage sensing for each phase in the normal/preferred source. Sense low phase-to-ground voltage on each phase. Provide sensing circuit with adjustable dropout, 75-98 percent of nominal value and adjustable pickup, 85-100 percent of nominal value. Factory set dropout value to 85 percent. Factory set pickup value to 90 percent.

2.1.2 Adjustable Time Delay - Override Transfer

Adjustable Time Delay - Override Transfer. For override of normal-source voltage sensing to delay transfer and engine starting signals. Engine starting control contacts with adjustable commit-to-start delay circuit, 0.0-6.0 seconds. Factory set at 1 second.

2.1.3 Voltage/Frequency Lockout Relay - Alternate Source

Voltage/Frequency Lockout Relay. Three-phase sensing must be provided on the normal and emergency source. Prevent premature transfer to alternate/emergency source. Provide pickup voltage that is adjustable from 85-100 percent of nominal. Factory set for pickup at 90 percent. Provide pickup frequency that is adjustable from 90-97 percent of nominal. Factor set frequency pickup for 95 percent.

2.1.4 Adjustable Time Delay - Transfer to Alternate Power Source

Adjustable Time Delay - Transfer to Alternate Power Source. Transfer to alternate power source time delay for transfer switches as indicated,

adjustable 0-5 minutes. Factory set to 0 seconds. ATS is to monitor the frequency and voltage of alternate power source and transfer when frequency and voltage are stabilized.

2.1.5 Adjustable Time Delay- Re-transfer to Normal/Preferred Source

Adjustable Time Delay- Transfer to Source. Re-transfer to normal source time delay, adjustable 0-30 minutes. Factory set at 10 minutes. Time delay is automatically defeated upon loss or sustained undervoltage of alternate power source, provided that normal source has been restored.

2.1.6 Engine-Generator Exerciser

Exerciser. Solid-state, programmable-time switch exerciser to allow automatic starting of the generator set, subsequent load transfer, retransfer of load and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from on a daily, weekly, bi-weekly or monthly basis.. Running periods are adjustable from 10-30 minutes. Factory settings are for 7-day exercise cycle, 20 minute running period and 5-minute cool-down period. Exerciser features include the following:

a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer or dual independent exercisers that allow for unloaded and loaded schedule testing.

b. Push-button programming control with digital display of settings.

c. Integral battery operation of time switch when normal control power is not available.

2.1.7 Engine Shutdown Time Delay

Engine Shutdown. Provide time delay that is adjustable from 0 to 5 minutes and is factory set at 5 minutes.

2.1.8 Engine Starting Contacts

Provide 2 isolated normally closed and 1 isolated normally open contact that is rated 5 A at 250 VAC/30 VDC minimum.

2.1.9 Delayed Transition With Time Delay Neutral

Provide an adjustable time delay transition for indicated transfer switches to allow safe transfer of highly inductive loads between two non-synchronized sources. This transfer between loads has a programmed neutral position arranged to provide a midpoint between the two working positions, with an intentional time-controlled pause at midpoint during transfer. Pause is adjustable from 1 to 300 seconds. Factory set time delay at 2 seconds. Time delay occurs for both transfer directions. Manufacturer is to provide recommendations for establishing the length of the time delay.

2.1.10 Motor Disconnect And Timing Relay

Motor Disconnect and Timing Relay: Controls designate starters so they disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters is through wiring external to automatic transfer switch. Time

delay for reconnecting individual motor loads is adjustable between 1 and 60 seconds, and settings are as indicated. Relay contacts handling motor-control circuit inrush and seal currents are rated for actual currents to be encountered.

2.1.11 Make Before Break Neutral

Contractor is required to coordinate with UPS manufacturer to determine if the unit being procured requires the neutral to be interconnected. If not required, then break before make neutral contacts are allowed. If required, then provide the ATS with make before break neutral contacts. Provide the ATS with a make before break neutral. Phase contacts are to break before make. The neutrals are to make for 50 ms.

2.1.12 Auxiliary Contact for Uninterruptible Power Supply

Provide a contact that closes when transferred to the alternate power source.

2.1.13 Unassigned Auxiliary Contacts

Provide two normally open and two normally closed, single-pole, double-throw auxiliary contacts for each switch position rated at 10 amperes at 480 volts.

2.1.14 Front Panel Devices

Provide devices mounted on cabinet front consisting of:

a. Mode selector switch with the following positions and associated functions. Selector switch can be part of the microprocessor controller consisting of an LCD screen with a graphical interface or as a stand-alone test switch.

   (1) TEST - Simulates loss of normal/preferred source system operation.

   (2) NORMAL - Transfers system to normal/preferred source bypassing re-transfer time delay.

b. Switch position indicating lights or graphical LCD display. Indicate source to which load is connected.

c. Source-Available Monitor. Provide source-available indicating lights or graphical LCD display monitor that is labeled to show when one or both sources of power are available. If indicating lights are used, then the preference is to have Green be normal/preferred power and Red be for alternate/emergency power; however, other color schemes are allowed if clearly marked.

d. Provide a transfer override switch. Provide automatic transfer switch microprocessor based controller, which offers field selectable/adjustable inputs and outputs for transfer switch operation. Override switch must bypass automatic transfer controls so ATS will transfer and remain connected to alternate generator power source, regardless of condition of normal/preferred source. Provide an indicating light to show override status. If alternate source fails and normal source is available, ATS is to automatically retransfer to normal source.

e. Lamp test button.

2.1.15 Voltage Unbalance

Provide automatic transfer switch controller or control logic to include positive and negative sequence voltage detection to identify a phase loss condition that can adversely effect motor loads.

2.1.16 In-Phase Monitor

Provide an in-phase monitor that consists of a factory-wired, internal relay that controls transfer so it occurs only when the two sources are synchronized in phase. Relay compares phase relationship and frequency difference between normal and emergency sources and initiates transfer when both sources are within 5 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer is initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage Manufacturer is to provide information regarding what conditions a transfer cannot be accomplished.

2.2 BY-PASS/ISOLATION SWITCH (BP/IS)

Include non-load-break by-pass/isolation switches for the indicated automatic transfer switches. Designs which disconnect or interrupt the load when bypassing are not acceptable. Include the following features for each combined by-pass/isolation switch and automatic transfer switch:

a. Bypass/isolation switch (BP/IS) and associated ATS are to be made by the same manufacturer and must be completely interconnected and tested at factory and at project site as specified.

b. ATS is to be manufactured, listed and tested in accordance with paragraph AUTOMATIC TRANSFER SWITCH. BP/IS switch current, voltage, closing, and short-circuit withstand closing ratings are to be equal or exceed comparable ratings specified for ATS and have the same phase arrangement and number of poles.

c. Provide externally operated and arranged selector switch or handle so designed and constructed not to stop in an intermediate or neutral position during operation and that one person can safely bypass the ATS. Accomplish isolation of the ATS externally by one person. Bypass and isolation handles must be permanently affixed and operable without opening the enclosure door. Provide interlocks that ensure ATS is disconnected from source and load during isolation. Interlocks prevent ATS operation, except for testing and maintenance, while isolated. BP/IS operation is to be accomplished without disconnecting switch load terminal conductors. Equipment which require separate tools, keys, or other devices to operate the bypass/isolation mechanism which may not be present during an emergency is not acceptable.

d. Provide drawout transfer switch that provides physical separation from bypass switch and live parts and accessibility for testing and maintenance operation.

e. Provide contacts that have the same contact temperature that do not exceed those of the ATS contacts when carrying rated load. Provide contacts as specified for associated ATS, including provisions for inspection of contacts without disassembly of BP/IS or removal of

entire contact enclosure. Provide manufacturer instructions for determining contact integrity in order To facilitate maintenance.

f. The ATS controls remain functional with the ATS isolated or in bypass mode to permit monitoring of the normal power source and automatic starting of the generator in the event of a loss of the normal power source. In the isolated mode, the bypass section is capable of functioning as a manual transfer to transfer the load to either power source for maintenance purposes or when automatic control has failed. Equipment that requires automatic controls to be functional to operate the bypass switch is not acceptable. The ATS can be completely removed from the enclosure, if required for maintenance or repair, while the bypass section continues to power the load.

g. Construct Bypass/isolation switch for convenient removal of parts from front of switch enclosure without removal of other parts or disconnection of external power conductors.

h. Achieve load by-pass to the source with no load interruption. Bypass/isolation equipment that breaks the load is not acceptable.

i. Provide drawout bypass switch that provides physical separation from ATS and live parts and accessibility for testing and maintenance operation.

j. Provide a means to ensure the switch is transferred to the alternate power source when normal power source becomes unavailable.

2.2.1 Markings

Mark isolation handle positions with engraved plates or other approved means to indicate position or operating condition of associated ATS, as follows:

a. Provide an indication that shows that BP/IS section is providing power to the load.

b. Provide indication of ATS isolation/test position.

c. Provide suitable control labels and instruction signs describing operating instructions.

d. Indicating lamps or LCD screen for indicating that shows the source availability, bypass switch position, transfer switch position, and isolation handle position. If indicating lights are used, provide a lamp test button that turns the indicating lights on, but does not cause any function to take place.

2.2.2 Interconnection

Interconnect BP/IS and associated ATS with suitably sized copper bus bars silver-plated at each connection point, and braced to withstand magnetic and thermal forces created at withstand current rating specified for associated ATS.

2.3 ENCLOSURE

Provide an enclosure that meets the following:

a. Provide ATS and accessories in a free-standing, floor-mounted, ventilated NEMA 250, Type 4X, smooth sheet metal enclosure constructed in accordance with applicable requirements of NEMA ICS 6, UL 508, UL 1066, and UL 1008. Provide door with suitable hinges, locking handle latch, and gasketed jamb. Provide at least No. 14 metal gauge.

b. Factory wiring within enclosure and field wiring terminating within enclosure must comply with NFPA 70. Provide wire that is permanently tagged or marked near terminal at each end with wire number shown on approved detail drawing, when wiring is not color coded. Conform terminal block to NEMA ICS 4. Arrange terminals for entrance of external conductors from bottom of enclosure as shown. Main switch terminals, including neutral terminal if used, must be pressure type suitable for termination of external copper conductors shown.

c. Provide thermostatically controlled heater within enclosure to prevent condensation over temperature range stipulated in paragraph SERVICE CONDITIONS. Heater must be powered from an integral transformer that does not require a separate circuit to provide power to the heater.

2.3.1 Construction

Construct enclosure for ease of removal and replacement of ATS components and control devices from front without disconnection of external power conductors or removal or disassembly of major components.

2.3.2 Cleaning and Painting

Protect both the inside and outside surfaces of an enclosure, including means for fastening against corrosion by enameling, galvanizing, plating, powder coating, or other equivalent means. Protection is not required for metal parts that are inherently resistant to corrosion, bearings, sliding surfaces of hinges, or other parts where such protection is impractical. Provide manufacturer's standard finish material, process, and color that is free from runs, sags, peeling, or other defects. An enclosure marked Type 1, 3R, 4 or 12 is acceptable if there is no visible rust at the conclusion of a salt spray (fog) test using the test method in ASTM B117, employing a 5 percent by weight, salt solution for 24 hours. Type 4X enclosures are acceptable following performance of the above test with an exposure time of 200 hours.

2.3.3 Field Fabricated Nameplates

Nameplate is to comply with ASTM D709. Provide laminated plastic nameplates for each equipment enclosure as specified or as indicated on the drawings. Provide an inscription on each nameplate that identifies the name of the equipment, sources of power, calculated short circuit with date and the location e.g. 'SWB-1 Electrical Room 103'. Provide nameplates that are made of melamine plastic, 0.125 inch thick, white with black center core. Provide the nameplate with a surface that is matte finished and that has square corners.. Accurately align lettering and engrave into the core. Provide nameplates that are at least 1.0 by 2.5 inches with a minimum lettering size of 0.25 inch high normal block style.

2.4 MANUAL TRANSFER SWITCH (MTS)/DOCKING STATION

2.4.1 Enclosure

UL50. Provide stainless steel, NEMA 3R Rain-Tight enclosure. Pad-lockable

front door shall include a hinged access plate at the bottom for entry of temporary cabling that prevents unauthorized tampering while in use. NEMA 3R Integrity shall be maintained while temporary cabling is connected during use. Provide with access in the front and rear for maintenance. Provide top, side, and bottom must be accessible for permanent cabling. Coordinate cable entrances prior to ordering equipment. Manual Operating Handle capable of external operation without opening enclosure door.

2.4.2 Equipment Ratings

Provide ratings as shown on the one-line diagram. Bus material must be silver-plated copper. Equipment ground bus must be bonded to enclosure. Neutral bus must be 100% rated.

Transfer switch must be mechanical operated, mechanically held. Positively locked, unaffected by momentary outages, such that contact pressure is maintained at constant value and contact temperature rise is minimized for maximum reliability and operating life. Mechanically interlocked to allow only one of three possible positions: Connected to Permanent Generator, Connected to Temporary Generator, Center OFF (disconnected position). Provide capability to pad-lock switch when connected to SOURCE 1 or SOURCE 2. Provide segmented, blow-on construction for high withstand and close-on capability, protected by separate arcing contacts. Designed to allow inspection of contacts from front without disassembly of operating linkages and disconnection of power conductors.

2.4.3 Connections

Temporary generator connections must be Camlock style connectors mounted on gland plate. Camlok shall be 16 Series model and color coded according to system voltage requirements. Camlok connections shall be Bus Bar Style, Cabling or Double Set Screw is not acceptable. Camlok connection shall be protected against accidental contact while not in use.

Load bank and permanent generator connections must be permanent connections. Permanent Connections shall be factory installed broad range set-screw mechanical type, located behind a physical barrier.

2.4.4 Factory Installed Phase Rotation Monitor Device

Provide a factory installed phase monitoring relay.

2.4.5 Breakers in Permanent Line, Temporary Line, and Temporary Load Bank Positions

Must be UL 489 Listed Breakers. Breakers shall be removable for service and maintenance. Interlocked permanent line breaker and temporary line breaker. Devices utilizing components of molded-case circuit breakers, contactors, or parts thereof, which are not intended for continuous duty, repetitive switching or transfer between two active power sources are not acceptable.

2.4.6 Enclosure Heater

Provide thermostatically controlled heater within the enclosure to prevent condensation over temperature range. Heater will be supplied power via a 120V, 1-phase circuit provided from the B403 electrical room. Coordinate underground conduits prior to installation of equipment.

2.4.7 Surge Protective Device

UL 1449. Surge Current Rating: 100 kA per mode, 200 kA per phase. Provide individually matched fused metal oxide varistors (MOVs). Provide LED status indication of normal operation, undervoltage, power loss, phase loss, and component failure. Provide From C dry contacts for external alarm/monitoring.

2.4.8 User Interface

Provide LED indicators for Permanent Generator (preferred) and Temporary Generator (alternate). Provide auxiliary position indicating contacts, rated 10 A, 250 VAC - one closed when connected to SOURCE 1 and one closed when connected to SOURCE 2. Provide Form A contact to indicate switch in CENTER OFF position.

2.5 FACTORY TESTING

Submit a description of proposed field test procedures, including proposed date and steps describing each test, its duration and expected results, not less than two weeks prior to test date. Submit certified factory and field test reports, within 14 days following completion of tests. Provide reports that are certified and dated and that demonstrate that tests were successfully completed prior to shipment of equipment.

2.5.1 Prototype Factory Testing

A prototype of specified ATS is to be factory tested in accordance with UL 1008. In addition, perform factory tests on each ATS as follows:

a. Insulation resistance test to ensure integrity and continuity of entire system

b. Main switch contact resistance test.

c. Visual inspection to verify that each ATS is as specified.

d. Mechanical test to verify that ATS sections are free of mechanical hindrances.

e. Electrical tests to verify complete system electrical operation and to set up time delays and voltage sensing settings.

2.5.2 Factory Test Reports

Provide three certified copies of factory test reports from the manufacturer.

PART 3 EXECUTION

3.1 INSTALLATION

Installation must conform to the requirements of NFPA 70 and manufacturer's recommendation.

3.2 PREREQUISITES FOR FUNCTIONAL ACCEPTANCE TESTING

Completion of the following requirements is mandatory prior to scheduling

functional acceptance tests for the automatic transfer switch.

3.2.1 Performance of Acceptance Checks and tests

Complete as specified in paragraph entitled "Acceptance Checks and Tests". The Acceptance Checks and Tests are to be accomplished by the Testing organization as described in Section 26 08 00 APPARATUS INSPECTION AND TESTING.

3.2.2 Manufacturers O&M Information

The manufacturers O&M information required by the paragraph entitled "SD-10 Operation and Maintenance Data", is to be submitted to and approved by the Contracting Officer.

3.2.3 Test Equipment

Ensure all test equipment and instruments is on hand prior to scheduling field tests, or subject to Contracting Officer's approval, evidence must be provided to show that arrangements have been made to have the necessary equipment and instruments on site prior to field testing.

3.3 FIELD QUALITY CONTROL

Give Contracting Officer 15 days notice of dates and times scheduled for tests which require the presence of the Contracting Officer. The Contracting Officer will coordinate with the using activity and schedule a time that will eliminate or minimize interruptions and interference with the activity operations. The contractor is responsible for costs associated with conducting tests outside of normal working hours and with incorporating special arrangements and procedures, including temporary power conditions. The contractor provides labor, equipment, apparatus, including test load, and consumables required for the specified tests. Calibration of all measuring devices and indicating devices must be certified. Provide the services of a qualified factory-trained manufacturer's representative to assist the contractor in installation and start-up of the equipment specified under this section. The manufacturer's representative is to provide technical direction and assistance to the contractor in general assembly of the equipment, connections and adjustments, and testing of the assembly components contained herein. Provide a test load that is a cataloged product in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Perform the following field tests in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.3.1 Automatic Transfer Switch Acceptance Checks and Tests

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Confirm correct application of manufacturer's recommended lubricants.

(4) Verify that manual transfer warnings are attached and visible.

(5) Verify tightness of all control connections.

(6) Verify tightness of accessible bolted connections by calibrated torque-wrench method. Thermographic survey is not required.

(7) Perform manual transfer operation.

(8) Verify positive mechanical interlocking between normal and alternate sources.

b. Electrical Tests

(1) Measure contact-resistance. Correct values that exceed 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.

(2) Perform insulation-resistance on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole for one minute. Perform tests in both source positions.

(3) Verify settings and operations of control devices.

(4) Calibrate and set all relays and timers.

(5) Test ground-fault protective device.

3.3.2 Functional Acceptance Tests

Functional Acceptance Tests must be coordinated with Section 26 32 15 ENGINE-GENERATOR SET STATIONARY 15-2500 KW, WITH AUXILIARIES. Include simulating power failure and demonstrating the following operations for each automatic transfer switch. Demonstrate in service that the automatic transfer switches are in good operating condition, and function not less than five times.

a. Perform automatic transfer tests:

(1) Simulate loss of normal/preferred power.

(2) Return to normal/preferred power.

(3) Simulate loss of alternate power.

(4) Simulate all forms of single-phase conditions.

b. Verify correct operation and timing of the following functions:

(1) Normal source voltage-sensing relays.

(2) Engine start sequence.

(3) Time delay upon transfer.

(4) Alternate source voltage-sensing relays.

(5) Automatic transfer operation.

(6) Interlocks and limit switch function.

(7) Time delay and retransfer upon normal power restoration.

(8) By-pass/isolation functional modes and related automatic transfer switch operations.

3.3.3 Infrared Scanning

After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.

a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after acceptance.

b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

c. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.4 TRAINING

Provide 4 hours of training to maintenance personnel on the proper operation, maintenance and adjustment of the automatic transfer switch. Coordinate this training with that of the generator equipment.

-- End of Section --

SECTION 26 41 00

LIGHTNING PROTECTION SYSTEM
08/23

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2026; TIA 26-1; ERTA 26-1; TIA 26-2; TIA 26-3; TIA 26-4; TIA 26-5; TIA 26-6; TIA 26-7; ERTA 26-2; ERTA 26-3) National Electrical Code
NFPA 780	(2023) Standard for the Installation of Lightning Protection Systems

U.S. AIR FORCE (USAF)

DAFMAN 32-1065	(2020) Grounding and Electrical Systems

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-575-01	(2012; with Change 1, 2021) Lightning and Static Electricity Protection Systems

UL SOLUTIONS (UL)

UL 96	(2016; May 2023) UL Standard for Safety Lightning Protection Components
UL 96A	(2023) UL Standard for Safety Installation Requirements for Lightning Protection Systems
UL 1449	(2021; Reprint Oct 2025) UL Standard for Safety Surge Protective Devices
UL Electrical Construction	(2012) Electrical Construction Equipment Directory

1.2 RELATED REQUIREMENTS

1.2.1 Verification of Dimensions

Confirm all details of work, verify all dimensions in field, and advise

Contracting Officer of any discrepancy before performing work. Obtain prior approval of Contracting Officer after engineering approval and before making any departures from the design.

1.2.2 System Requirements

Provide a system furnished under this specification consisting of the latest products of a manufacturer regularly engaged in production of lightning protection system components. Products must be UL listed for use on lightning protection systems unless this rating does not exist for items in question.

Comply with NFPA 70, NFPA 780, UL 96, and UFC 3-575-01.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-06 Test Reports

Lightning Protection and Grounding System Test Plan; G

Grounding Systems Testing; G

SD-07 Certificates

Component UL Listed and Labeled; G

Lightning Protection System Inspection Certificate; G

Roof Manufacturer's Warranty; G

1.4 QUALITY ASSURANCE

In each standard referred to herein, consider the advisory provisions to be mandatory, as though the word "shall" or "must" has been substituted for "should," wherever it appears. Interpret references that require LPS expertise in these standards to mean Base Civil Engineer (BCE) or BCE-designated representative with LPS training certification.

1.4.1 Component UL Listed and Labeled

Submit proof of compliance that components are UL Listed and Labeled for use on lightning protection systems. Listing alone in UL Electrical Construction, which is the UL Electrical Construction Directory, is not acceptable evidence. In lieu of Listed and Labeled, submit written certificate from an approved, nationally-recognized testing organization equipped to perform such services, stating that items have been tested and conform to requirements and testing methods of Underwriters Laboratories (UL).

1.4.2 Lightning Protection and Grounding System Test Plan

Provide lightning protection system and grounding system test plans in compliance with NFPA 780 and DAFMAN 32-1065 chapters 8 and 10, and Attachment 7. DAFMAN 32-1065, Attachment 7, contains a Sample Visual

Inspection Form (Figure A7.6) and a Sample 24-month Resistance/Continuity Test/Visual Inspection of LPS and Grounding System (Figure A7.7). Substitute-Forms may be used, but those forms created or substituted by the base must include the same contents and information as the samples provided in Attachment 7, Figures A7.6 and A7.7. As a minimum, include a sketch of the facility and surrounding lightning protection system as part of the specific test plan for each structure. Include the requirements as "Testing of Integral Lightning Protection System" in the test plan. Testing of Surge Protective Devices must comply with UL 1449 and annual inspection of Surge Protective Devices should be included on Figures A7.6 and A7.7.

1.4.3 Lightning Protection System Inspection Certificate of Qualifications

Provide an approved third-party inspector who meets training certification requirements for final acceptance of the LPS. Inspection and certification of the LPS must be completed and certified in writing, before occupancy of the building. Compliance requirements are in UFC 3-575-01 and DAFMAN 32-1065, paragraphs 4.2 and 4.3. Signed Certificate of Qualifications must be placed in the LPS records.

Note that the Contracting Officer may not accept the LPS system without a recommendation from a qualified person identified in the project documents.

1.5 SITE CONDITIONS

Confirm all details of work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before starting any work, if known at that time, or when it becomes known while performing work. Obtain prior approval of the BCE or BCE-designated representative with LPS training certification before design changes are made.

PART 2 PRODUCTS

2.1 MATERIALS

See NFPA 70, NFPA 780, UFC 3-575-01, DAFMAN 32-1065. Do not use a combination of materials that forms an electrolytic couple of such nature that corrosion is accelerated in the presence of moisture unless moisture is permanently excluded from the junction of such metals. Where unusual conditions exist which would cause corrosion of conductors, provide conductors with protective coatings, such as tin or lead, or oversize conductors. Where a mechanical hazard is involved, increase conductor size to compensate for the hazard or protect conductors. When metallic conduit or tubing is provided, electrically bond conductor to conduit or tubing at the upper and lower ends by clamp type connectors or welds (including exothermic). All lightning protection components, such as bonding plates, air terminals, air terminal supports and braces, chimney bands, clips, connector fittings, and fasteners are to comply with the requirements of UL 96 classes, as applicable.

2.1.1 Main and Bonding Conductors

Main and Bonding Conductors should be NFPA 780 and UL 96 Class I or Class II materials, as applicable. For explosives, Class II materials are in accordance with NFPA 780, Chapter 8.

2.1.2 Conductors

Provide copper or aluminum conductors, as applicable. See NFPA 780, UFC 3-575-01, DAFMAN 32-1065.

2.2 COMPONENTS

2.2.1 Air Terminals on Integral Systems

Provide solid air terminals. Tubular air terminals are not permitted. Support air terminals more than 24 inches in length by suitable brace, supported at not less than one-half the height of the terminal.

2.2.2 Ground Rods

Provide ground rods conforming to NFPA 780. Provide ground rods that are not less than 5/8 inch in diameter and 8 feet in length. Do not mix ground rods of copper-clad steel and solid copper on the job.

2.2.3 Connections and Terminations

Provide connectors for splicing conductors that conform to UL 96, class as applicable. Conductor connections can be made by compression clamps or welds (including exothermic). Provide style and size connectors required for the installation.

2.2.4 Connector Fittings

Provide connector fittings for "end-to-end", "Tee", or "Y" splices that conform to NFPA 780 and UL 96.

PART 3 EXECUTION

3.1 LIGHTNING PROTECTION SYSTEMS

Provide a lightning protection system that meets the requirements of NFPA 780 and UFC 3-575-01.

3.1.1 Integral Lightning Protection System

The integral type lightning protection system consists of air terminals, roof conductors, down conductors, ground connections, grounding electrodes and ground ring electrode conductor for the purpose of carrying lightning current from a direct strike to ground in a manner that will protect assets and personnel. Expose all conductors on the structures except where exterior down conductors are required to be in protective sleeves for prevention of mechanical damage (6 feet above grade level). Integral systems are the least preferred, especially for explosives and communications facilities. When use of integral systems is determined by the designer or site conditions to be necessary, do not run down conductors inside columns or other methods which will prevent visual access for required inspections. Visual access is required by NFPA 780 and DAFMAN 32-1065 so that the annual visual inspection may be performed on all LPS components.

Make interconnections within side-flash distances between down conductors and metallic equipment mounted on the exterior or interior of a facility, at or below the level of the grounded metallic parts. Calculate side-flash distances in accordance with NFPA 780. Be aware of side

flashes that may occur through exterior walls.

Note that integral systems should be avoided as LPS for Explosives and Communications facilities and is discouraged for general facilities. Installation and maintenance costs of an integral system are excessive and this method is maintenance intensive. The complexity and number of test points dictates frequent interruption to missions and daily operations for required annual inspections and testing. Integral systems require fall protection and maintenance of that fall protection system. For fall protection, maintain NFPA 780-compliant separation distance between the integral system and metallic fall protection.

3.1.1.1 Roof-Mounted Components

Coordinate with the roofing manufacturer and provide certification that the roof manufacturer's warranty is not violated by the installation methods for air terminals and roof conductors. Adhesive fasteners may be used on the roof if the installation is observed by base-qualified personnel to be compliant with manufacturer's instructions. Installation must be observed until the observer is satisfied that the proper methods for preparing the surface are being performed. These fasteners will be added and considered a test point in Base records and must be part of the annual inspection. Observer must date and sign the test record.

No connection or physical attachment is allowed to any coping system on the roof as this violates the integrity and warranty of the coping system.

3.1.1.2 Air Terminals

Use of adhesive fasteners, when installing air terminals on "rubber" (EPDM) type roofs, should be in accordance with adhesive and roof manufactures’ recommendations. See paragraph ROOF-MOUNTED COMPONENTS.

3.1.1.3 Roof Conductors

Roof conductors should comply with NFPA 780 and DAFMAN 32-1065.

3.1.2 Down Conductors

A minimum of two paths to ground shall be provided on any system. This may be by two down conductors or with a down conductor in combination with other metallic connections to ground. Protect exposed down conductors from physical damage from ground level up to 6 feet. If this protection is a metal conduit, both ends must be bonded to the down conductor passing through it. For Schedule 80 conduit providing this protection, no bonding at both ends is necessary. Schedule 80 conduit or metallic conduit may be painted to match the surrounding surface. NO CONNECTIONS OR FASTENERS OF ANY LIGHTNING PROTECTION SYSTEM MAY BE PAINTED because this affects the ease with which lightning current can pass to ground.

3.1.3 Ground Connections

Attach each down conductor and ground ring electrode to a ground rod below grade by exothermic weld for all buried connections and exothermic weld or compression connectors for connections inside test wells. Terminate all down conductors to a grounding electrode inside a test well. Test connections and record resistances and continuity readings prior to covering.

Accessible connections above ground level and in test wells can be grounded with mechanical clamping, meeting installation requirements in NFPA 780.

3.1.4 Installation of Grounding Electrodes (Ground Rods)

Extend driven ground rods vertically into the existing undisturbed earth for a distance of not-less-than 8 feet if exothermic welds are used for bonds. Inside test wells, the 5/8 in. by 8 ft rod may be driven to a point above the base of the test well, that will provide working/testing access to the mechanically-fastened bond. Set ground rods not less than 3 feet nor more than 6 feet (see NFPA 780) from the structural foundation, and at least 3 feet beyond the drip line for the facility. After the completed installation, measure the total resistance to ground using the fall-of-potential method described in IEEE 81. Maximum allowed resistance of a single driven ground rod is 25 ohms (NFPA 70). If resistance-to-ground of a single ground rod for the lightning protection system exceeds 25 ohms and another ground rod is driven in accordance with NFPA 780, 25 ohms does not apply to this test point. See NFPA 70 exception to Article 250.53.

3.2 APPLICATIONS

3.2.1 Personnel Ramps and Covered Passageways

Lightning Protection is required in accordance with NFPA 780 and UFC 3-575-01.

3.3 INTERFACE WITH OTHER STRUCTURES

3.3.1 Fences

Bond metal fence and gate systems to the lightning protection system at the point where the fence, any fence post, or gate is within 6 feet of any part of the lightning protection system (usually a down conductor) in accordance with ANSI C2 and NFPA 780 and UFC 3-575-01.

3.4 RESTORATION

Where sod has been removed, replace sod as soon as possible after completing the backfilling. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work, to original condition. Overfill the trench to accommodate for settling. Include necessary topsoil, fertilizing, liming, seeding, sodding, sprigging or mulching in any restoration, to match existing. Maintain disturbed surfaces and replacements until final acceptance. Return to site after six months to fill in compacted surface.

3.5 FIELD QUALITY CONTROL

3.5.1 Lightning Protection Systems Testing

A 100 percent test point test and inspection is required by all services. Identify test points for lightning protection system connections and bonds. Provide a sketch (NTS) with identified test points as part of the contract acceptance. Number points in a manner consistent with the installation (Base or Post) nomenclature for existing lightning protection systems; for example, use letters or numbers to track the test results. Test each lightning protection system connection to ensure continuity

across each connection or bond is 1 ohm or less, and record the value indicated on a copy of the test form located at the back of DAFMAN 32-1065, Attachment 7.

a. LPS testing must also be accomplished on smaller projects, such as roofing and HVAC projects, where lightning protection systems are installed on any facility with existing LPS, to ensure the LPS is not damaged or reconfigured during construction.

b. Comply with UL 96A. A third-party inspector (not the designer and not the installer) must be present for the 100 percent inspection and data documentation by the contractor. This is to take place prior to project acceptance. Note that in many cases Air Force personnel have been trained to inspect and accept projects as the third-party inspector. Verify this before contract award.

3.5.2 Grounding Systems Testing

A 100 percent test point resistance test and inspection is required. Identify all test points for grounding system connections and bonds. Provide a sketch (NTS) with identified test points as part of the contract acceptance. Number points in a manner consistent with the installation (Base or Post) nomenclature for existing grounding systems; for example, use letters or numbers to track the test results. Test each grounding system connection or bond to ensure resistance-to-ground is 25 ohms or less or as excepted by NFPA 70 or NFPA 780. Record the resistance measurement on a copy of the test form located at the back of DAFMAN 32-1065 for Air Force or a similar form provided by the Army or Navy. Test the ground rod for resistance to ground before making connections to the rod. Tie the grounding system together and test for resistance to ground. Make resistance measurements in dry weather, and not earlier than 48 hours after rainfall. Include in the written report: locations of test points, measured values for continuity and ground resistances, and soil conditions at the time that measurements were made. Submit results of each test to the Contracting Officer.

-- End of Section --

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SECTION 26 51 00

INTERIOR LIGHTING
05/20, CHG 2: 11/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A580/A580M	(2023) Standard Specification for Stainless Steel Wire
ASTM A641/A641M	(2019) Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire
ASTM A653/A653M	(2025a) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A1008/A1008M	(2024) Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable
ASTM B164	(2003; R 2014) Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire
ASTM B633	(2023) Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel
ASTM D4674 REV A	(2002; R 2010) Standard Practice for Accelerated Testing for Color Stability of Plastics Exposed to Indoor Office Environments

EUROPEAN UNION (EU)

Directive 2011/65/EU	(2011) Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment

ILLUMINATING ENGINEERING SOCIETY (IES)

ANSI/IES LM-79	(2019) Approved Method: Electrical and Photometric Measurements of Solid State Lighting Products
ANSI/IES LM-80	(2020) Approved Method: Measuring Luminous Flux and Color Maintenance of LED

	Packages, Arrays and Modules
ANSI/IES LS-1	(2020) Lighting Science: Nomenclature and Definitions for Illuminating Engineering
ANSI/IES TM-15	(2020) Technical Memorandum: Luminaire Classification System for Outdoor Luminaires
ANSI/IES TM-21	(2021) Technical Memorandum: Projecting Long-TermLuminous, Photon, and Radiant Flux Maintenance of LED Light Sources
ANSI/IES TM-30	(2020) Technical Memorandum: IES Method for Evaluating Light Source Color Rendition
IES Lighting Library	IES Lighting Library

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C2	(2023) National Electrical Safety Code
IEEE C62.41	(1991; R 1995) Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 77	(2017) Temporal Light Artifacts: Test Methods and Guidance for Acceptance Criteria
NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ANSLG C78.377	(2024) Electric Lamps– Specifications for the Chromaticity of Solid State Lighting Products
NEMA C82.77-10	(2020) Harmonic Emission Limits - Related Power Quality Requirements
NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA SSL 1	(2016) Electronic Drivers for LED Devices, Arrays, or Systems
NEMA SSL 3	(2011) High-Power White LED Binning for General Illumination
NEMA SSL 7A	(2015) Phase-Cut Dimming for Solid State

	Lighting: Basic Compatibility
NEMA WD 1	(1999; R 2020) Standard for General Color Requirements for Wiring Devices
NEMA WD 7	(2011; R 2016; R 2021) Occupancy Motion Sensors Standard

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2026; TIA 26-1; ERTA 26-1; TIA 26-2; TIA 26-3; TIA 26-4; TIA 26-5; TIA 26-6; TIA 26-7; ERTA 26-2; ERTA 26-3) National Electrical Code
NFPA 101	(2024) Life Safety Code

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 15	Radio Frequency Devices

UL SOLUTIONS (UL)

UL 20	(2018; Reprint May 2023) UL Standard for Safety General-Use Snap Switches
UL 94	(2023; Reprint Jan 2024) UL Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL 508	(2018; Reprint Jul 2021) UL Standard for Safety Industrial Control Equipment
UL 916	(2015; Reprint Oct 2021) UL Standard for Safety Energy Management Equipment
UL 924	(2016; Reprint Dec 2022) UL Standard for Safety Emergency Lighting and Power Equipment
UL 1472	(2015) UL Standard for Safety Solid-State Dimming Controls
UL 1598	(2021; Reprint Jan 2024) UL Standard for Safety Luminaires
UL 2043	(2023) Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces
UL 8750	(2020; Reprint Aug 2024) UL Standard for Safety Light Emitting Diode (LED) Equipment for Use in Lighting Products

1.2 RELATED REQUIREMENTS

Materials not considered to be luminaires, luminaire accessories, or

lighting equipment are specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Luminaires and accessories that are mounted in exterior environments and not attached to the exterior of the building are specified in Section 26 56 00 EXTERIOR LIGHTING. Commissioning requirements are specified in Section 01 91 00.15 BUILDING COMMISSIONING.

1.3 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications and on the drawings, must be as defined in IEEE 100 and ANSI/IES LS-1.

b. For LED luminaire light sources, "Useful Life" is the operating hours before reaching 70 percent of the initial rated lumen output (L70) with no catastrophic failures under normal operating conditions. This is also known as 70 percent "Rated Lumen Maintenance Life" as defined in ANSI/IES LM-80.

c. For LED luminaires, "Luminaire Efficacy" (LE) is the appropriate measure of energy efficiency, measured in lumens/watt. This is gathered from LM-79 data for the luminaire, in which absolute photometry is used to measure the lumen output of the luminaire as one entity, not the source separately and then the source and housing together.

d. Total harmonic distortion (THD) is the root mean square (RMS) of all the harmonic components divided by the total fundamental current.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Luminaire Drawings; G

Occupancy/Vacancy Sensor Coverage Layout; G; S

Lighting Control System One-Line Diagram; G

Sequence of Operation for Lighting Control System; G

SD-03 Product Data

Luminaires; G

Light Sources; G

LED Drivers; G

Luminaire Warranty; G

Lighting Controls Warranty; G

Local Area Controller; G

Lighting Contactor; G

Switches; G

Wall Box Dimmers; G

Scene Wallstations; G

Occupancy/Vacancy Sensors; G

Photosensors; G

Power Packs; G

Exit Signs; G

Emergency Drivers; G

SD-05 Design Data

Luminaire Design Data; G

SD-06 Test Reports

ANSI/IES LM-79 Test Report; G

ANSI/IES LM-80 Test Report; G

ANSI/IES TM-21 Test Report; G

ANSI/IES TM-30 Test Report; G

Occupancy/Vacancy Sensor Verification Test; G

Photosensor Verification Test; G

SD-07 Certificates

LED Driver and Dimming Switch Compatibility Certificate; G

SD-10 Operation and Maintenance Data

Lighting System, Data Package 5; G

Lighting Control System, Data Package 5; G

Maintenance Staff Training Plan; G

End-User Training Plan; G

1.5 QUALITY ASSURANCE

Data, drawings, and reports must employ the terminology, classifications and methods prescribed by the IES Lighting Library as applicable, for the lighting system specified.

1.5.1 Luminaire Drawings

Include dimensions, accessories installation details, and construction

details. Photometric data, including CRI, CCT, LED driver type, zonal lumen data, and candlepower distribution data must accompany shop drawings.

1.5.2 Luminaire Design Data

a. Provide safety certification and file number for the luminaire family that must be listed, labeled, or identified in accordance with the NFPA 70. Applicable testing bodies are determined by the US Occupational Safety Health Administration (OSHA) as Nationally Recognized Testing Laboratories (NRTL) and include: CSA (Canadian Standards Association), ETL (Edison Testing Laboratory), and UL (Underwriters Laboratories).

b. Provide long term lumen maintenance projections for each LED luminaire in accordance with ANSI/IES TM-21. Data used for projections must be obtained from testing in accordance with ANSI/IES LM-80.

1.5.3 ANSI/IES LM-79 Test Report

Submit test report on manufacturer's standard production model of specified luminaire. Testing must be performed at the same operating drive current as specified luminaire. Include all applicable and required data in IES format as outlined under "14.0 Test Report" in ANSI/IES LM-79.

1.5.4 ANSI/IES LM-80 Test Report

Submit report on manufacturer's standard production LED light source (package, array, or module) of specified luminaire. Testing must be performed at the same operating drive current as specified luminaire. Include all applicable and required data as outlined under "8.0 Test Report" in ANSI/IES LM-80.

1.5.5 ANSI/IES TM-21 Test Report

Submit test report on manufacturer's standard production LED light source (package, array, or module) of specified luminaire. Testing must be performed at the same operating drive current as specified luminaire. Include all applicable and required data, as well as required interpolation information as outlined under "7.0 Report" in ANSI/IES TM-21.

1.5.6 ANSI/IES TM-30 Test Report

Submit color vector graphic in accordance with ANSI/IES TM-30 on manufacturer's standard production LED light source (package, array, or module) of specified luminaire. Include spectral distribution of test LED light source.

1.5.7 LED Driver and Dimming Switch Compatibility Certificate

Submit certification from the luminaire, driver, or dimmer switch manufacturer that ensures compatibility and operability between devices without flickering and to specified dimming levels.

1.5.8 Occupancy/Vacancy Sensor Coverage Layout

Provide floor plans showing coverage layouts of all devices using manufacturer's product information.

1.5.9 Test Laboratories

Test laboratories for the ANSI/IES LM-79 and ANSI/IES LM-80 test reports must be one of the following:

a. National Voluntary Laboratory Accreditation Program (NVLAP) accredited for solid-state lighting testing as part of the Energy-Efficient Lighting Products laboratory accreditation program for both LM-79 and LM-80 testing.

b. One of the qualified labs listed on the Department of Energy - LED Lighting Facts Approved Testing Laboratories List for LM-79 testing.

c. One of the EPA-Recognized Laboratories listed for LM-80 testing.

1.5.10 Regulatory Requirements

Equipment, materials, installation, and workmanship must be in accordance with the mandatory and advisory provisions of NFPA 70, unless more stringent requirements are specified or indicated. Provide luminaires and assembled components that are approved by and bear the label of UL for the applicable location and conditions unless otherwise specified.

1.5.11 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design, and workmanship. Products must have been in satisfactory commercial or industrial use for six months prior to bid opening. The six-month period must include applications of equipment and materials under similar circumstances and of similar size. The product must have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the six-month period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.11.1 Alternative Qualifications

Products having less than a six-month field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.11.2 Material and Equipment Manufacturing Date

Do not use products manufactured more than six months prior to date of delivery to site, unless specified otherwise.

1.6 WARRANTY

Support all equipment items by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.6.1 Luminaire Warranty

Provide and transfer to the government the original LED luminaire manufacturers standard commercial warranty for each different luminaire manufacturer used in the project.

a. Provide a written five year minimum replacement warranty for material, luminaire finish, and workmanship. Provide written warranty document that contains all warranty processing information needed, including customer service point of contact, whether or not a return authorization number is required, return shipping information, and closest return location to the luminaire location.

(1) Finish warranty must include failure and substantial deterioration such as blistering, cracking, peeling, chalking, or fading.

(2) Material warranty must include:

(a) All LED drivers and integral control equipment.

(b) Replacement when more than 15 percent of LED sources in any lightbar or subassembly(s) are defective, non-starting, or operating below 70 percent of specified lumen output.

b. Warranty period must begin in accordance with the manufacturer's standard warranty starting date.

c. Provide replacements that are promptly shipped, without charge, to the using Government facility point of contact and that are identical to or an improvement upon the original equipment. All replacements must include testing of new components and assembly.

1.6.2 Lighting Controls Warranty

Provide and transfer to the government the original lighting controls manufacturers standard commercial warranty for each different lighting controls manufacturer used in the project. Warranty coverage must begin from date of final system commissioning or three months from date of delivery, whichever is the earliest. Warranty service must be performed by a factory-trained engineer or technician.

a. Unless otherwise noted, provide a written five year minimum warranty on the complete system for all systems with factory commissioning. Provide warranty that covers 100 percent of the cost of any replacement parts and services required over the five years which are directly attributable to the product failure. Failures include, but are not limited to, the following:

(1) Software: Failure of input/output to execute switching or dimming commands.

(2) Damage of electronic components due to transient voltage surges.

(3) Failure of control devices, including but not limited to occupancy sensors, photosensors, and manual wall station control devices.

b. Provide a written five year minimum warranty on all input devices

against defect in workmanship or materials provided by device manufacturer.

c. Provide a written five year minimum warranty on all control components attached to luminaires against defect in workmanship or materials.

1.7 OPERATION AND MAINTENANCE MANUALS

1.7.1 Lighting System

Provide operation and maintenance manuals for the lighting system in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA that provide basic data relating to the design, operation, and maintenance of the lighting system for the building. Include the following:

a. Manufacturers' operating and maintenance manuals.

b. Luminaire shop drawings for modified and custom luminaires.

c. Luminaire Manufacturers' standard commercial warranty information as specified in paragraph LUMINAIRE WARRANTY.

1.7.2 Lighting Control System

Provide operation and maintenance manuals for the lighting control system in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA that provide basic data relating to the design, operation, and maintenance of the lighting control system for the building. Include the following:

a. Lighting control system layout and wiring plan.

b. Lighting control system one-line diagram.

c. Product data for all devices, including installation and programming instructions.

d. Occupancy/vacancy sensor coverage layout.

e. Training materials, such as videos or in-depth manuals, that cover basic operation of the lighting control system and instructions on modifying the lighting control system. Training materials must include calibration, adjustment, troubleshooting, maintenance, repair, and replacement.

f. Sequence of operation descriptions for each typical room type, including final programming, schedules, and calibration settings.

g. "As-built" lighting control panel schedules.

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

2.2 LUMINAIRES

UL 1598, NEMA C82.77-10. Provide luminaires as indicated in the luminaire schedule and NL plates or details on project plans, complete with light source, wattage, and lumen output indicated. All luminaires of the same type must be provided by the same manufacturer. Luminaires must be

specifically designed for use with the driver and light source provided.

2.2.1 Spares

Provide 10 percent of each type of luminaire with a minimum of 2 spare luminaires of each type. Provide at least one of each type with an emergency driver. Spares must be turned over to civil engineering (CE).

2.2.2 Luminaires

UL 8750, ANSI/IES LM-79, ANSI/IES LM-80. For all luminaires, provide:

a. Complete system with LED drivers and light sources.

b. Housings constructed of non-corrosive materials. All new aluminum housings must be anodized or powder-coated. All new steel housings must be treated to be corrosion resistant.

c. ANSI/IES TM-21, ANSI/IES LM-80. Minimum L70 lumen maintenance value of 50,000 hours unless otherwise indicated in the luminaire schedule. Luminaire drive current value must be identical to that provided by test data for luminaire in question.

d. Minimum efficacy as specified in the luminaire schedule. Theoretical models of initial lamp lumens per watt are not acceptable. If efficacy values are not listed in the luminaire schedule, provide luminaires that meet the following minimum values:

Luminaire Style	Minimum Luminaire Efficacy
Recessed 1 by 4, 2 by 4, and 2 by 2	100 LPW
Recessed Downlight (fixed, adjustable, wallwash)	80 LPW
Linear, Accent (undercabinet, cove)	45 LPW
Linear, Ambient (indirect wall mount, linear pendent)	100 LPW
Industrial Locations	100 LPW
Other (track, residential diffusers)	50 LPW
Exterior Wall Sconce	50 LPW

e. UL listed for dry or damp location typical of interior installations. Any luminaire mounted on the exterior of the building must be UL listed for wet location typical of exterior installations.

f. LED driver and light source package, array, or module are accessible for service or replacement without removal or destruction of luminaire.

g. Lenses constructed of heat tempered borosilicate glass, UV-resistant acrylic, or silicone. Provide polycarbonate vandal-resistant lenses as indicated. Sandblasting, etching and polishing must be performed as indicated in the luminaire description.

h. ANSI/IES TM-15. Provide exterior building-mounted luminaires that do

not exceed the BUG ratings as listed in the luminaire schedule. If BUG ratings are not listed in the luminaire schedule, provide luminaires that meet the following minimum values for each application and mounting conditions:

Lighting Application	Mounting Conditions	BUG Rating
Exterior Wall Sconce	Above 4 feet AFF	B1-U0-G2
Exterior Wall Sconce	Below or at 4 feet AFF	B4-U0-G4

i. For all recessed luminaires that are identified to be in contact with insulation, provide luminaires that are IC-rated.

2.3 LIGHT SOURCES

NEMA ANSLG C78.377, NEMA SSL 3. Provide type, delivered lumen output, and wattage as indicated in the luminaire schedule on project plans.

2.3.1 LED Light Sources

Provide LED light sources that meet the following requirements:

a. NEMA ANSLG C78.377. Emit white light and have a nominal CCT of 4000 Kelvin.

b. Minimum Color Rendering Index (CRI) of 80.

c. Directive 2011/65/EU. Restriction of Hazardous Substances (RoHS) compliant.

d. Light source color consistency by utilizing a binning tolerance within a 3-step McAdam ellipse.

e. Color maintenance value of no greater than 0.003 (delta u'v') at 6000 hours as listed in ANSI/IES LM-79 Test Report.

2.4 LED DRIVERS

NEMA SSL 1, UL 8750. Provide LED drivers that are electronic, UL Class 1 or Class 2, constant-current type and that comply with the following requirements:

a. The combined driver and LED light source system does not exceed the minimum luminaire efficacy values as listed in the luminaire schedule provided.

b. Operates at a voltage of 120-277 volts at 50/60 hertz, with input voltage fluctuations of plus/minus 10 percent.

c. Power Factor (PF) greater than or equal to 0.90 at full input power and across specified dimming range.

d. Maximum Total Harmonic Distortion (THD) less than 20 percent at full input power and across specified dimming range.

e. Operates for at least 50,000 hours at maximum case temperature and 90 percent non-condensing relative humidity.

f. Withstands Category A surges of 2 kV without impairment of performance. Provide surge protection that is integral to the driver.

g. Integral thermal protection that reduces the output power to protect the driver and light source from damage if the case temperature approaches or exceeds the driver's maximum operating temperature.

h. 47 CFR 15. Complies with the requirements of the Federal Communications Commission (FCC) rules and regulations, Non-Consumer (Class A) for EMI/RFI (conducted and radiated).

i. Class A sound rating.

j. Directive 2011/65/EU. Restriction of Hazardous Substances (RoHS) compliant.

k. Provide dimming capability as indicated in the luminaire schedule on project plans. Dimmable drivers must dim down to 10 percent. Dimmable drivers must be controlled by a Class 2 low voltage 0-10VDC controller dimming signal protocol unless otherwise specified. LED drivers of the same family/series must track evenly across multiple luminaires at all light levels.

2.5 LIGHTING CONTROLS

Provide lighting control systems that do not switch off battery-operated or emergency backup luminaires or exit signs in path of egress. Provide system with override of lighting control devices controlling luminaires in path of egress with activation of fire alarm system.

2.5.1 System

Provide lighting control system that operates the lighting system as described in the lighting control strategies in the project plans. Submit Sequence of Operation for Lighting Control System describing the operation of the proposed lighting control system and devices. Sequence of Operation must provide the strategies identified in the lighting control strategies.

2.5.1.1 Localized Control Systems

Provide room or area-wide lighting control system capable of manual control, time-based control, and receiving input from photosensors and occupancy/vacancy sensors.

2.5.1.1.1 Local Area Controller

Provide controller designed for single area or room with the following requirements:

a. Operates at a voltage of 120-277 volts at 50/60 hertz.

b. 2 zone, with 2 relays rated 20 amps each with one manual dimmer per zone.

c. Provide inputs for occupancy/vacancy sensors, photosensors, and low-voltage wall switches.

d. Provide daylight harvesting capability with full-range dimming control with input from photosensor.

e. Provide capability for receptacle load control from occupancy sensors.

f. Provide full 'OFF' function with input from external time clock input.

g. Capable of 0-10V dimming.

h. Provide override 'ON' function with input from Fire Alarm Control Panel for all emergency lighting. Controller must not turn off power to emergency batteries or exit signs.

2.5.1.2 Centralized Control Systems

Provide a centralized lighting control system capable of manual control, time-based control, receiving input from photosensors and occupancy/vacancy sensors, with the capabilities of controlling, monitoring, and programming changes from one centralized on-site location, and integration with other building systems.

2.5.1.2.1 Lighting Contactor

NEMA ICS 2, NEMA ICS 6. Provide an electrically-held lighting contactor housed in a NEMA 1 enclosure. Provide contactor with two normally-open(NO) normally closed(NC), single pole contacts, rated 600 volts, 30 amps. Provide coil operating voltage of 120 volts.

2.5.2 Devices

2.5.2.1 Switches

Provide line-voltage toggle switches as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. When used for non-digital loads, devices must be rated at 20 Amps inductive load, and be compatible with the lighting control systems.

2.5.2.2 Wall Box Dimmers

UL 1472, UL 20, IEEE C62.41, NEMA 77, NEMA SSL 7A. Dimmers must provide flicker-free, continuously variable light output throughout the dimming range of 10 percent to 100 percent. Devices must be capable of operating at their full rated capacity regardless of being single or ganged-mounted, and be compatible with three-way and four-way switching scenarios.

Provide wall-box dimmers that meet the following requirements:

a. Device operates as part of a lighting control system.

b. Device operates with the use of a vertical slider, paddle, rotary, button, or toggle with adjacent vertical slider.

c. Finish of device matches switches and outlets in the same area.

d. Back box in wall has sufficient depth to accommodate body of switch and wiring.

e. Dimmer is capable of controlling 0-10 volt LED drivers. Dimmers and the drivers they control must be provided from the same manufacturer

or tested and certified as compatible for use together.

f. Radio frequency interference suppression is integral to device.

2.5.2.3 Scene Wallstations

Provide scene wallstations that are compatible with the other components of the lighting control system and capable of Class 1 or 2 wiring methods in accordance with the NEC and local codes. Provide devices that contain on/off group, preset scene functions, or dim up/dim down interface through front panel. Programming of new scenes or zone assignments must be accomplished by authorized personnel from the space being controlled. Provide labeling for each button, including laminated sheet with scene descriptions to be posted near each scene controller.

2.5.2.4 Occupancy/Vacancy Sensors

IEEE C62.41, NEMA WD 1, UL 94, UL 916, UL 508, ASTM D4674 REV A, NEMA WD 7. Provide occupancy/vacancy sensors with coverage patterns as indicated on project plans. Provide no less quantity of sensors as shown on plans, but add additional sensors when required to fulfill coverage requirement for the specific model of sensor provided. Provide sensor types as described in the sequence of operations. Sensor locations and quantities are shown in shop drawings provided by the lighting control system manufacturer. Provide occupancy sensor operation that requires movement to activate luminaires controlled and turns luminaires off after a set time of inactivity. Provide vacancy sensor operation that requires manual control to activate luminaires and turns luminaires off after a set time of inactivity. Provide ceiling or wall-mounted occupancy/vacancy sensors that meet the following requirements:

a. Operating voltage of 12-24 volts.

b. Time delay of 30 seconds to 30 minutes with at least four intermediate time delay settings.

c. Sensors are ceiling mounted unless otherwise stated in Contract Documents.

d. Networked sensor with no minimum or maximum load. Sensor is programmed to control zones.

e. Shielded or controlled by internal logic to adjust sensitivity to avoid false triggering due to ambient temperature, air temperature variations or HVAC air movement.

f. Sensor is equipped to automatically energize the connected load upon loss of normal power when located in a means of egress.

g. Occupancy and vacancy operation is field-adjustable and programmable via lighting control system processor.

h. No leakage current to load when in the off mode.

i. Utilize zero-crossing circuitry to prevent damage from high inrush current and to promote long life operation.

j. Allow the adding or deleting of specific luminaires or zones to the assigned sensor without the use of ladders.

k. Provide an isolated relay for integrating control of HVAC or other automated systems.

2.5.2.4.1 Passive Infrared Sensors

Provide Passive Infrared Sensors (PIR) sensors that detect occupancy by sensing heat and movement in the area of coverage. Provide sensors are constructed of a housing of high-impact, injection-molded thermoplastic. Provide PIR sensors that are temperature compensated, with a dual element sensor and a multi-element fresnel lens of POLY IR4 material.

2.5.2.4.2 Ultrasonic Sensors

Provide ultrasonic sensors that detect occupancy by sensing a change in pattern of reflected ultrasonic waves in the area of coverage. Provide sensors that are constructed of a housing of high-impact, injection-molded thermoplastic. Provide ultrasonic sensors that operate at 40 kHz.

2.5.2.4.3 Dual Technology Sensors

Provide dual technology sensors that meet the requirements for PIR sensors and ultrasonic sensors indicated above. If either the PIR or ultrasonic sensing registers occupancy, the luminaires must remain on.

2.5.2.4.4 Integrated Sensors

Provide integrated occupancy/vacancy sensors that mount directly to the luminaires as indicated in project plans. Sensor mounts to standard junction box or directly to luminaire using a nipple mount. Provide sensors that communicate to local area controller via RJ45.

2.5.2.4.5 Power Packs

UL 2043. Provide power packs to provide power to lighting control sensors as required in accordance with the manufacturer's specifications. Provide power packs that meet the following requirements:

a. Operate at an input voltage of 120-277 VAC, with an output voltage 12-24 VDC at 225 mA.

b. Constructed of plenum-rated, high-impact thermoplastic enclosure.

c. Utilizes zero-crossing circuitry to prevent damage from inrush current.

d. Maximum load rating of 16 amps for electronic lighting loads.

e. Directive 2011/65/EU. Restriction of Hazardous Substances (RoHS) compliant.

2.5.2.5 Photosensors

Provide photosensors that meet the following requirements:

a. Detect changes in ambient lighting level and enable dimming as required by sequence of operation by operating in an open-loop system.

b. Contain a detection cone, where the base of the cone may be circular or an elongated shape, and where the smallest angle between the edge

and the axis of the cone is between 20 and 50 degrees. The cone axis may be tilted to the vertical when installed to give the sensor preferred directionality.

c. Sensors are ceiling-mounted with sensitivity, filtering, range and viewing angle to meet requirements of sequence of operation, scope of work and construction documents.

d. Time delay that is adjustable from 1 to 30 seconds ON delay, and 1 to 30 minutes OFF delay to prevent cycling, with deadband adjustment of 25 percent to 100 percent above lower setpoint.

e. Output dimming signal is linear to light level with less than 1 percent variation. Cadmium sulfide photo-resistors are not acceptable.

f. Sensor is not combined in the same housing or location with occupancy or vacancy sensors if the proper location for one function compromises the successful operation of the other function, or in any way reduces the system's ability to meet the design intent.

2.6 EXIT AND EMERGENCY LIGHTING EQUIPMENT

2.6.1 Exit Signs

UL 924, NFPA 101. Provide wattage as indicated in the luminaire schedule on project plans. Provide LED Exit Signs that meet the following criteria:

a. Housing as indicated on drawings.

b. UL listed.

c. Configured for universal mounting.

d. 6 inch high, 3/4 inch stroke green lettering on face of sign with chevrons on either side of lettering to indicate direction.

e. Single or double face as indicated in project plans and luminaire schedule.

2.6.1.1 Exit Signs with Battery Backup

Equip with automatic power failure device, test switch, and pilot light, and fully automatic high/low trickle charger in a self-contained power pack. Battery must be sealed, maintenance free nickel-cadmium type, and must operate unattended for a period of not less than five years. Emergency run time must be a minimum of 1-1/2 hours. LEDs must have a minimum rated life of 10 years. Provide self-diagnostic circuitry integral to emergency LED driver.

2.6.2 LED Emergency Drivers

UL 924, NFPA 101. Provide LED emergency driver with automatic power failure detection, test switch and LED indicator (or combination switch/indicator) located on luminaire exterior, and fully-automatic solid-state charger, battery and inverter integral to a self-contained housing. Provide self-diagnostic function integral to emergency driver. Integral nickel-cadmium battery is required to supply a minimum of 90 minutes of emergency power at 10 watts, 10-50 VDC, constant output. Driver must be RoHS compliant, rated for installation in plenum-rated

spaces and damp locations, and be warranted for a minimum of five years.

2.6.3 Self-Diagnostic Circuitry for LED Drivers

UL 924, NFPA 101. Provide emergency lighting unit with fully-automatic, integral self-testing/diagnostic electronic circuitry. Circuitry must provide for a one minute diagnostic test every 28 days, and a 30 minute diagnostic test every six months, minimum. Any malfunction of the unit must be indicated by LED(s) visible from the exterior of the luminaire. A manual test switch must also be provided to perform a diagnostic test at any given time.

2.7 LUMINAIRE MOUNTING ACCESSORIES

2.7.1 Suspended Luminaires

a. Provide hangers capable of supporting twice the combined weight of luminaires supported by hangers.

b. Hangers must allow luminaires to swing within an angle of 45 degrees. Brace pendents 4 feet or longer to limit swinging. Provide with swivel hangers to ensure a plumb installation for rigid stem pendents. Provide cadmium-plated steel with a swivel-ball tapped for the conduit size indicated.

c. Single-unit suspended luminaires must have cable hangers. Multiple-unit or continuous row luminaires with a separate power supply cord must have a tubing or stem for wiring at one point and a tubing or rod suspension provided for each unit length of chassis, including one at each end.

d. Provide all linear pendent and surface mounted luminaires with two supports per four-foot section or three per eight-foot section unless otherwise recommended by manufacturer.

e. Provide rods in minimum 0.18 inch diameter.

2.7.2 Recess and Surface Mounted Luminaires

Provide access to light source and LED driver from bottom of luminaire. Provide trim and lenses for the exposed surface of flush-mounted luminaires as indicated on project drawings and specifications. Luminaires recessed in ceilings which have a fire resistive rating of one hour or more must be enclosed in a box which has a fire resistive rating equal to that of the ceiling. For surface mounted luminaires with brackets, provide flanged metal stem attached to outlet box, with threaded end suitable for supporting the luminaire rigidly in design position. Flanged part of luminaire stud must be of broad base type, secured to outlet box at not fewer than three points.

2.7.3 Luminaire Support Hardware

2.7.3.1 Wire

ASTM A641/A641M. Galvanized, soft tempered steel, minimum 0.11 inches in diameter, or galvanized, braided steel, minimum 0.08 inches in diameter.

2.7.3.2 Wire for Humid Spaces

ASTM A580/A580M. Composition 302 or 304, annealed stainless steel, minimum 0.11 inches in diameter.

ASTM B164. UNS NO4400, annealed nickel-copper alloy, minimum 0.11 inches in diameter.

2.7.3.3 Threaded Rods

Threaded steel rods, 3/16 inch diameter, zinc or cadmium coated.

2.7.3.4 Straps

Galvanized steel, one by 3/16 inch, conforming to ASTM A653/A653M, with a light commercial zinc coating or ASTM A1008/A1008M with an electrodeposited zinc coating conforming to ASTM B633, Type RS.

2.8 EQUIPMENT IDENTIFICATION

2.8.1 Manufacturer's Nameplate

Each item of equipment must have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.8.2 Labels

UL 1598. All luminaires must be clearly marked for operation of specific light sources and LED drivers. The labels must be easy to read when standing next to the equipment, and durable to match the life of the equipment to which they are attached. Note the following light source characteristics in the format "Use Only _____":

a. Correlated Color Temperature (CCT) and Color Rendering Index (CRI) for all luminaires.

b. Driver and dimming protocol.

All markings related to light source type must be clear and located to be readily visible to service personnel, but unseen from normal viewing angles when light sources are in place. LED drivers must have clear markings indicating dimming type and indicate proper terminals for the various outputs.

2.9 FACTORY APPLIED FINISH

NEMA 250. Provide all luminaires and lighting equipment with factory-applied painting system that as a minimum, meets requirements of corrosion-resistance testing.

PART 3 EXECUTION

3.1 INSTALLATION

IEEE C2, NFPA 70.

3.1.1 Light Sources

When light sources are not provided as an integral part of the luminaire, deliver light sources of the type, wattage, lumen output, color temperature (CCT), color rendering index (CRI), and voltage rating indicated to the project site and install just prior to project completion, if not already installed in the luminaires from the factory.

3.1.2 Luminaires

Set luminaires plumb, square, and level with ceiling and walls, in alignment with adjacent luminaires and secure in accordance with manufacturers' directions and approved drawings. Provide accessories as required for ceiling construction type indicated on Finish Schedule. Luminaire catalog numbers do not necessarily denote specific mounting accessories for type of ceiling in which a luminaire may be installed. Provide wires, straps, or rods for luminaire support in this section. Install luminaires with vent holes free of air blocking obstacles.

3.1.2.1 Suspended Luminaires

Measure mounting heights from the bottom of the luminaire for ceiling-mounted luminaires and to center of luminaire for wall-mounted luminaires. Obtain architect approval of the exact mounting height on the job before commencing installation and, where applicable, after coordinating with the type, style, and pattern of the ceiling being installed. Support suspended luminaires from structural framework of ceiling or from inserts cast into slab.

a. Provide suspended luminaires with 45 degree swivel hangers so that they hang plumb and level.

b. Locate so that there are no obstructions within the 45 degree range in all directions.

c. The stem, canopy and luminaire must be capable of 45 degree swing.

d. Rigid pendent stem, aircraft cable, rods, or chains 4 feet or longer excluding luminaire must be braced to prevent swaying using three cables at 120 degree separation.

e. Suspended luminaires in continuous rows must have internal wireway systems for end to end wiring and must be properly aligned to provide a straight and continuous row without bends, gaps, light leaks or filler pieces.

f. Utilize aligning splines on extruded aluminum luminaires to assure minimal hairline joints.

g. Support steel luminaires to prevent "oil-canning" effects.

h. Match supporting pendents with supported luminaire. Aircraft cable must be stainless steel.

i. Match finish of canopies to match the ceiling, and provide low profile canopies unless otherwise shown.

j. Maximum distance between suspension points must be 10 feet or as recommended by the manufacturer, whichever is less.

3.1.2.2 Recessed and Semi-Recessed Luminaires

a. Support recessed and semi-recessed luminaires independently from the building structure by a minimum of two wires, straps or rods per luminaire and located near opposite corners of the luminaire. Secure horizontal movement with clips provided by manufacturer. Ceiling grid clips are not allowed as an alternative to independently supported luminaires.

b. Support round luminaires or luminaires smaller in size than the ceiling grid independently from the building structure by a minimum of four wires, straps or rods per luminaire, spaced approximately equidistant around.

c. Do not support luminaires by acoustical tile ceiling panels.

d. Where luminaires of sizes less than the ceiling grid are indicated to be centered in the acoustical panel, support each independently and provide at least two 3/4 inch metal channels spanning, and secured to, the ceiling tees for centering and aligning the luminaire.

e. Luminaires installed in suspended ceilings must also comply with the requirements of Section 09 51 00 ACOUSTICAL CEILINGS.

f. Adjust aperture rings on all applicable ceiling recessed luminaires to accommodate various ceiling material thickness. Coordinate cut-out size in ceiling to ensure aperture covers cut-out entirely. Install aperture rings such that the bottom of the ring is flush with finished ceiling or not more than 1/16 inch above. Do not install luminaires such that the aperture ring extends below the finished ceiling surface.

3.1.2.3 Field Applied Painting

Provide field applied painting for luminaire type where indicated in Drawings. Paint lighting equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Provide painting as specified in Section 09 90 00 PAINTS AND COATINGS.

3.1.3 LED Drivers

Provide LED drivers integral to luminaire as constructed by the manufacturer.

3.1.4 Exit Signs

NFPA 101. Wire exit signs and emergency lighting units ahead of the local switch, to the normal lighting circuit located in the same room or area.

3.2 FIELD QUALITY CONTROL

3.2.1 Tests

3.2.1.1 Lighting Control Verification Tests

Verify lighting control system and devices operate according to approved sequence of operations. Verification tests are to be completed after commissioning.

a. Verify occupancy/vacancy sensors operate as described in sequence of operations. Provide testing of sensor coverage, sensitivity, and time-out settings in all spaces where sensors are placed. This is to be completed only after all furnishings have been installed. Submit occupancy/vacancy sensor verification test.

b. Verify photosensors operate as described in sequence of operations. Provide testing of sensor coverage, aiming, and calibration in all spaces where sensors are placed. This is to be completed only after all furnishings have been installed. Submit photosensor verification test.

c. Verify wall box dimmers and scene wallstations operate as described in sequence of operations.

3.2.1.2 Emergency Lighting Test

Interrupt power supply to demonstrate proper operation of emergency lighting. If adjustments are made to the lighting system, re-test system to show compliance with standards.

3.3 CLOSEOUT ACTIVITIES

3.3.1 Commissioning

NFPA 101. Commission all components of the lighting system and lighting control system in accordance with Section 01 91 00.15 BUILDING COMMISSIONING. Factory Trained Field Service Technician is responsible for calibration and programming sequences for input devices and systems in accordance with the requirements described in the sequence of operation.

3.3.2 Training

3.3.2.1 Maintenance Staff Training

Submit a Maintenance Staff Training Plan at least 30 calendar days prior to training session that describes training procedures for Owner's personnel in the operation and maintenance of lighting and lighting control system. Provide on-site training which demonstrates full system functionality, assigning schedules, calibration adjustments for light levels and sensor sensitivity, integration procedures for connecting to third-party devices, and manual override including information on appropriate use. Provide protocols for troubleshooting, maintenance, repair, and replacement, and literature on available system updates and process for implementing updates.

3.3.2.2 End-User Training

Submit an End-User Training Plan at least 30 calendar days prior to training session that describes training procedures for end-users on the lighting control system. Provide users with a list of control devices located within user-occupied spaces, such as photosensors and occupancy and vacancy sensors, including information on the proper operation and schedule for each device. Provide demonstration for each type of interface. Provide users with the building schedule as currently commissioned, including conditional programming based on astronomic time clock functionality. Provide users with the correct contact information for maintenance personnel who will be available to address any lighting control issues.

Provide laminated instructions to the user at each scene wallstation. Provide only instructions relevant to the functionality of the specific scene wallstation. Provide a description of each labeled scene control button. If the room utilizes occupancy/vacancy sensors or photosensors, include a description of this functionality on the instruction sheet.

-- End of Section --

SECTION 26 56 00

EXTERIOR LIGHTING
08/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus

EUROPEAN UNION (EU)

Directive 2011/65/EU	(2011) Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment

ILLUMINATING ENGINEERING SOCIETY (IES)

ANSI/IES LM-79	(2019) Approved Method: Electrical and Photometric Measurements of Solid State Lighting Products
ANSI/IES LM-80	(2020) Approved Method: Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays and Modules
ANSI/IES LS-1	(2020) Lighting Science: Nomenclature and Definitions for Illuminating Engineering
ANSI/IES RP-8	(2018; Addenda 1 2020; Errata 1-2 2021) Recommended Practice for Design and Maintenance of Roadway and Parking Facility Lighting
ANSI/IES TM-15	(2020) Technical Memorandum: Luminaire Classification System for Outdoor Luminaires
ANSI/IES TM-21	(2021) Technical Memorandum: Projecting Long-TermLuminous, Photon, and Radiant Flux Maintenance of LED Light Sources
IES Lighting Library	IES Lighting Library

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C62.41.2	(2002) Recommended Practice on

	Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ANSLG C78.377	(2024) Electric Lamps– Specifications for the Chromaticity of Solid State Lighting Products
NEMA C82.77-10	(2020) Harmonic Emission Limits - Related Power Quality Requirements
NEMA C136.10	(2023) American National Standard for Roadway and Area Lighting Equipment-Locking-Type Photocontrol Devices and Mating Receptacles--Physical and Electrical Interchangeability and Testing
NEMA C136.31	(2023) Roadway and Area Lighting Equipment - Luminaire Vibration
NEMA SSL 1	(2016) Electronic Drivers for LED Devices, Arrays, or Systems
NEMA SSL 3	(2011) High-Power White LED Binning for General Illumination

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2026; TIA 26-1; ERTA 26-1; TIA 26-2; TIA 26-3; TIA 26-4; TIA 26-5; TIA 26-6; TIA 26-7; ERTA 26-2; ERTA 26-3) National Electrical Code

UL SOLUTIONS (UL)

UL 773	(2016; Reprint Jul 2020) UL Standard for Safety Plug-In, Locking Type Photocontrols for Use with Area Lighting
UL 773A	(2016; Reprint Jan 2024) UL Standard for Safety Nonindustrial Photoelectric Switches for Lighting Control
UL 1310	(2018; Reprint Jun 2022) UL Standard for Safety Class 2 Power Units
UL 1598	(2021; Reprint Jan 2024) UL Standard for Safety Luminaires
UL 8750	(2020; Reprint Aug 2024) UL Standard for Safety Light Emitting Diode (LED) Equipment for Use in Lighting Products

1.2 RELATED REQUIREMENTS

Materials not considered to be luminaires, luminaire accessories, or lighting equipment are specified in Section(s) 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Luminaires and accessories installed in interior of buildings or attached to the exterior of a building are specified in Section 26 51 00 INTERIOR LIGHTING. Commissioning requirements are specified in Section 01 91 00.15 BUILDING COMMISSIONING.

1.3 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications and on the drawings must be as defined in IEEE 100 and ANSI/IES LS-1.

b. For LED luminaire light sources, "Useful Life" is the operating hours before reaching 70 percent of the initial rated lumen output (L70) with no catastrophic failures under normal operating conditions. This is also known as 70 percent "Rated Lumen Maintenance Life" as defined in ANSI/IES LM-80.

c. For LED luminaires, "Luminaire Efficacy" (LE) is the appropriate measure of energy efficiency, measured in lumens/watt. This is gathered from LM-79 data for the luminaire, in which absolute photometry is used to measure the lumen output of the luminaire as one entity, not the source separately and then the source and housing together.

d. Total Harmonic Distortion (THD) is the Root Mean Square (RMS) of all the harmonic components divided by the total fundamental current.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Luminaire Drawings; G

Control System One-Line Diagram; G

Sequence of Operation for Exterior Lighting Control System; G

SD-03 Product Data

Luminaires; G

Light Sources; G

LED Drivers; G

Luminaire Warranty; G

Lighting Controls Warranty; G

Photosensors; G

SD-05 Design Data

Luminaire Design Data; G

SD-06 Test Reports

ANSI/IES LM-79 Test Report; G

ANSI/IES LM-80 Test Report; G

ANSI/IES TM-21 Test Report; G

SD-10 Operation and Maintenance Data

Lighting System, Data Package 5; G

Exterior Lighting Control System, Data Package 5; G

Maintenance Staff Training Plan; G

End-User Training Plan; G

1.5 QUALITY ASSURANCE

Data, drawings, and reports must employ the terminology, classifications and methods prescribed by the IES Lighting Library as applicable, for the lighting system specified.

1.5.1 Drawing Requirements

1.5.1.1 Luminaire Drawings

Include dimensions, accessories, and installation and construction details. Photometric data, including CRI, CCT, TM-15-11 BUG rating, LED driver type, zonal lumen data, and candlepower distribution data per LM-79 must accompany shop drawings.

1.5.2 Luminaire Design Data

a. Provide distribution data according to IES classification type as defined in IES Lighting Library and ANSI/IES RP-8.

b. B.U.G. rating for the installed position as defined by ANSI/IES TM-15 and shielding as defined by ANSI/IES RP-8.

c. Provide safety certification and file number for the luminaire family. Include listing, labeling and identification in accordance with NFPA 70 (NEC). Applicable testing bodies are determined by the US Occupational Safety Health Administration (OSHA) as Nationally Recognized Testing Laboratories (NRTL) and include: CSA (Canadian Standards Association), ETL (Edison Testing Laboratory), and UL (Underwriters Laboratories).

d. Provide long term lumen maintenance projections for each LED luminaire in accordance with ANSI/IES TM-21. Data used for projections must be obtained from testing in accordance with ANSI/IES LM-80.

1.5.3 ANSI/IES LM-79 Test Report

Submit test report on manufacturer's standard production model of specified luminaire. Testing must be performed at the same operating drive current as specified luminaire. Include all applicable and required data as outlined under "14.0 Test Report" in ANSI/IES LM-79.

1.5.4 ANSI/IES LM-80 Test Report

Submit report on manufacturer's standard production LED light source (package, array, or module) of specified luminaire. Testing must be performed at the same operating drive current as specified luminaire. Include all applicable and required data as outlined under "8.0 Test Report" in ANSI/IES LM-80.

1.5.5 ANSI/IES TM-21 Test Report

Submit test report on manufacturer's standard production LED light source (package, array or module) of specified luminaire. Testing must be performed at the same operating drive current as specified luminaire. Include all applicable and required data, as well as required interpolation information as outlined under "7.0 Report" in ANSI/IES TM-21.

1.5.6 Test Laboratories

Test laboratories for the ANSI/IES LM-79 and ANSI/IES LM-80 test reports must be one of the following:

a. National Voluntary Laboratory Accreditation Program (NVLAP) accredited for solid-state lighting testing as part of the Energy-Efficient Lighting Products laboratory accreditation program.

b. One of the qualified labs listed on the Department of Energy - Energy Efficiency & Renewable Energy, Solid-State Lighting web site.

c. One of the EPA-Recognized Laboratories listed at for LM-80 testing.

1.5.7 Regulatory Requirements

Equipment, materials, installation, and workmanship must be in accordance with the mandatory provisions of NFPA 70 unless more stringent requirements are specified or indicated. Provide luminaires and assembled components that are approved by and bear the label of UL for the applicable location and conditions unless otherwise specified.

1.5.8 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products must have been in satisfactory commercial or industrial use for six months prior to bid opening. The six-month period must include applications of equipment and materials under similar circumstances and of similar size. The product must have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the six-month period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.8.1 Alternative Qualifications

Products having less than a six-month field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.8.2 Material and Equipment Manufacturing Date

Do not use products manufactured more than six months prior to date of delivery to site, unless specified otherwise.

1.6 DELIVERY, STORAGE, AND HANDLING OF POLES

1.7 WARRANTY

Support all equipment items by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.7.1 Luminaire Warranty

Provide and transfer to the government the original LED luminaire manufacturers standard commercial warranty for each different luminaire manufacturer used in the project.

a. Provide a written five year minimum replacement warranty for material, luminaire finish, and workmanship. Provide written warranty document that contains all warranty processing information needed, including customer service point of contact, whether or not a return authorization number is required, return shipping information, and closest return location to the luminaire location.

    (1) Finish warranty must include failure and substantial deterioration such as blistering, cracking, peeling, chalking, or fading.

    (2) Material warranty must include:

        (a) All LED drivers and integral control equipment.

        (b) Replacement when more than 15 percent of LED sources in any lightbar or subassembly(s) are defective, non-starting, or operating below 70 percent of specified lumen output.

b. Warranty period must begin in accordance with the manufacturer's standard warranty starting date.

c. Provide replacements that are promptly shipped, without charge, to the using Government facility point of contact and that are identical to or an improvement upon the original equipment. All replacements must include testing of new components and installation.

1.7.2 Lighting Controls Warranty

Provide and transfer to the government the original lighting controls manufacturers standard commercial warranty for each different lighting

controls manufacturer used in the project. Warranty coverage must begin from date of final system commissioning or three months from date of delivery, whichever is the earliest. Warranty service must be performed by a factory-trained engineer or technician.

a. Unless otherwise noted, provide a written five year minimum warranty on the complete system for all systems with factory commissioning. Provide warranty that covers 100 percent of the cost of any replacement parts and services required over the five years which are directly attributable to the product failure. Failures include, but are not limited to, the following:

(1) Software: Failure of input/output to execute switching or dimming commands.

(2) Damage of electronic components due to transient voltage surges.

(3) Failure of control devices, including but not limited to photosensors and motion sensors.

b. Provide a written five year minimum warranty on all input devices against defect in workmanship or materials provided by device manufacturer.

c. Provide a written five year minimum warranty on all control components attached to luminaires against defect in workmanship or materials.

1.8 OPERATION AND MAINTENANCE MANUALS

1.8.1 Lighting System

Provide operation and maintenance manuals for the lighting system in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA that provide basic data relating to the design, operation, and maintenance of the lighting system. Include the following:

a. Manufacturers' operating and maintenance manuals.

b. Luminaire shop drawings for modified and custom luminaires.

c. Luminaire Manufacturers' standard commercial warranty information as specified in paragraph LUMINAIRE WARRANTY.

1.8.2 Exterior Lighting Control System

Provide operation and maintenance manuals for the exterior lighting control system in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA that provide basic data relating to the design, operation, and maintenance of the exterior lighting control system. Include the following:

a. Control System One-Line Diagram

b. Product data for all devices, including installation and programming instructions.

c. Training materials, such as videos or in-depth manuals, that cover basic operation of the lighting control system and instructions on modifying the control system. Training materials must include

calibration, adjustment, troubleshooting, maintenance, repair, and replacement.

d. Motion sensor coverage layout.

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

2.2 LUMINAIRES

UL 1598, NEMA C82.77-10. Provide luminaires as indicated in the luminaire schedule and XL plates or details on project plans, complete with light source, wattage, and lumen output indicated. All luminaires of the same type must be provided by the same manufacturer. Luminaires must be specifically designed for use with the LED driver and light source provided.

2.2.1 Spares

Provide 10 percent of each type of luminaire with a minimum of 2 spare luminaires of each type. Provide at least one of each type with an emergency driver. Spares must be turned over to civil engineering (CE).

2.2.2 Luminaires

UL 8750, ANSI/IES LM-79, ANSI/IES LM-80. For all luminaires, provide:

a. Complete system with LED drivers and light sources.

b. Housing constructed of non-corrosive materials. All new aluminum housings must be anodized or powder-coated. All new steel housings must be treated to be corrosion resistant.

c. ANSI/IES TM-21, ANSI/IES LM-80. Minimum L70 lumen maintenance value of 50,000 hours unless otherwise indicated in the luminaire schedule. Luminaire drive current value must be identical to that provided by test data for luminaire in question.

d. Minimum efficacy as specified in the luminaire schedule. Theoretical models of initial lamp lumens per watt are not acceptable. If efficacy values are not listed in the luminaire schedule, provide luminaires that meet the following minimum values:

Luminaire Style	Minimum Luminaire Efficacy
Exterior Wall Sconce	50 LPW

e. Product rated for operation within an ambient temperature range of minus 22 degrees F to 104 degrees F.

f. UL listed for wet locations.

g. IES Lighting Library. Light distribution and NEMA field angle classifications as indicated in luminaire schedule on project plans.

h. Housing finish that is baked-on enamel, anodized, or baked-on powder coat paint. Finish must be capable of surviving ASTM B117 salt fog

environment testing for 2500 hours minimum without blistering or peeling.

i. LED driver and light source package, array, or module are accessible for service or replacement without removal or destruction of luminaire.

j. ANSI/IES TM-15. Does not exceed the BUG ratings as listed in the luminaire schedule. If BUG ratings are not listed in the luminaire schedule, provide luminaires that meet the following minimum values for each application and mounting conditions:

Lighting Application	Mounting Conditions	BUG Rating
Exterior Wall Sconce	Above 4 feet AFF	B1-U0-G2

k. Fully assembled and electrically tested prior to shipment from factory.

l. Finish color is as indicated in the luminaire schedule or detail on the project plans.

m. Lenses constructed of clear tempered glass or UV-resistant acrylic.

n. All factory electrical connections are made using crimp, locking, or latching style connectors. Twist-style wire nuts are not acceptable.

o. NEMA C136.31. Comply with 3G vibration testing.

p. Incorporate modular electrical connections, and construct luminaires to allow replacement of all or any part of the optics, heat sinks, LED drivers, surge suppressors and other electrical components using only a simple tool, such as a manual or cordless electric screwdriver.

2.3 LIGHT SOURCES

NEMA ANSLG C78.377, NEMA SSL 3. Provide type, lumen rating, and wattage as indicated in luminaire schedule on project plans.

2.3.1 LED Light Sources

Provide LED light sources that meet the following requirements:

a. NEMA ANSLG C78.377. Emit white light and have a nominal Correlated Color Temperature (CCT) of 4000 Kelvin.

b. Minimum Color Rendering Index (CRI) of 70.

c. Directive 2011/65/EU. Restriction of Hazardous Substances (RoHS) compliant.

d. Light source color consistency by utilizing a binning tolerance within a 4-step McAdam ellipse.

2.4 LED DRIVERS

NEMA SSL 1, UL 1310. Provide LED Drivers that are electronic, UL Class 1 or Class 2, constant-current type and meet the following requirements:

a. The combined LED driver and LED light source system is greater than or

equal to the minimum luminaire efficacy values as listed in the luminaire schedule provided.

b. Operate at a voltage of 120-277 volts at 50/60 hertz, with input voltage fluctuations of plus or minus 10 percent.

c. Power Factor (PF) greater than or equal to 0.90 at full input power and across specified dimming range.

d. Maximum Total Harmonic Distortion (THD) less than or equal to 20 percent at full input power and across specified dimming range.

e. Operates for at least 50,000 hours at maximum case temperature and 90 percent non-condensing relative humidity.

f. Meets the "Elevated" (10kV/10kA) requirements per IEEE C62.41.2 -2002. Manufacturer must indicate whether failure of the electrical immunity system can possibly result in disconnect of power to luminaire. Provide surge protection that is integral to the LED driver.

g. Contains integral thermal protection that reduces the output power to protect the driver and light source from damage if the case temperature approaches or exceeds the driver's maximum operating temperature.

h. Complies with the requirements of the Federal Communications Commission (FCC) rules and regulations, Title 47 CFR part 15, Non-Consumer (Class A) for EMI/RFI (conducted and radiated).

i. Class A sound rating for all drivers mounted under a covered structure, such as a canopy, or where otherwise appropriate.

j. Directive 2011/65/EU. Restriction of Hazardous Substances (RoHS) compliant.

k. UL listed for wet locations typical of exterior installations.

l. Dimmable, and compatible with a standard dimming control circuit of 0 - 10V.

m. Rated to operate between ambient temperatures of minus 22 degrees F and 104 degrees F.

2.5 LIGHTING CONTROLS

Provide lighting controls as shown on Contract Documents.

2.5.1 System

Provide exterior lighting control system that operates the exterior lighting system as described in the exterior lighting control strategies in the project plans. Submit Sequence of Operation for Exterior Lighting Control System describing the operation of the proposed exterior lighting control system and devices. Sequence of Operation must provide the strategies identified in the exterior lighting control strategies.

2.5.2 Devices

2.5.2.1 Photosensors

UL 773, UL 773A. Provide Photosensors that meet the following requirements:

a. Hermetically sealed, silicon diode light sensor type, rated at 3000 watts, 120 volts, 50/60 Hz with single-pole, single-throw contacts.

b. Turns ON at 1 to 3 footcandles and turns OFF at 3 to 15 footcandles.

c. Designed to fail to the ON position.

d. Housing is constructed of UV stabilized polypropylene, rated to operate within a temperature range of minus 40 to 158 degrees F.

e. Time delay that prevents accidental switching from transient light sources.

f. Directional lens in front of the cell to prevent fixed light sources from creating a turnoff condition.

g. Designed for 20-year service to match life expectancy of long-life LED fixtures and exceed 15,000 operations at full load. Provide photosensors with zero-cross technology to withstand severe in-rush current and extend relay life.

h. Fixed base type housing with 1/2 in threaded base for mounting to a junction box or conduit.

i. NEMA C136.10. Twist-lock receptacle type. Provide with solid brass prongs and voltage markings and color coding on exterior of housing.

j. Provide photosensors with metal oxide varistor (MOV) type surge protection.

2.6 EQUIPMENT IDENTIFICATION

2.6.1 Manufacturer's Nameplate

Each item of equipment must have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.6.2 Labels

UL 1598. Luminaires must be clearly marked for operation of specific light sources and drivers according to proper light source type. Note the following luminaire characteristics in the format "Use Only _____":

a. Correlated color temperature (CCT) and color rendering index (CRI) for all luminaires.

b. Driver and dimming protocol.

Markings related to light source type must be clear and located to be readily visible to service personnel, but unseen from normal viewing

angles when light sources are in place. LED drivers must have clear markings indicating dimming type and indicate proper terminals for the various outputs.

2.7 FACTORY APPLIED FINISH

NEMA 250. Provide all luminaires and lighting equipment with factory-applied painting system that as a minimum meets requirements of corrosion-resistance testing.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Luminaires

Install all luminaires in accordance with the luminaire manufacturer's written instructions. Install all luminaires at locations and heights as indicated on the project plans. Level all luminaires in accordance to manufacturer's written instructions.

3.1.2 LED Drivers

Provide LED drivers integral to luminaire as constructed by the manufacturer.

3.1.3 Grounding

Ground noncurrent-carrying parts of equipment including luminaires, mounting arms, brackets, and metallic enclosures as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Where copper grounding conductor is connected to a metal other than copper, provide specially treated or lined connectors suitable for this purpose.

3.2 FIELD QUALITY CONTROL

3.2.1 Tests

Upon completion of installation, verify that equipment is properly installed, connected, and adjusted. Perform initial operational test, consisting of the entire system energized for 72 consecutive hours without any failures of any kind occurring in the system. All circuits must test clear of faults, grounds, and open circuits.

3.2.1.1 Lighting Control Verification Test

Verify lighting control system and devices operate according to approved sequence of operations. Verification tests are to be completed after commissioning.

3.3 CLOSEOUT ACTIVITIES

3.3.1 Training

Provide on-site training to the Owner's personnel in the operation and maintenance of lighting and lighting control system. Provide training that includes calibration, adjustment, troubleshooting, maintenance, repair, and replacement.

3.3.1.1 Maintenance Staff Training

Submit a Maintenance Staff Training Plan at least 30 calendar days prior to training session that describes training procedures for Owner's personnel in the operation and maintenance of lighting and lighting control system. Provide on-site training which demonstrate full system functionality, assigning schedules, calibration adjustments for light levels and sensor sensitivity, integration procedures for connecting to third-party devices, and manual override including information on appropriate use. Provide protocols for troubleshooting, maintenance, repair, and replacement, and literature on available system updates and process for implementing updates.

3.3.1.2 End-User Training

Submit a End-User Training Plan at least 30 calendar days prior to training session that describes training procedures for end-users on the lighting control system. Provide demonstration for each type of user interface. Provide users with the curfew schedule as currently commissioned, including conditional programming based on astronomic time clock functionality. Provide users with the correct contact information for maintenance personnel who will be available to address any lighting control issues.

-- End of Section --

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SECTION 27 10 00

BUILDING TELECOMMUNICATIONS CABLING SYSTEM
08/11

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials

ELECTRONIC COMPONENTS INDUSTRY ASSOCIATION (ECIA)

ECIA EIA/ECA 310-E	(2005) Cabinets, Racks, Panels, and Associated Equipment

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

ICEA S-83-596	(2021) Indoor Optical Cable
ICEA S-90-661	(2021) Category 3 and 5E Individually Unshielded Twisted Pairs, Indoor Cables (With or Without an Overall Shield) for Use in General Purpose and LAN Communications Wiring Systems

NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION (NECA)

NECA/BICSI 568	(2006) Standard for Installing Building Telecommunications Cabling

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI/NEMA WC 66	(2019) Performance Standard for Category 6 and Category 7 100 Ohm Shielded and Unshielded Twisted Pairs

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2026; TIA 26-1; ERTA 26-1; TIA 26-2; TIA 26-3; TIA 26-4; TIA 26-5; TIA 26-6; TIA 26-7; ERTA 26-2; ERTA 26-3) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-455-21	(1988a; R 2012) FOTP-21 - Mating Durability of Fiber Optic Interconnecting Devices
TIA-526-7	(2015a; R 2022) Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant, Adoption of IEC 61280-4-2 edition 2: Fibre-Optic Communications Subsystem Test Procedures - Part 4-2: Installed Cable Plant - Single-Mode Attenuation and Optical Return Loss Measurement
TIA-526-14	(2023d) OFSTP-14A Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant
TIA-568.0	(2020e) Generic Telecommunications Cabling for Customer Premises
TIA-568.1	(2020e) Commercial Building Telecommunications Infrastructure Standard
TIA-568.2	(2024e) Balanced Twisted-Pair Telecommunications Cabling and Components Standards
TIA-568.3	(2022e) Optical Fiber Cabling Components Standard
TIA-569	(2019e; Add 1 2022) Telecommunications Pathways and Spaces
TIA-570	(2024e) Residential Telecommunications Infrastructure Standard
TIA-606	(2021d) Administration Standard for Telecommunications Infrastructure
TIA-607	(2019d) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises
TIA-1152	(2016; R 2021) Requirements for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling
TIA/EIA-598	(2014D; Add 2 2018) Optical Fiber Cable Color Coding
TIA/EIA-604-3	(2004b; R 2014) Fiber Optic Connector Intermateability Standard (FOCIS), Type SC and SC-APC, FOCIS-3
TIA/EIA-604-10	(2002a) FOCIS 10 Fiber Optic Connector Intermateability Standard - Type LC

U.S. FEDERAL COMMUNICATIONS COMMISSION (FCC)

FCC Part 68	Connection of Terminal Equipment to the Telephone Network (47 CFR 68)

UL SOLUTIONS (UL)

UL 50	(2024) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations
UL 444	(2017; Reprint Jun 2021) UL Standard for Safety Communications Cables
UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment
UL 514C	(2014; Reprint Apr 2024) UL Standard for Safety Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL 723	(2020) UL Standard for Safety Test for Surface Burning Characteristics of Building Materials
UL 969	(2017; Reprint May 2023) UL Standard for Safety Marking and Labeling Systems
UL 1286	(2022; Reprint Mar 2024) UL Standard for Safety Office Furnishings
UL 1666	(2007; Reprint Sep 2021) UL Standard for Safety Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts
UL 1863	(2004; Reprint Oct 2019) UL Standard for Safety Communication Circuit Accessories

1.2 RELATED REQUIREMENTS

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM and Section 33 82 00 TELECOMMUNICATIONS, OUTSIDE PLANT (OSP), apply to this section with additions and modifications specified herein.

1.3 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in this specification shall be as defined in TIA-568.1, TIA-568.2, TIA-568.3, TIA-569, TIA-606 and IEEE 100 and herein.

1.3.1 Campus Distributor (CD)

A distributor from which the campus backbone cabling emanates. (International expression for main cross-connect (MC).)

1.3.2 Building Distributor (BD)

A distributor in which the building backbone cables terminate and at which

connections to the campus backbone cables may be made. (International expression for intermediate cross-connect (IC).)

1.3.3 Floor Distributor (FD)

A distributor used to connect horizontal cable and cabling subsystems or equipment. (International expression for horizontal cross-connect (HC).)

1.3.4 Telecommunications Room (TR)

An enclosed space for housing telecommunications equipment, cable, terminations, and cross-connects. The room is the recognized cross-connect between the backbone cable and the horizontal cabling.

1.3.5 Entrance Facility (EF) (Telecommunications)

An entrance to the building for both private and public network service cables (including wireless) including the entrance point at the building wall and continuing to the equipment room.

1.3.6 Equipment Room (ER) (Telecommunications)

An environmentally controlled centralized space for telecommunications equipment that serves the occupants of a building. Equipment housed therein is considered distinct from a telecommunications room because of the nature of its complexity.

1.3.7 Open Cable

Cabling that is not run in a raceway as defined by NFPA 70. This refers to cabling that is "open" to the space in which the cable has been installed and is therefore exposed to the environmental conditions associated with that space.

1.3.8 Open Office

A floor space division provided by furniture, moveable partitions, or other means instead of by building walls.

1.3.9 Pathway

A physical infrastructure utilized for the placement and routing of telecommunications cable.

1.4 SYSTEM DESCRIPTION

The building telecommunications cabling and pathway system shall include permanently installed backbone and horizontal cabling, horizontal and backbone pathways, service entrance facilities, work area pathways, telecommunications outlet assemblies, conduit, raceway, and hardware for splicing, terminating, and interconnecting cabling necessary to transport telephone and data (including LAN) between equipment items in a building. The horizontal system shall be wired in a star topology from the telecommunications work area to the floor distributor or campus distributor at the center or hub of the star. The backbone cabling and pathway system includes intrabuilding and interbuilding interconnecting cabling, pathway, and terminal hardware. The intrabuilding backbone provides connectivity from the floor distributors to the building distributors or to the campus distributor and from the building

distributors to the campus distributor as required. The backbone system shall be wired in a star topology with the campus distributor at the center or hub of the star. The interbuilding backbone system provides connectivity between the campus distributors and is specified in Section 33 82 00 TELECOMMUNICATIONS OUTSIDE PLANT (OSP). Provide telecommunications pathway systems referenced herein as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. The telecommunications contractor must coordinate with the NMCI/COSC/NGEN contractor concerning access to and configuration of telecommunications spaces. The telecommunications contractor may be required to coordinate work effort within the telecommunications spaces with the NMCI/COSC/NGEN contractor.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Telecommunications Drawings; G

Telecommunications Space Drawings; G

In addition to Section 01 33 00 SUBMITTAL PROCEDURES, provide shop drawings in accordance with paragraph SHOP DRAWINGS.

SD-03 Product Data

Telecommunications Cabling (backbone and horizontal); G

Patch Panels; G

Telecommunications Outlet/Connector Assemblies; G

Equipment Support Frame; G

Connector Blocks; G

Submittals shall include the manufacturer's name, trade name, place of manufacture, and catalog model or number. Include performance and characteristic curves. Submittals shall also include applicable federal, military, industry, and technical society publication references. Should manufacturer's data require supplemental information for clarification, the supplemental information shall be submitted as specified in paragraph REGULATORY REQUIREMENTS and as required in Section 01 33 00 SUBMITTAL PROCEDURES.

SD-06 Test Reports

Telecommunications Cabling Testing; G

SD-07 Certificates

Telecommunications Contractor Qualifications; G

Key Personnel Qualifications; G

Manufacturer Qualifications; G

Test Plan; G

SD-09 Manufacturer's Field Reports

Factory Reel Tests; G

SD-10 Operation and Maintenance Data

Telecommunications Cabling and Pathway System Data Package 5; G

SD-11 Closeout Submittals

Record Documentation; G

1.6 QUALITY ASSURANCE

1.6.1 Shop Drawings

In exception to Section 01 33 00 SUBMITTAL PROCEDURES, submitted plan drawings shall be a minimum of 11 by 17 inches in size using a minimum scale of 1/8 inch per foot, except as specified otherwise. Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. Submittals shall include the nameplate data, size, and capacity. Submittals shall also include applicable federal, military, industry, and technical society publication references.

1.6.1.1 Telecommunications Drawings

Provide registered communications distribution designer (RCDD) approved, drawings in accordance with TIA-606. The identifier for each termination and cable shall appear on the drawings. Drawings shall depict final telecommunications installed wiring system infrastructure in accordance with TIA-606. The drawings should provide details required to prove that the distribution system shall properly support connectivity from the EF telecommunications and ER telecommunications, CD's, and FD's to the telecommunications work area outlets. Provide a plastic laminated schematic of the as-installed telecommunications cable system showing cabling, CD's, BD's, FD's, and the EF and ER for telecommunications keyed to floor plans by room number. Mount the laminated schematic in the EF telecommunications space as directed by the Contracting Officer. The following drawings shall be provided as a minimum:

a. T1 - Layout of complete building per floor - Building Area/Serving Zone Boundaries, Backbone Systems, and Horizontal Pathways. Layout of complete building per floor. The drawing indicates location of building areas, serving zones, vertical backbone diagrams, telecommunications rooms, access points, pathways, grounding system, and other systems that need to be viewed from the complete building perspective.

b. T2 - Serving Zones/Building Area Drawings - Drop Locations and Cable Identification (ID'S). Shows a building area or serving zone. These drawings show drop locations, telecommunications rooms, access points and detail call outs for common equipment rooms and other congested areas.

c. T4 - Typical Detail Drawings - Faceplate Labeling, Firestopping, Americans with Disabilities Act (ADA), Safety, Department of Transportation (DOT). Detailed drawings of symbols and typicals such as faceplate labeling, faceplate types, faceplate population installation procedures, detail racking, and raceways.

1.6.1.2 Telecommunications Space Drawings

Provide T3 drawings in accordance with TIA-606 that include telecommunications rooms plan views, pathway layout (cable tray, racks, ladder-racks, etc.), mechanical/electrical layout, and cabinet, rack, backboard and wall elevations. Drawings shall show layout of applicable equipment including incoming cable stub or connector blocks, building protector assembly, outgoing cable connector blocks, patch panels and equipment spaces and cabinet/racks. Drawings shall include a complete list of equipment and material, equipment rack details, proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearance for maintenance and operation. Drawings may also be an enlargement of a congested area of T1 or T2 drawings.

1.6.2 Telecommunications Qualifications

Work under this section shall be performed by and the equipment shall be provided by the approved telecommunications contractor and key personnel. Qualifications shall be provided for: the telecommunications system contractor, the telecommunications system installer, and the supervisor (if different from the installer). A minimum of 30 days prior to installation, submit documentation of the experience of the telecommunications contractor and of the key personnel.

1.6.2.1 Telecommunications Contractor

The telecommunications contractor shall be a firm which is regularly and professionally engaged in the business of the applications, installation, and testing of the specified telecommunications systems and equipment. The telecommunications contractor shall demonstrate experience in providing successful telecommunications systems within the past 3 years of similar scope and size. Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for the telecommunications contractor.

1.6.2.2 Key Personnel

Provide key personnel who are regularly and professionally engaged in the business of the application, installation and testing of the specified telecommunications systems and equipment. There may be one key person or more key persons proposed for this solicitation depending upon how many of the key roles each has successfully provided. Each of the key personnel shall demonstrate experience in providing successful telecommunications systems within the past 3 years.

Supervisors and installers assigned to the installation of this system or

any of its components shall be Building Industry Consulting Services International (BICSI) Registered Cabling Installers, Technician Level. Submit documentation of current BICSI certification for each of the key personnel.

In lieu of BICSI certification, supervisors and installers assigned to the installation of this system or any of its components shall have a minimum of 3 years experience in the installation of the specified copper and fiber optic cable and components. They shall have factory or factory approved certification from each equipment manufacturer indicating that they are qualified to install and test the provided products. Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for each of the key personnel. Documentation for each key person shall include at least two successful system installations provided that are equivalent in system size and in construction complexity to the telecommunications system proposed for this solicitation. Include specific experience in installing and testing telecommunications systems and provide the names and locations of at least two project installations successfully completed using optical fiber and copper telecommunications cabling systems. All of the existing telecommunications system installations offered by the key persons as successful experience shall have been in successful full-time service for at least 18 months prior to the issuance date for this solicitation. Provide the name and role of the key person, the title, location, and completed installation date of the referenced project, the referenced project owner point of contact information including name, organization, title, and telephone number, and generally, the referenced project description including system size and construction complexity.

Indicate that all key persons are currently employed by the telecommunications contractor, or have a commitment to the telecommunications contractor to work on this project. All key persons shall be employed by the telecommunications contractor at the date of issuance of this solicitation, or if not, have a commitment to the telecommunications contractor to work on this project by the date that the bid was due to the Contracting Officer.

Note that only the key personnel approved by the Contracting Officer in the successful proposal shall do work on this solicitation's telecommunications system. Key personnel shall function in the same roles in this contract, as they functioned in the offered successful experience. Any substitutions for the telecommunications contractor's key personnel requires approval from The Contracting Officer.

1.6.2.3 Minimum Manufacturer Qualifications

Cabling, equipment and hardware manufacturers shall have a minimum of 3 years experience in the manufacturing, assembly, and factory testing of components which comply with TIA-568.1, TIA-568.2 and TIA-568.3.

1.6.3 Test Plan

Provide a complete and detailed test plan for the telecommunications cabling system including a complete list of test equipment for the components and accessories for each cable type specified, 60 days prior to the proposed test date. Include procedures for certification, validation, and testing.

1.6.4 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.6.5 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.6.5.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.6.5.2 Material and Equipment Manufacturing Date

Products manufactured more than 1 year prior to date of delivery to site shall not be used, unless specified otherwise.

1.7 DELIVERY AND STORAGE

Provide protection from weather, moisture, extreme heat and cold, dirt, dust, and other contaminants for telecommunications cabling and equipment placed in storage.

1.8 ENVIRONMENTAL REQUIREMENTS

Connecting hardware shall be rated for operation under ambient conditions of 32 to 140 degrees F and in the range of 0 to 95 percent relative humidity, noncondensing.

1.9 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.10 MAINTENANCE

1.10.1 Operation and Maintenance Manuals

Commercial off the shelf manuals shall be furnished for operation, installation, configuration, and maintenance of products provided as a part of the telecommunications cabling and pathway system, Data Package 5. Submit operations and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and as specified herein not later than 2 months prior to the date of beneficial occupancy. In addition to requirements of Data Package 5, include the requirements of paragraphs TELECOMMUNICATIONS DRAWINGS, TELECOMMUNICATIONS SPACE DRAWINGS, and RECORD DOCUMENTATION. Ensure that these drawings and documents depict the as-built configuration.

1.10.2 Record Documentation

Provide T5 drawings including documentation on cables and termination hardware in accordance with TIA-606. T5 drawings shall include schedules to show information for cut-overs and cable plant management, patch panel layouts and cover plate assignments, cross-connect information and connecting terminal layout as a minimum. T5 drawings shall be provided on electronic media using Windows based computer cable management software. Provide the following T5 drawing documentation as a minimum:

a. Cables - A record of installed cable shall be provided in accordance with TIA-606. The cable records shall include the required data fields for each cable and complete end-to-end circuit report for each complete circuit from the assigned outlet to the entry facility in accordance with TIA-606. Include manufacture date of cable with submittal.

b. Termination Hardware - A record of installed patch panels, cross-connect points, distribution frames, terminating block arrangements and type, and outlets shall be provided in accordance with TIA-606. Documentation shall include the required data fields as a minimum in accordance with TIA-606.

PART 2 PRODUCTS

2.1 COMPONENTS

Components shall be UL or third party certified. Where equipment or materials are specified to conform to industry and technical society reference standards of the organizations, submit proof of such compliance. The label or listing by the specified organization will be acceptable evidence of compliance. In lieu of the label or listing, submit a certificate from an independent testing organization, competent to perform testing, and approved by the Contracting Officer. The certificate shall state that the item has been tested in accordance with the specified organization's test methods and that the item complies with the specified organization's reference standard. Provide a complete system of telecommunications cabling and pathway components using star topology. Provide support structures and pathways, complete with outlets, cables, connecting hardware and telecommunications cabinets/racks. Cabling and interconnecting hardware and components for telecommunications systems shall be UL listed or third party independent testing laboratory certified, and shall comply with NFPA 70 and conform to the requirements specified herein.

2.2 TELECOMMUNICATIONS PATHWAY

Provide telecommunications pathways in accordance with TIA-569 and as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide system furniture pathways in accordance with UL 1286.

2.3 TELECOMMUNICATIONS CABLING

Cabling shall be UL listed for the application and shall comply with TIA-568.0, TIA-568.1, TIA-568.2, TIA-568.3 and NFPA 70. Provide a labeling system for cabling as required by TIA-606 and UL 969. Ship cable on reels or in boxes bearing manufacture date for for shielded twisted pair (STP) in accordance with ICEA S-90-661 and optical fiber cables in accordance with ICEA S-83-596 for all cable used on this project. Cabling manufactured more than 12 months prior to date of installation shall not be used.

2.3.1 Backbone Cabling

2.3.1.1 Backbone Optical Fiber

Provide in accordance with ICEA S-83-596, TIA-568.3, UL 1666 and NFPA 70. Cable shall be imprinted with fiber count, fiber type and aggregate length at regular intervals not to exceed 40 inches.

Provide the number of strands indicated, (but not less than 12 strands between the main telecommunication room and each of the other telecommunication rooms), of single-mode(OS1), tight buffered fiber optic cable.

Provide tight buffered fiber optic multimode, 50/125-um diameter laser optimized(OM3) cable as indicated.

Provide plenum (OFNP), riser (OFNR), or general purpose (OFN or OFNG) rated non-conductive, fiber optic cable in accordance with NFPA 70. Substitution of a higher rated cable shall be permitted in accordance with NFPA 70. The cable cordage jacket, fiber, unit, and group color shall be in accordance with TIA/EIA-598.

Provide plenum (OFNP) riser (OFNR), or general purpose (OFN or OFNG) rated non-conductive, fiber optic cable in accordance with NFPA 70. Substitution of a higher rated cable shall be permitted in accordance with NFPA 70. The cable cordage jacket, fiber, unit, and group color shall be in accordance with TIA/EIA-598.

2.3.2 Horizontal Cabling

Provide horizontal cable in compliance with NFPA 70 and performance characteristics in accordance with TIA-568.1.

2.3.2.1 Horizontal Copper

Provide horizontal copper cable, STP, 100 ohm in accordance with TIA-568.2, UL 444, ANSI/NEMA WC 66, ICEA S-90-661 . Provide four each individually foiled twisted pairs, minimum size 24 AWG conductors, Category 6 shielded, with a red thermoplastic jacket. Cable shall be imprinted with manufacturers name or identifier, flammability rating, gauge of conductor, transmission performance rating (category designation) and length marking

at regular intervals in accordance with ICEA S-90-661. Provide plenum (CMP) communications rated cabling in accordance with NFPA 70. Substitution of a higher rated cable shall be permitted in accordance with NFPA 70. Cables installed in conduit within and under slabs shall be UL listed and labeled for wet locations in accordance with NFPA 70.

2.3.2.2 Horizontal Optical Fiber

Provide optical fiber horizontal cable in accordance with ICEA S-83-596and TIA-568.3. Cable shall be tight buffered, multimode, 50/125-um diameter laser optimized, OM3. Cable shall be imprinted with manufacturer, flammability rating and fiber count at regular intervals not to exceed 40 inches.

Provide plenum (OFNP), riser (OFNR), or general purpose (OFN or OFNG) rated non-conductive, fiber optic cable in accordance with NFPA 70. Substitution of a higher rated cable shall be permitted in accordance with NFPA 70.Cables installed in conduit within and under slabs be UL listed and labeled for wet locations in accordance with NFPA 70. The cable jacket shall be of single jacket construction with color coding of cordage jacket, fiber, unit, and group in accordance with TIA/EIA-598.

2.3.3 Work Area Cabling

2.3.3.1 Work Area Optical Fiber

Provide optical work area cable in accordance with TIA-568.3.

2.4 TELECOMMUNICATIONS SPACES

Provide connecting hardware and termination equipment in the telecommunications entrance facility and telecommunication equipment rooms to facilitate installation as shown on design drawings for terminating and cross-connecting permanent cabling. Provide telecommunications interconnecting hardware color coding in accordance with TIA-606.

2.4.1 Backboards

Provide void-free, interior grade A-C plywood 3/4 inch thick. Backboards shall be fire rated by manufacturing process. Fire stamp shall be clearly visible. Paint applied over fire retardant backboard shall be UL 723 fire retardant paint. Provide label including paint manufacturer, date painted, UL listing and name of Installer. When painted, paint label and fire stamp shall be clearly visible. Backboards shall be provided on a minimum of two adjacent walls in the telecommunication spaces.

2.4.2 Equipment Support Frame

Provide in accordance with ECIA EIA/ECA 310-E and UL 50.

a. Cabinets, freestanding modular type, 16 gauge steel construction, minimum, treated to resist corrosion. Cabinet shall have removable and lockable side panels, front and rear doors, and have adjustable feet for leveling. Cabinet shall be vented in the roof and rear door. Cabinet shall have cable access in the roof and base and be compatible with 19 inches panel mounting. Provide cabinet with grounding bar. All cabinets shall be keyed alike.

b. Each cabinet must have a power distribution unit (PDU).

2.4.3 Connector Blocks

Provide shielded insulation displacement connector (IDC) Type 110 for Category 6 systems. Provide blocks for the number of horizontal and backbone cables terminated on the block plus 25 percent spare.

2.4.4 Cable Guides

Provide cable guides specifically manufactured for the purpose of routing cables, wires and patch cords horizontally and vertically on 19 inches equipment cabinets. Cable guides of ring or bracket type devices mounted on cabinet panels for horizontal cable management and individually mounted for vertical cable management. Mount cable guides with screws, lockwashers.

2.4.5 Patch Panels

Provide ports for the number of horizontal and backbone cables terminated on the panel plus 25 percent spare. Provide pre-connectorized optical fiber and shielded copper patch cords for patch panels. Provide patch cords, as complete assemblies, with matching connectors as specified. Provide fiber optic patch cables with crossover orientation in accordance with TIA-568.3. Patch cords shall meet minimum performance requirements specified in TIA-568.1, TIA-568.2 and TIA-568.3 for cables, cable length and hardware specified.

2.4.5.1 Modular to 110 Block Patch Panel

Provide in accordance with TIA-568.1 and TIA-568.2. Panels shall be third party verified and shall comply with EIA/TIA Category 6 requirements. Panel shall be constructed of 0.09 inches minimum aluminum and shall be cabinet mounted and compatible with an ECIA EIA/ECA 310-E 19 inches equipment cabinet. Panel shall provide 48 non-keyed, 8-pin modular ports, wired to T568A. Patch panels shall terminate the building cabling on Type 110 IDCs and shall utilize a printed circuit board interface. The rear of each panel shall have incoming cable strain-relief and routing guides. Panels shall have each port factory numbered and be equipped with laminated plastic nameplates above each port.

2.4.5.2 Fiber Optic Patch Panel

Provide panel for maintenance and cross-connecting of optical fiber cables. Panel shall be constructed of 16 gauge steel minimum and shall be cabinet mounted and compatible with a ECIA EIA/ECA 310-E 19 inches equipment rack. Each panel shall provide multimode adapters as duplex LC in accordance with TIA/EIA-604-10 with zirconia ceramic alignment sleeves, alignment sleeves. Provide dust cover for unused adapters. The rear of each panel shall have a cable management tray a minimum of 8 inches deep with removable cover, incoming cable strain-relief and routing guides. Panels shall have each adapter factory numbered and be equipped with laminated plastic nameplates above each adapter.

2.4.6 Optical Fiber Distribution Panel

Cabinet mounted optical fiber distribution panel (OFDP) shall be constructed in accordance with ECIA EIA/ECA 310-E utilizing 18 gauge steel minimum. Panel shall be divided into two sections, distribution and user. Distribution section shall have strain relief, routing guides,

splice tray and shall be lockable, user section shall have a cover for patch cord protection. Each panel shall provide 12 multimode pigtails and adapters. Provide adapters as duplex LC with zirconia ceramic alignment sleeves. Provide dust covers for adapters. Provide patch cords as specified in the paragraph PATCH PANELS.

2.5 TELECOMMUNICATIONS OUTLET/CONNECTOR ASSEMBLIES

2.5.1 Outlet/Connector Copper

Outlet/connectors shall comply with FCC Part 68, TIA-568.1, and TIA-568.2. STP outlet/connectors shall be UL 1863 listed, non-keyed, 8-pin modular, constructed of high impact rated thermoplastic housing and shall be third party verified. Outlet/connectors provided for UTP cabling shall meet or exceed the requirements for the cable provided. Outlet/connectors shall be terminated using a Type 110 IDC PC board connector, color-coded for both T568A and T568B wiring. Each outlet/connector shall be wired T568A. STP outlet/connectors shall comply with TIA-568.2 for 200 mating cycles.

2.5.2 Optical Fiber Adapters(Couplers)

Provide optical fiber adapters suitable for duplex LC in accordance with TIA/EIA-604-10 with zirconia ceramic alignment sleeves, as indicated. Provide dust cover for adapters. Optical fiber adapters shall comply with TIA-455-21 for 500 mating cycles.

2.5.3 Optical Fiber Connectors

Provide in accordance with TIA-455-21. Optical fiber connectors shall be duplex LC in accordance with TIA/EIA-604-10 with zirconia ceramic alignment sleeves, duplex LC in accordance with TIA/EIA-604-3 with zirconia ceramic ferrule, epoxyless compatible with multimode fiber. The connectors shall provide a maximum attenuation of 0.3 dB at 1300 nm with less than a 0.2 dB change after 500 mating cycles.

2.5.4 Cover Plates

Telecommunications cover plates shall comply with UL 514C, and TIA-568.1, TIA-568.2, TIA-568.3; flush design constructed of high impact thermoplastic material white in colorto match color of receptacle/switch cover plates specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide labeling in accordance with the paragraph LABELING in this section.

2.5.5 Fiber Zone Box

Fiber zone box is a cabling infrastructure distribution implement for passive applications in zone cabling. It must provide interconnect or cross-connect points for horizontal LAN distribution areas. Zone box is to be sized to fit a 2 x 2 ft subfloor opening and is equipped with a seal to inhibit dust and liquid penetration. The box must accept up to 12 fiber connector panels, modules or splitter modules for LC duplex connector fiber termination and distribution.

2.6 GROUNDING AND BONDING PRODUCTS

Provide in accordance with UL 467, TIA-607, and NFPA 70. Components shall be identified as required by TIA-606. Provide ground rods, bonding conductors, and grounding busbars as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.7 FIRESTOPPING MATERIAL

Provide as specified in Section 07 84 00 FIRESTOPPING.

2.8 MANUFACTURER'S NAMEPLATE

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.9 FIELD FABRICATED NAMEPLATES

ASTM D709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 0.125 inches thick, white with black center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be one by 2.5 inches. Lettering shall be a minimum of 0.25 inches high normal block style.

2.10 TESTS, INSPECTIONS, AND VERIFICATIONS

2.10.1 Factory Reel Tests

Provide documentation of the testing and verification actions taken by manufacturer to confirm compliance with TIA-568.1, TIA-568.2, TIA-568.3, TIA-526-7 for single mode optical fiber , and TIA-526-14 for multimode optical fiber cables.

PART 3 EXECUTION

3.1 INSTALLATION

Install telecommunications cabling and pathway systems, including the horizontal and backbone cable, pathway systems, telecommunications outlet/connector assemblies, and associated hardware in accordance with NECA/BICSI 568, TIA-568.1, TIA-568.2, TIA-568.3, TIA-569, NFPA 70, and UL standards as applicable. Provide cabling in a star topology network. Pathways and outlet boxes shall be installed as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Install telecommunications cabling with copper media in accordance with the following criteria to avoid potential electromagnetic interference between power and telecommunications equipment. The interference ceiling shall not exceed 3.0 volts per meter measured over the usable bandwidth of the telecommunications cabling. Cabling shall be run with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.

3.1.1 Cabling

Install STP, and optical fiber telecommunications cabling system as detailed in TIA-568.1, TIA-568.2, TIA-568.3 and TIA-570 for residential cabling. Screw terminals shall not be used except where specifically indicated on plans. Use an approved insulation displacement connection (IDC) tool kit for copper cable terminations. Do not exceed manufacturers' cable pull tensions for copper and optical fiber cables.

Provide a device to monitor cable pull tensions. Do not exceed 25 pounds pull tension for four pair copper cables. Do not chafe or damage outer jacket materials. Use only lubricants approved by cable manufacturer. Do not over cinch cables, or crush cables with staples. For STP cable, bend radii shall not be less than four times the cable diameter. Cables shall be terminated; no cable shall contain unterminated elements. Cables shall not be spliced. Label cabling in accordance with paragraph LABELING in this section.

3.1.1.1 Open Cable

Use only where specifically indicated on plans for use below raised floors. Install in accordance with TIA-568.1, TIA-568.2 and TIA-568.3. Do not exceed cable pull tensions recommended by the manufacturer. Copper cable not in a wireway or pathway shall be suspended each floor joist. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items. Placement of cable parallel to power conductors shall be avoided, if possible; a minimum separation of 12 inches shall be maintained when such placement cannot be avoided.

Plenum cable shall be used where open cables are routed through plenum areas. Cable routed exposed under raised floors shall be plenum rated. Plenum cables shall comply with flammability plenum requirements of NFPA 70. Install cabling after the flooring system has been installed in raised floor areas. Cable 6 feet long shall be neatly coiled not less than 12 inches in diameter below each feed point in raised floor areas.

3.1.1.2 Backbone Cable

a. Optical fiber Backbone Cable. Install intrabuilding backbone optical fiber in indicated pathways. Do not exceed manufacturer's recommended bending radii and pull tension. Prepare cable for pulling by cutting outer jacket 10 inches leaving strength members exposed for approximately 10 inches. Twist strength members together and attach to pulling eye. Vertical cable support intervals shall be in accordance with manufacturer's recommendations.

3.1.1.3 Horizontal Cabling

Install horizontal cabling as indicated on drawings Do not untwist Category 6 STP cables more than one half inch from the point of termination to maintain cable geometry. Provide slack cable in the form of a figure eight (not a service loop) on each end of the cable, 10 feet in the telecommunications room, and 12 inches in the work area outlet.

3.1.2 Pathway Installations

Provide in accordance with TIA-569 and NFPA 70. Provide building pathway as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.1.3 Service Entrance Conduit, Underground

Provide service entrance underground as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.1.4 Cable Tray Installation

Install cable tray as specified in Section 26 20 00 INTERIOR DISTRIBUTION

SYSTEM. Only CMP and OFNP type cable shall be installed in a plenum.

3.1.5 Work Area Outlets

3.1.5.1 Terminations

Terminate STP cable in accordance with TIA-568.1, TIA-568.2 and wiring configuration as specified. Terminate fiber optic cables in accordance with TIA-568.3.

3.1.5.2 Cover Plates

As a minimum, each outlet/connector shall be labeled as to its function and a unique number to identify cable link in accordance with the paragraph LABELING in this section.

3.1.5.3 Cables

Shielded twisted pair and fiber optic cables shall have a minimum of 12 inches of slack cable loosely coiled into the telecommunications outlet boxes. Minimum manufacturer's bend radius for each type of cable shall not be exceeded.

3.1.5.4 Pull Cords

Pull cords shall be installed in conduit serving telecommunications outlets that do not have cable installed.

3.1.6 Telecommunications Space Termination

Install termination hardware required for Shielded Category 6 and optical fiber system. An insulation displacement tool shall be used for terminating copper cable to insulation displacement connectors.

3.1.6.1 Connector Blocks

Connector blocks shall be cabinet mounted in orderly rows and columns. Adequate vertical and horizontal wire routing areas shall be provided between groups of blocks. Install in accordance with industry standard wire routing guides in accordance with TIA-569.

3.1.6.2 Patch Panels

Patch panels shall be mounted in equipment cabinets with sufficient ports to accommodate the installed cable plant plus 25 percent spares.

a. Copper Patch Panel. Copper cable entering a patch panel shall be secured to the panel as recommended by the manufacturer to prevent movement of the cable.

b. Fiber Optic Patch Panel. Fiber optic cable loop shall be 3 feet in length. The outer jacket of each cable entering a patch panel shall be secured to the panel to prevent movement of the fibers within the panel, using clamps or brackets specifically manufactured for that purpose.

3.1.6.3 Equipment Support Frames

Install in accordance with TIA-569:

a. Cabinets, freestanding modular type. When cabinets are connected together, remove adjoining side panels for cable routing between cabinets. Provide and install solid blanking panels to prohibit airflow from front to rear of cabinets in all cabinets.

3.1.7 Electrical Penetrations

Seal openings around electrical penetrations through fire resistance-rated wall, partitions, floors, or ceilings as specified in Section 07 84 00 FIRESTOPPING.

3.1.8 Grounding and Bonding

Provide in accordance with TIA-607, NFPA 70 and as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.2 LABELING

3.2.1 Labels

Provide labeling in accordance with TIA-606. Handwritten labeling is unacceptable. Stenciled lettering for voice and data circuits shall be provided using thermal ink transfer process laser printer .

3.2.2 Cable

Cables shall be labeled using color labels on both ends with identifiers in accordance with TIA-606.

3.2.3 Termination Hardware

Workstation outlets and patch panel connections shall be labeled using color coded labels with identifiers in accordance with TIA-606.

3.3 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.3.1 Painting Backboards

If backboards are required to be painted, then the manufactured fire retardant backboard must be painted with fire retardant paint, so as not to increase flame spread and smoke density and must be appropriately labeled. Label and fire rating stamp must be unpainted.

3.4 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.5 TESTING

3.5.1 Telecommunications Cabling Testing

Perform telecommunications cabling inspection, verification, and performance tests in accordance with TIA-568.1, TIA-568.2, TIA-568.3. Test equipment shall conform to TIA-1152. Perform optical fiber field inspection tests via attenuation measurements on factory reels and provide results along with manufacturer certification for factory reel tests. Remove failed cable reels from project site upon attenuation test failure.

3.5.1.1 Inspection

Visually inspect STP and optical fiber jacket materials for UL or third party certification markings. Inspect cabling terminations in telecommunications rooms and at workstations to confirm color code for T568A or T568B pin assignments, and inspect cabling connections to confirm compliance with TIA-568.1, TIA-568.2, TIA-568.3. Visually confirm marking of outlets, cover plates, outlet/connectors, and patch panels.

3.5.1.2 Verification Tests

For multimode optical fiber, perform optical fiber end-to-end attenuation tests in accordance with TIA-568.3 and TIA-526-14 using Method A, Optical Power Meter and Light Source for multimode optical fiber. For single-mode optical fiber, perform optical fiber end-to-end attenuation tests in accordance with TIA-568.3 and TIA-526-7 using Method A, Optical Power Meter and Light Source for single-mode optical fiber. Perform verification acceptance tests.

3.5.1.3 Performance Tests

Perform testing for each outlet as follows:

a. Perform Category 6 link tests in accordance with TIA-568.1 and TIA-568.2. Tests shall include wire map, length, insertion loss, NEXT, PSNEXT, ELFEXT, PSELFEXT, return loss, propagation delay, and delay skew.

b. Optical fiber Links. Perform optical fiber end-to-end link tests in accordance with TIA-568.3.

3.5.1.4 Final Verification Tests

Perform verification tests for STP and optical fiber systems after the complete telecommunications cabling and workstation outlet/connectors are installed.

a. Data Tests. These tests assume the Information Technology Staff has a network installed and are available to assist with testing. Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network.

-- End of Section --

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SECTION 28 08 10

ELECTRONIC SECURITY SYSTEM ACCEPTANCE TESTING
08/23

PART 1 GENERAL

1.1 SUMMARY

This specification defines the process and procedures for initial acceptance testing of electronic security systems (ESS) to include intrusion detection, access control and video as well as associated power and communications. Requirements to plan, conduct, and document all testing activities are covered along with the Government responsibility to witness testing and review and approve submittals. During the course of the acceptance test, demonstrate that, without exception, the completed and integrated ESS complies with the contract requirements.

1.2 DEFINITIONS

The Government Representative is a qualified individual given specific authority to witness system acceptance testing and evaluate the results.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-05 Design Data

Test Plan; G

SD-06 Test Reports

Final Test Report; G

Pre-Acceptance Test Certification; G

SD-07 Certificates

Qualifications

1.4 QUALITY ASSURANCE

1.4.1 Qualifications

1.4.1.1 General

The Test Director, Operator, and Technician must have prior experience with the specific equipment, hardware and software installed under the contract.

1.4.1.2 Test Director

The Test Director must have at least five years of hands-on ESS experience to include any combination of design, installation, testing and

maintenance.

1.4.1.3 Operator

The Operator must have at least two years of hands-on experience installing and maintaining ESS workstations to include both hardware and software. The Operator must be capable of demonstrating all workstation features and capabilities.

1.4.1.4 Technician

The technician must have at least two years of hands-on experience installing and maintaining ESS field equipment to include sensors, card readers, cameras, local processors, and communications equipment. The Technician must be capable of demonstrating all features and capabilities of ESS field equipment. Qualifications may be met by the individual experience of one technician or by the combined experience of a team of technicians.

1.4.1.5 Test Intruder

The purpose of the test intruder is to activate intrusion sensors in a realistic and repeatable manner. The test intruder must be between 70 and 72 inches tall and weigh between 175 and 190 pounds. The test intruder must possess sufficient physical strength, agility, and endurance to perform movements required for intrusion testing. These movements may include, but are not limited to, walking, running, crawling, jumping, and climbing.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 TEST PLAN

The Government will witness all system acceptance testing and endurance testing. Obtain written permission from the Government before proceeding with testing. Clearly establish the scope for ESS testing prior to beginning testing. Submit a Test Plan that addresses all testing requirements to include the following topics:

3.1.1 Personnel

Identify the Test Director, Operator, Technician, Test Intruder, and any other personnel that will be performing test activities.

3.1.2 Equipment

List all equipment that is required to support testing. State the purpose of each piece of equipment. Describe equipment that will be used to enable voice communications between the monitoring location and the field.

3.1.3 Procedures

Provide a step-by-step procedure for conducting each functional test. Describe actions and expected results. Ensure that functional test procedures address performance standards described in contract

specifications especially any probability of detection (Pd) and nuisance and false alarm rate (NAR/FAR) requirements. Pd and NAR/FAR are not typically a concern for interior sensors installed per manufacturers specifications. For exterior sensors NAR/FAR needs to be verified but Pd may not need to be verified if installed IAW manufacturers or service specific guidance.

Download example procedures from http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphic and review for applicability and completeness. Adapt example procedures to meet specific project requirements and develop additional ones as needed. Follow TEST-MASTERTP0023-005 for Air Force projects.

3.1.4 Special Provisions

Discuss any special test provisions such as facility access, safety, integration with existing systems, and coordination with other work.

3.1.5 Test Logs

Provide logs for recording all data from functional testing and burn-in testing.

Download example logs from http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphic and review for applicability and completeness. Adapt example logs to identify each component by location to meet specific project components and system test requirements. Develop additional logs as needed.

3.1.6 Schedule

Provide an overall schedule that includes all testing milestones.

3.2 PRE-ACCEPTANCE TESTING

Conduct a complete test of all field equipment, workstations, and central system hardware and software in accordance with the approved Test Plan. The Test Director must be on site to conduct a pre-test inspection and oversee all testing activities. Prior to testing, visually inspect all ESS components and correct workmanship and neatness deficiencies as needed. During the pre-test inspection, verify the accuracy of redline drawings and update drawings as needed. Verify and document performance of each device and system feature to include sensor nuisance and false alarm rates. Review all positioning and field of view adjustments for each camera view in day and night operation.

Prepare and submit Pre-Acceptance Test Certification detailing the results of the testing. Refer to paragraph FINAL TEST REPORT for required content. Include a cover letter signed by the Test Director stating that pre-acceptance testing has been completed and that the system is ready for acceptance testing.

3.3 SYSTEM ACCEPTANCE

Test the ESS in accordance with the approved Test Plan in the presence of the Government Representative to certify acceptable performance. Verify that the total system meets all requirements of the specification and complies with the specified standards.

a. Demonstrate that the completed system complies with the contract requirements. Using approved test procedures, all physical and functional requirements of the project must be demonstrated and shown. The SAT, as specified, is not to be started until after receipt by the Contractor of written permission from the Government.

b. Begin acceptance testing upon arrival of the Government Representative at the project site. Place the ESS in normal operating mode and evaluate system performance during the testing period. Immediately report any deficiencies observed during testing to the Government Representative and discuss possible causes and corrective measures. Obtain Government approval prior to making any adjustments, repairs or modifications. The Government retains the right to terminate testing at any time the ESS is found to be incomplete or fails to perform as specified. Such termination of acceptance testing constitutes a FAILED system acceptance test.

c. Upon termination of testing by the Government or by the Contractor, commence an assessment period as described in paragraph Test Termination Assessment Period.

d. Upon successful completion of the system acceptance test, deliver test reports and other documentation as specified to the Government prior to commencing the endurance test.

3.3.1 Test Termination Assessment Period

Identify all failures, determine causes of all failures, repair all failures, and deliver a written report to the Government. Ensure that the report explains in detail the nature of each failure, corrective action taken, results of tests performed, and recommend the point at which testing should be resumed. After delivering the written report, convene a test review meeting to present the results and recommendations to the Government. Schedule the test review meeting at least 5 business days after receipt of the report by the Government. As a part of this test review meeting, demonstrate that all failures have been corrected by performing appropriate portions of the system acceptance test. Based on the Contractor's report and the test review meeting, the Government will determine the restart date, or may require that the entire test be repeated.

3.3.2 Preparation

Notify the Contracting Officer of system readiness 15 days prior to the expected start date of acceptance testing. Prior to acceptance testing, complete all clean-up and patch work requirements. Ensure that security equipment closets and similar areas are free of accumulation of waste materials or rubbish caused by prior installation work.

3.3.3 Personnel

Ensure that the following personnel are on site to perform test activities: Test Director, Operator, Technician, and Test Intruder. Ensure that the Quality Control Manager is on site during acceptance testing.

3.3.4 Visual Inspection

Assist the Government Representative in conducting a visual inspection of ESS equipment and wiring. This inspection will focus on the general neatness and quality of workmanship and compliance with applicable codes and manufacturers' recommended installation methods. Provide a comprehensive listing of installed equipment and software, sorted by location, along with a complete set of ESS red line drawings to be used during the inspection. Document deficiencies identified during the inspection.

3.3.5 Phased Testing

3.3.5.1 Functional Testing

During the functional testing, verify system performance in accordance with the approved Test Plan. Record results in approved Test Logs and provide a written explanation of each failure to include cause, corrective action, and retest result. Continue functional testing until all tests have been successfully completed with no unresolved failures. Comply with requests from the Government Representative to repeat functional tests performed previously. The Government reserves the right to request the Contractor to repeat all functional tests or a representative sampling thereof as a means of performance verification. Document all test results on approved Test Logs.

3.3.5.2 System Activity Reports

Retrieve archived data from the system and provide unaltered activity reports as requested by the Government Representative. Reports may address any type of activity to include alarms, portal transactions, and video archives. Assist with analyzing reports to identify trends and anomalies.

3.3.5.3 Corrective Actions

Correct any deficiencies in coordination with the Government Representative. Maintain a punch list and review status at the end of each day. Work diligently to complete corrective actions the same day that deficiencies are observed. Add deficiencies not corrected on the same day to the rework items list maintained by the Quality Control Manager. Failure to resolve punch list items to the satisfaction of the Government constitutes a FAILED system acceptance test.

3.3.5.4 Endurance Testing

Following the successful completion of the functional test and completion of all corrective actions, monitor all components for a continuous period of 7 days upon written approval from the government representative. Active monitoring will take place for a total of 8 hours per day and staggered throughout duty hours to sample normal operational and environmental site conditions during daytime and nighttime hours. All events, anomalies, and alarms will be reviewed, assessed in real time, and documented. Date and time of each activation will be recorded, assessed for cause, and noted. Events that occur outside the 8-hour window will be assessed during the following work period. All cameras are to be reviewed for operability and clarity of view, day, and night.

a. The endurance test must demonstrate system reliability and operability. The endurance test will not be started until the Government notifies the Contractor, in writing, that the system acceptance test is satisfactorily completed, and correction of all outstanding deficiencies has been satisfactorily completed.

b. Provide 1 operator to operate the system 24 hours per day in addition to any Government personnel that may be made available. The Government may terminate testing at any time if the system fails to perform as specified.

c. Upon termination of testing by the Government or by the Contractor, commence an assessment period as defined in paragraph Test Termination Assessment Period. Verify the operation of each terminal device during the last day of the test. Upon successful completion of the endurance test, deliver test reports and other documentation as specified to the Government prior to acceptance of the system.

d. The endurance test for sensors is required to demonstrate the configuration meets the requirements of Section 28 10 05 ELECTRONIC SECURITY SYSTEMS (ESS) paragraphs False Alarm Rate and Nuisance Alarm Rate. The Government Representative must be directly notified if any section of the fence exceeds the requirement. Upon coordination, re-calibrate the failed section, repeat functional test, and restart the endurance test period for that section.

3.4 FINAL TEST REPORT

Submit a Final Test Report following the successful completion of acceptance testing to include all failures, remediation, and resolution of all punch list items. Address the following topics in the Final Test Report:

3.4.1 Summary

Provide a chronological summary of all testing. Describe test activities and results in narrative form.

3.4.2 Personnel

Provide a list of all Contractor and Government personnel who participated in the testing.

3.4.3 Test Logs

Provide all completed test logs along with a test log verification signed by the Test Director.

3.4.4 False and Nuisance Alarm Rates

Provide a tabulated and summarized listing of all events based on the system activity reports. Categorize every alarm as one of four types: 1) Valid/Actual, 2) False, 3) Nuisance, or 4) Test/Authorized Alarm.

3.4.4.1 Valid or Actual Alarm

An alarm received due to an actual intruder attempting to enter or entering a protected area or attempting to cross or crossing a line of detection.

3.4.4.2 False Alarm

An alarm received for which no cause can be determined. Typically, false alarms are due to aging or malfunctioning equipment and communications pathways that the alarm monitor cannot assess. False alarms in excess of established rates will cause complacency and lead to unsecure protected areas.

3.4.4.3 Nuisance Alarm

An alarm received due to an influence for which the sensor was designed to detect but which is not related to an intrusion attempt. The influence that caused the alarm must be clearly identifiable. These alarms fall into three categories: preventable, mitigatable, and unpreventable. Preventable nuisance alarms typically include personnel using improper entry/exit procedures, or an unauthorized incursion into the sensor zone. Preventable nuisance alarms must be included in the nuisance alarm rate. Mitigatable nuisance alarms can include: an animal entering into the sensor zone; a weather event typical/normal to the area, a noise event (i.e., a jet taking off in afterburner, a training explosion from the base range, etc.), or a seismic event (large vehicle vibrations from regular traffic in the area). Steps must be taken to reduce mitigatable events such as critter/animal control fences or animal abatement, bird abatement programs such as Bird/wildlife Aircraft Strike Hazard (BASH) or reprograming the system to filter out certain vibrations/noises. Mitigatable nuisance alarms must be included in the nuisance alarm rate. Unpreventable nuisance alarms can include a weather event not typical/normal to the area (i.e., thunderstorm, hurricane, typhoon, etc.) or other atypical events to the area and will not be included in the nuisance alarm rate. Nuisance alarms in excess of established rates will cause complacency and lead to unsecure protected areas.

3.4.4.4 Test or Authorized Alarm

An alarm received due to authorized personnel performing required testing on the ESS. Tests can include daily, weekly, or monthly operational checks as well as acceptance, quarterly, semi-annual, or annual system functional checks.

3.5 Probability of Detection and Confidence Level

If Probability of Detection (Pd) requirements need to be validated, then Pd testing must be completed. The binomial table below uses a statistical method to determine Pd and Confidence level based on the number of sequential annunciated alarms due to test intrusions. Regulatory or contractual requirements will define the Pd and Confidence Level needed for specific zones or lines of detection. If the number of successive detections cannot be met without a missed detection, then adjustments to detection sensor coverage and sensitivity must be made.

Probability of Detection	0.9	0.9	0.95	0.95	Number of Misses Allowed
Confidence Level	90%	95%	90%	95%	
Number of Intrusion Attempts	22	29	45	59	0
	38	46	77	93	1
	52	61	105	124	2
	65	76	132	153	3
	78	89	158	181	4
	91	103	184	208	5

-- End of Section --

SECTION 28 10 05

ELECTRONIC SECURITY SYSTEMS (ESS)
05/24

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ASC/X9 X9.52	(1998) Triple Data Encryption Algorithm Modes of Operation

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2024) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM B32	(2020) Standard Specification for Solder Metal
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials
ASTM E84	(2025) Standard Test Method for Surface Burning Characteristics of Building Materials

BUILDERS HARDWARE MANUFACTURERS ASSOCIATION (BHMA)

ANSI/BHMA A156.23	(2010) Electromagnetic Locks

ELECTRONIC COMPONENTS INDUSTRY ASSOCIATION (ECIA)

ECIA EIA/ECA 310-E	(2005) Cabinets, Racks, Panels, and Associated Equipment

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 802.3	(2022) Ethernet
IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

INTELLIGENCE COMMUNITY STANDARD (ICS)

ICS 705-1	(2010) Physical and Technical Security

	Standard for Sensitive Secure Information Facilities

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ANSI ISO/IEC 7816	(R 2009) Identification Cards - Integrated Circuit Cards

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 1	(2022) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2026; TIA 26-1; ERTA 26-1; TIA 26-2; TIA 26-3; TIA 26-4; TIA 26-5; TIA 26-6; TIA 26-7; ERTA 26-2; ERTA 26-3) National Electrical Code

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST FIPS 140-2	(2001) Security Requirements for Cryptographic Modules
NIST FIPS 197	(2001) Advance Encryption Standard
NIST FIPS 201-2	(2013) Personal Identity Verification (PIV) of Federal Employees and Contractors
NIST SP 800-116	(2018; Rev 1) Guidelines for the Use of PIV Credentials in Facility Access

OPEN NETWORK VIDEO INTERFACE FORUM (ONVIF)

ONVIF	(2017) Core Specification Version 17.06

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-222	(2018H; Add 1 2019) Structural Standard for Antenna Supporting Structures and Antennas and Small Wind Turbine Support Structures
TIA-568.2	(2024e) Balanced Twisted-Pair Telecommunications Cabling and Components Standards
TIA-606	(2021d) Administration Standard for

Telecommunications Infrastructure

TIA-607 (2019d) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-HDBK-419 (1987; Rev A) Grounding, Bonding, and Shielding for Electronic Equipments and Facilities Volumes 1 of 2 Basic Theory

MIL-STD-188-124 (1998; Rev B; Notice 2 1998; Notice 3 2000; Notice 4 2013) Grounding, Bonding and Shielding for Common Long Haul/Tactical Communications Systems, Including Ground Based Communications - Electronics Facilities and Equipments

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 15 Radio Frequency Devices

UL SOLUTIONS (UL)

UL 50 (2024) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations

UL 294 (2023) UL Standard for Safety Access Control System Units

UL 437 (2013; Reprint Jan 2022) UL Standard for Safety Key Locks

UL 634 (2007; Reprint Mar 2015) Connectors and Switches for Use with Burglar-Alarm Systems

UL 639 (2007; Reprint Jun 2024) Standard for Intrusion Detection Units

UL 681 (2014; Reprint Jan 2021) UL Standard for Safety Installation and Classification of Burglar and Holdup Alarm Systems

UL 796 (2020; Reprint Oct 2023) UL Standard for Safety Printed Wiring Boards

UL 969 (2017; Reprint May 2023) UL Standard for Safety Marking and Labeling Systems

UL 972 (2006; Reprint Nov 2020) UL Standard for Safety Burglary Resisting Glazing Material Type

UL 1037 (2016; Reprint Aug 2023) UL Standard for Safety Antitheft Alarms and Devices

UL 1076 (2018; Reprint Feb 2021) UL Standard for

	Safety Proprietary Burglar Alarm Units and Systems
UL 1610	(2016; Reprint Apr 2021) UL Standard for Safety Central-Station Burglar-Alarm Units
UL 2050	(2003; 4th Edition) Standard for National Industrial Security Systems for the Protection of Classified Materials (limited distribution publication, direct purchase request with justification to UL)
UL 2802	(2013; Reprint Apr 7 2020) UL Standard for Safety Performance Testing of Camera Image Quality
UL 62368-1	(2019) UL Standard for Audio/Video, Information, and Communication Technology Equipment - Part 1: Safety Requirements

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

The Base Security Office will review and will approve submittals requiring special review in this section.

SD-02 Shop Drawings

ESS Components; G

Access Control System (ACS); G

Security Hardware Door Schedule; G

Overall System Schematic; G

Video Surveillance System (VSS) Schedule; G

SD-03 Product Data

Premise Control Unit; G

Detection Sensors; G

Access Control Unit; G

Access Control Devices; G

Cameras; G

Camera Lenses; G

Camera Housing and Mounts; G

Video Recording; G

Printers; G

Communications Interface Devices; G

Radio Frequency Link; G

Network Switch; G

Video and ESS Transmission; G

Component Enclosure; G

Equipment Rack; G

SD-05 Design Data

Backup Battery Capacity Calculations; G

Video Surveillance System (VSS) Storage Calculations; G

Error and Throughput Rates; G

SD-07 Certificates

Contractor Qualifications; G

Instructor Qualifications; G

Contact Card Readers; G

Contactless Card Readers; G

Data Encryption; G

Wire And Cable; G

Bonding, Grounding, And Shielding; G

SD-10 Operation and Maintenance Data

ESS Components; G

ESS Software, Data Package 4; G

ESS Training; G

ESS Training Outline; G

Submit data package in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA

SD-11 Closeout Submittals

As-Built Drawings; G

Warranty; G

1.3 QUALITY ASSURANCE

Provide a sole-source Electronic Security System (ESS) manufactured by Advantor Systems Corporation. No substitutions are permitted. Coordinate all aspects of the ESS with Advantor Systems Corporation. Partial systems, third-party integrations not approved by Advantor Systems Corporation, or deviations from the specified system are not acceptable.

1.3.1 Regulatory Requirements

The advisory provisions in each of the publications referred to in this specification are mandatory. Interpret these publications as though the word "must" has been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer.

Equipment, materials, installation, and workmanship must be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.3.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship and:

a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening and have been utilized in applications of equipment and materials under similar circumstances and of similar size.

b. Have been available on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.

c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer.

d. Provide commercial off-the-shelf (COTS) products in which the manufacturer allows a network of qualified distributors to sell, install, integrate, maintain, and repair the hardware and software products that make up the system. All products are to be NDAA and FAR subpart 4.21 compliant.

1.3.2.1 Alternative Qualifications

Products having less than a 2 year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.3.2.2 Material and Equipment Manufacturing Date

Products manufactured more than one year prior to date of delivery to the site are not acceptable.

1.3.2.3 Product Safety

System components are to conform to applicable rules and requirements of NFPA 70. Equip system components with instruction stickers including

warnings and cautions describing physical safety, and special or important procedures to be followed in operating and servicing system equipment.

1.3.3 Shop Drawings

1.3.3.1 ESS Components

Submit the ESS Components, Data Package 4 with the ESS Software submittal package in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Submit drawings that clearly and completely indicate each ESS component function that includes:

a. Termination device points

b. Interconnections required for system operation

c. Interconnections between modules and devices

d. Component and device wiring diagrams.

e. Proposed wireway or conduit systems to be used including:

(1) Locations

(2) Sizes

(3) Types

f. Drawings showing:

(1) Device locations and spacing

(2) Mounting and positioning details

(3) Riser Diagrams with cable sizes and types

(4) Bill of Materials (Device make, model and quantities)

(5) Alarm and access control zones

(6) Video Surveillance System (VSS) and sensor coverage areas

(7) Spare capacity

(8) Tables with (Security Hardware Door Schedule) identifying security devices requirements per building, room, and door

(9) Overall system schematic diagram(s).

1.3.4 Evidence of Experience and Qualifications

1.3.4.1 Contractor Qualifications

Contractor or its subcontractor(s) must be a Value Added Resaler (VAR)/Authorized Dealer (AD) of the manufacturer line of products being installed. Provide manufacturer certificate showing current dealership status. Technicians working the project must provide certificates of training for the requirements of the manufacturer, and those certificates must be from the manufacturer or approved by the manufacturer.

Submit experience and certified qualifications data prior to installation. Show that specific installers who will perform the work have a minimum of 5 years of experience successfully installing ESS of the same type and similar design as specified. Include the names, locations, and points of contact of at least two installations of similar type and design as specified in this document where the installer has installed such systems. Indicate the type of each system installed. Certify that each system has performed satisfactorily in the manner intended for a period of at least 24 months. Installation and maintenances of IDS for the protection of classified information to be performed by US citizens who have been subject to a trustworthiness determination.

1.3.4.2 Instructor Qualifications

Submit the instructor's experience and certified qualifications data prior to installation. Show that the instructor has received a minimum of 24 hours of ESS training from the manufacturer of the product being installed, and 2 years experience in installing the specified ESS type.

1.4 ENVIRONMENTAL CONDITIONS

1.4.1 Interior Conditions

Equipment installed in environmentally protected interior areas must meet performance requirements specified for the following ambient conditions:

1.4.1.1 Temperature

32 to 120 degrees F. Components installed in unheated security protected areas must meet performance requirements for temperatures as low as 0 degrees F

1.4.1.2 Pressure

Sea level to 15,000 feet above sea level

1.4.1.3 Relative Humidity

5 to 95 percent

1.4.1.4 Fungus

Components must be constructed of non-fungus nutrient materials or be treated to inhibit fungus growth

1.4.1.5 Acoustical Noise

Components must be suitable for use in high noise areas above 100 dB, without adversely affecting their performance

1.4.2 Exterior Conditions

Components in enclosures must meet performance requirements when exposed to the following ambient conditions:

1.4.2.1 Temperature

Minus 25 to 140 degrees F

1.4.2.2 Pressure

Sea level to 15,000 feet above sea level

1.4.2.3 Solar Radiation

Six hours of solar radiation per day at dry bulb temperature of 120 degrees F including 4 hours of solar radiation at 104 watts per square foot

1.4.2.4 Rain

2 inches per hour and 5 inches per hour cyclic with wind plus one period of 12 inches per hour in accordance with UL 294 and UL 639.

1.4.2.5 Humidity

5 to 95 percent

1.4.2.6 Snow

Snow loading of 48 (psf) per hour; blowing snow of 4.6 psf per hour. Blowing snow from any angle (falling vertically to horizontal blowing from any azimuth) must not penetrate ESS equipment.

1.4.2.7 Ice Accretion

Up to 1/2 inches of radial ice

1.4.2.8 Wind

Continual velocity up to 50 mph with gusts to 66 mph.

1.4.2.9 Acoustical Noise

Visual alert device and components should be used in high noise areas above 110 dB without adversely affecting their performance. Examples areas include flight lines, run-up pads, and generator sites.

1.5 SYSTEM CALCULATIONS AND ANALYSIS

1.5.1 Backup Battery Capacity Calculations

Submit calculations showing that backup battery capacity exceeds sensor operation, communications supervision, and alarm annunciation power requirements for proposed equipment plus 25 percent spare capacity. In environments regularly exposed to conditions of 32 degrees F provide 50 percent spare capacity. In environments regularly exposed to conditions of 120 degrees F provide resistance to thermal runaway for lithium based batteries.

1.5.2 Video Surveillance System (VSS) Storage Calculations

Submit calculations showing the required storage capacity for each video storage device. Calculations must be based on the recording parameters specified by the end user/customers operational requirements.

1.6 ESS SOFTWARE, DATA PACKAGE 4

Submit the ESS software, Data Package 4 with the ESS Components submittal package in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Describe the functions of all software in the software manual and include:

a. All information necessary to enable proper loading, testing, and operation

b. Terms and functions definitions

c. Use of system and application software

d. Procedures for system initialization, start-up and shutdown

e. Alarm reports

f. Reports generation

g. Database format and data entry requirements

h. Directory of all files

i. All communication protocol descriptions, including data formats, command characters, and a sample of each type of data transfer

j. Interface definition

k. List of software keys

l. Backup and restore procedures and instructions on how to archive reports and video footage on DVD for forensics investigations.

1.7 AS-BUILT DRAWINGS

Maintain a separate set of drawings, elementary diagrams, and wiring diagrams of the system to be used for as-built drawings. Keep this set accurately and neatly up to date with all changes and additions. This set is not to be used for installation purposes.

Finish the final drawings submitted with the endurance test report in accordance with Section 01 78 00 CLOSEOUT SUBMITTALS for as-built requirements.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide a complete and integrated electronic security system (ESS) that meets the requirements of Joint Program Office and Base. ESS must be compatible with the Installation's central monitoring system and monitored within the secure/protected area and at the Installation central monitoring station. The Installation's existing ESS is manufactured by Advantor Systems. Provide an ESS that is integrated with the Installation's existing ESS and works seamlessly with the Installation's existing ESS. Installation's central monitoring system is manufactured by DSX. ESS consisting of the following subsystems and features:

a. Intrusion Detection System (IDS)

b. Access Control System (ACS)

c. Video Surveillance System (VSS)

d. Security Command Center (SCC)

e. Communications System

f. Security Lighting Systems

2.2 PERFORMANCE REQUIREMENTS

Integrate the installed and operating subsystems into the overall ESS system to detect intrusion, control access, video surveillance, visual verification, and perform as an entity, as specified below. Provide electronic equipment that complies with 47 CFR 15 and are suitable for the environment where they will be installed.

2.2.1 Growth Capability

Provide capability for modular ESS expansion of inputs, outputs, card readers, and remote-control stations with minimal equipment modification. Software must be able to handle design requirements plus 25 percent spare capacity. Growth capability is not to be limited by the provided products.

2.2.2 Hazardous Locations

When located in areas where fire or explosion hazards exist, provide system components rated and installed according to Chapter 5 of NFPA 70.

2.2.3 Maintainability

Provide components that can be maintained using commercially available tools and equipment. Arrange and assemble components to be readily accessible to maintenance personnel without compromising system defeat resistance and with no degradation in tamper protection, structural integrity, EMI or RFI attenuation, or line supervision after maintenance when it is performed in accordance with manufacturer's instructions.

2.2.4 Availability

Provide components rated for continuous operation. Provide solid-state electronic components mounted on printed circuit boards, conforming to UL 796. Provide boards that are plug-in, quick-disconnect type. Do not impede maintenance with densely packed circuitry. Provide power-dissipating components with safety margins of not less than 25 percent with respect to dissipation ratings, maximum voltages, and current-carrying capacity. Provide heat sinks or other heat dissipation devices on appropriate components and assemblies. Provide solid-state type or hermetically sealed electromechanical type light duty relays and similar switching devices.

2.2.5 Fail-Safe Capability

Provide fail-safe capability in critical elements of the ESS including, but not be limited to, the capability to monitor communication link integrity and to provide self-test. Provide fault annunciation when

diminished functional capabilities are detected. Annunciate fail-safe alarms to clearly distinguish from other types of alarms.

2.2.6 Line Supervision

Provide the same geographic resolution for fault isolation at the systems level as provided for intrusion detection. Provide either a static or dynamic system with active mode for line supervision of communication links of the ESS.

a. The static system must represent "no-alarm" always by the same signal, which is different than the originally transmitted signal.

b. The dynamic system must represent "no-alarm" with a signal which continually changes with time.

2.2.7 Power Loss Detection

Detect AC and DC power loss and generate an alarm when a critical component of the system experiences temporary or permanent loss of power. Annunciate the alarm in the Secured Area and the Security Command Center to clearly identify the component experiencing power loss.

2.2.8 Controls and Designations

Provide controls and designations in accordance with NEMA ICS 1.

2.2.9 Special Test Equipment

Provide all special test equipment, special hardware, software, tools, instructions, and programming or initialization equipment needed to start or maintain any part of the system and its components. Special test equipment is defined as any test equipment not normally used in an electronics maintenance facility.

2.2.10 Electromagnetic Interference (EMI)

Configure and provide ESS components employing electromagnetic radiation constructed to provide minimal vulnerability to electronic countermeasures.

2.2.11 Electromagnetic Radiation (EMR)

Provide only ESS communication components which are Federal Communications Commission (FCC) licensed and approved. Provide system components which are electromagnetically compatible.

2.2.12 Interchangeability

Use off-the-shelf components which are physically, electrically, and functionally interchangeable with equivalent components as complete items. Equivalent, replacement components must not require new or other component modification. Do not use custom designed or one-of-a-kind items. Interchangeable components or modules must not require trial and error matching in order to meet integrated system requirements, system accuracy, or restore complete system functionality.

2.2.13 Date and Time Generator

The ESS system date and time are to originate from the ESS network time

server.

2.3 INTRUSION DETECTION SYSTEM (IDS)

Provide an IDS that is compatible with the Installation's existing central monitoring system. The Installation's existing IDS is manufactured by Advantor systems. Provide and IDS that is integrated with the Installation's existing IDS and works seamlessly with the Installation's existing IDS.

The IDS primary function is to detect intrusion into secured areas. Utilize a single database for all IDS programming data that seamlessly integrates with the ESS under a single operating environment. The IDS events must be viewable as separate or as a combined list of all ESS events. Control the IDS alarm monitoring through software control from the ESS.

a. Provide both supervised and non-supervised alarm point monitoring.

b. Secure or access alarm points both manually and automatically by time of day, day of week or by operator command.

c. For classified assets, IDS installation related components and monitoring stations must comply with UL 2050.

2.3.1 IDS Components

Provide components:

a. Premise Control Units (PCU)

b. Detection Sensors

c. Tamper Switches

d. Arm/Disarm Keypads

2.3.2 Detection Sensitivity

The sensitivity of the IDS must allow for the following:

a. Locating intrusions at individually protected assets or at an individual portal

b. Locating intrusions within the coverage on a single volumetric sensor

c. Locating failures or tampering at individual sensors

2.3.3 Detection Alarm and Reporting Capacity

Collect, communicate, and display up to 12 sensor zone alarms and to enable control of one card reader with integral keypad for secure and access outside of the protected area with instant alarm.

Identify individual sensors in alarm if the sensor zone is a multiple alarm source combination. Annunciate a single alarm within 2 seconds maximum, after sensor transducer or other detection device activation .

2.3.4 False Alarm Rate

The false alarm rate for each interior IDS zone must not exceed one false alarm per 30-day period. The false alarm rate for each exterior IDS zone must not exceed one false alarm per 24-hour period.

2.3.5 Nuisance Alarm Rate

The nuisance alarm rate for each interior IDS zone must not exceed three nuisance alarms per 30-day period. The nuisance alarm rate for each exterior IDS zone must not exceed three nuisance alarms per 24-hour period.

2.3.6 Premise Control Unit (PCU)

Install the PCU command processor in a tamper resistant enclosure that is specified in paragraph COMPONENT ENCLOSURE. Package the following with the PCU:

a. Power transformer

b. Battery(s)

c. Network connection cable

d. Keypad(s)

e. Keypad connection cable(s)

f. Additional components as required for full functionality

2.3.6.1 PCU Capabilities

Provide the PCU at a minimum but not limited to, the following capabilities;

a. Expansion to a total of at least 10,000 user codes with 99 user profile definitions.

b. Support 8 keypads with alphanumeric display. Each keypad must be capable of securing and accessing any system area based on a pass code or access control card and or key FOB authorization. Provide keypad alphanumeric display with complete prompt messages during all stages of operation and system programming and display all relevant operating and test data.

c. A total of at least 100 programmable output relay schedules.

d. 32 individual reporting areas.

e. Data line supervision or two separate lines of communication.

f. Two-man access code or credentials.

g. Support programming to require the same or different access code entered within a programmed delay time of 1 to 15 minutes after disarming before activating a silent ambush alarm.

h. Support area programming that disables schedule and time-of-day changes while system is armed so that area can only be disarmed during

scheduled times.

i. Provide a minimum of a 4,000 event log buffer per PCU. Record and hold alarm activity information in the log buffer until the ESS is connected and receives the information. Provide a software-configurable warning log buffer filling notification for PCU(s) configured with network switch capabilities.

j. Support a Network Interface Card (NIC) plug-in module with built in network router capable of 128 Bit AES Rijndael Encryption process certified by NIST (National Institute of Standards and Technology).

2.3.6.2 Overcurrent Protection and Indication

When overcurrent more than it is rated for is detected by the PCU, communication bus(es) and keypad(s) are to be shut down and an overcurrent notification LED lit to indicate the situation.

2.3.6.3 Manual and Self-Test

All alphanumeric keypad to include testing for: standby battery, alarm bell or siren, and communication to the Security Command Center (SCC). Include provisions for an automatic, daily, weekly, 30 day, or up to 60 day communication link test from the PCU installation site to the SCC. Include a provision for displaying the internal system power and wiring conditions.

Include the following for internal monitoring points:

a. The bell circuit

b. AC power

c. Battery voltage level

d. Charging voltage

e. Panel box tamper

f. Phone trouble line 1

g. Phone trouble line 2

h. Transmit trouble

i. Network trouble

A battery test must be automatically performed to test the integrity of the standby battery by disconnecting the standby battery from the charging circuit and placing a load on the battery. Perform this test at an interval no greater than 180 days.

2.3.7 Detection Sensors

a. Sensors are to detect facility perimeter or protected zone penetrations by unauthorized personnel or intruders and transmit an alarm signal to the alarm annunciation system upon change detection. Accomplish this with a probability of detection (PD) of 0.95 with a 95 percent confidence level and conforming to UL 639 where applicable.

Probability of Detection	0.9	0.9	0.95	0.95	Number of Misses Allowed
Confidence Level	90 Percent	95 Percent	90 Percent	95 Percent	
Number of Intrusion Attempts	22	29	45	59	0
	38	46	77	93	1
	52	61	105	124	2
	65	76	132	153	3
	78	89	158	181	4
	91	103	184	208	5

b. Required sensor power is 12 VDC unless otherwise specified.

c. An interior IDS zone is a room or space within a building that can be secured and accessed independently from all other zones.

d. Provide line supervision for all sensors with an end-of-line resistor at the sensor or within a tampered junction box with conduit from the junction box to the sensor.

e. Provide sensors and components rated for operation in the installed environment. The sensors must transmit an alarm signal to the alarm annunciation system upon change detection. Provide all sensors with a tamper switch and elements housed in a tamper-alarmed enclosure in accordance of paragraph COMPONENT ENCLOSURE.

2.3.7.1 Interior Sensors

2.3.7.1.1 High Security Switch (HSS)

Mount the HSS inside the secure location and on the opening side of the door. HSS sensors do not have the capability to incorporate an end-of-line (EOL) resistor.

2.3.7.1.1.1 Level 1 Switch

UL 634. Level 1 High Security

2.3.7.1.1.2 Level 2 Switch

UL 634. Level 2 High Security

2.3.7.1.2 Glass Break Detection

UL 639.

2.3.7.1.2.1 Window-Mounted Glass Break Shock Sensor

Provide sensors with an LED for adjusting sensitivity.

Provide sensor with an exterior label to protect tape from direct sunlight. Seismic vibrations or other ambient stimuli are not to initiate an alarm. Test glass breakage sensors by using test units supplied by the manufacturer which simulate glass breakage.

2.3.7.1.2.2 Ceiling Or Wall-Mounted Dual Technology Glass Break Sensor

Provide a sensor that eliminates occupant-generated false alarms by combining a passive infrared motion detector (PIR) with glass break sensing. The combination will extend coverage to occupied areas, allowing the sensors to be armed while people are present.

2.3.7.1.2.3 Ceiling or Wall-Mounted Recessed Glass Break Sensor

Provide a sensor employing pattern recognition technology that listens for the actual pattern of breaking glass. The sensor is to be able to detect the difference from breaking glass and normal room sounds by listening across the glass break frequency spectrum. Provide a range of 25 feet to cover the area to be protected.

2.3.7.1.3 Vibration Vault Sensor

Provide a sensor that senses short duration, large amplitude signals like those produced in attacks from explosions, hammering or chiseling and also detect long duration, small amplitude signals like those produced in attacks from torches, thermic lances, drills, grinders, or cutting discs.

Provide sensor equipped with a manual and an automatic test alarm output with test indicator not visible or audible during normal operations. The test indicator is to annunciate when the sensor detects an intruder when active. The alarm indication may be located within the sensor or as a separate device.

2.3.7.1.4 Fiber Optic Mesh Sensors

Fiber optic mesh sensors are to be comprised of a web of optical fiber cables which are deployed within:

a. Building walls

b. Partitions

c. Flexible structures

d. Water-side installations

e. Mobile facilities

f. Mobile container shells

2.3.7.1.5 Utility Inlet Opening Protection

Provide protection by a sensor of the breakwire type consisting of up to 26 AWG hard-drawn copper wire with a tensile strength of 4 pounds maximum interlaced throughout the opening such that no opening between wires is

larger than 4 inches on center.

Tamper protect terminated sensors so that any attempts to cut the wire or enlarge openings between wires cause an alarm.

2.3.7.1.6 Passive Infrared Sensors

UL 639.

2.3.7.1.7 Microwave Sensors

UL 639.

2.3.7.1.8 Dual Technology Sensors

UL 639. Provide sensor combining passive infrared (PIR) and microwave sensors configured and manufactured specifically to be mounted in a single tamper alarmed enclosure. The sensor must provide "AND" logic for alarm indication. Provide sensors that have a local means of indicating detection for use during installation and calibration with a means of disabling the indication.

The sensor is to have an LED walk test indicator which is not visible during normal operations. When visible, the walk test indicator will light when the sensor detects an intruder. Provide a sensor equipped with a manual control, located within the sensor's housing, to enable and disable the test indicator or with the test indicator located within the sensor housing so that it can only be seen when the housing is open or removed.

2.3.7.1.9 Photoelectric Sensors

UL 639. The sensor is to detect opaque bodies and not allow an intruder to disable detection by shining another light source into the receiver.

Provide sensor with a local means of indicating detection for use during installation and calibration with a means of disabling the indication.

2.3.7.2 Tamper Switches

a. Corrosion-resistant tamper switches are required for the following IDS and VSS equipment with hinged doors or removable covers that contain open circuits:

(1) Enclosures

(2) Cabinets

(3) Housings

(4) Boxes

(5) Raceways

(6) Fittings

(7) Sensors

b. Tamper switches are to initiate an alarm signal when the door or cover

is moved as little as 1/4 inch from the normally closed position. Mechanically mount tamper switches to maximize defeat time when enclosure covers are opened or removed. One second is the minimum amount of time required to depress or defeat the tamper switch after opening or removing the cover. Enclosure and tamper switch must prevent direct line of sight to internal components and prevent switch or circuit tampering. Conceal mounting hardware so switch cannot be observed from enclosure exterior.

c. Tamper switches on doors which are opened to make normal maintenance adjustments to the system and to service power supplies must not have a maintenance position.

2.3.7.2.1 Tamper Switch Performance Requirements

Tamper switches are to be:

a. Inaccessible until switch is activated.

b. Under electrical supervision at all times, irrespective of the protection mode in which the circuit is operating.

c. Annunciated to be clearly distinguishable from intrusion detection alarms and exempt from being disarmed, shunted, or silenced.

d. Spring-loaded and held in the closed position by the door, or cover protected.

e. Wired to break the circuit when the door or cover is disturbed.

f. Wired so that each sensor and device is annunciated individually at the central reporting processor.

2.3.8 Intrusion Detection System Date and Time

Provide system date and time per paragraph DATE AND TIME GENERATOR.

2.4 ACCESS CONTROL SYSTEM (ACS)

Provide an access control system based upon a modular distributed microprocessor architecture complete with access control cards and ready for operation.

a. The ACS card credentials are required to be Common Access Cards (CAC), and CAC cards are being provided by the Government. Interface system with and provide alarm and other status to the overall ESS. Provide ACS that meets the communications requirements of UL 1076 and UL 294 and has the capability of controlling up to 8 card readers and keypads per card reader controller, 128 alarm inputs, or 128 relay outputs or any components combination.

b. System is to grant or deny access or exit based upon:

(1) Keypad identification data

(2) Common Access Card (CAC) card identification data

(3) Time of day, day of week, and special day and holiday scheduling with card validation override.

c. Decision to grant or deny access or exit is to be based upon authorization for such data to be input at a specific location for the current duration. Access decisions for high security areas are to be based upon two identification technology combinations: card and keypad or card.

d. Provide ACS that supports the configuration and simultaneous monitoring of multiple access control devices when TCP/IP communication interfaces are used between the ESS and the primary Access Control Unit (ACU). The events of the ACS are to be viewable as separate or as a combined list of all ESS events. Provide overall control of the ACS, alarm monitoring, and photo identification through software control of the ESS.

e. Access control, photo imaging, and programming data must reside on a single database and instantly accessible to every networked PC workstation connected to the ESS.

f. Provide both supervised and non-supervised alarm point monitoring.

g. Provide the capability to arm or disarm alarm points both manually and automatically by time of day, day of week or by operator command and the capability to disarm alarm points based on a valid access event.

h. Provide programmable 'delay' setting for all alarm points. The alarm points are not to report an ENTRY type alarm until the delay setting has expired and not report a dwell type alarm condition until the alarm has been active for the full delay period.

i. Provide the capability to place ACU(s) in an off-line mode. In the off-line mode, the ACU(s) must retain a historical summary of all ACU activity transactions, up to the maximum capacity of the ACU memory buffer. Provide the ability for manual operator control of system output relays with the manual functions to energize, de-energize, enable or disable.

2.4.1 ACS Programming

Provide software capable of, but not limited to, the following programming:

2.4.1.1 Time Schedules

Provide up to 256 user-definable time schedules. These time schedules are to determine the day(s) and times that access will be granted, or a scheduled event is to occur. Any and all of the time schedules are to be available for defining access privileges and scheduled events. Provide ALWAYS and NEVER schedules that cannot be altered or removed from the system. Each user-defined time schedule must have the option of reacting or not reacting to user-defined special days, with the ability to react uniquely to each type of special day.

2.4.1.2 Special Days

Provide an unlimited number of user definable special days to be used for configuring exceptions to the normal operating rules, typically for specifying holiday operating rules. Allow for each special day to be assigned to a user-defined type.

2.4.1.3 ACU Daylight Savings Time Adjustment

Provide a software-configurable, user defined adjustment for Daylight Savings Time. The ACU must not need to be connected to a PC workstation for the adjustment to occur.

2.4.1.4 Scheduled Events

Any access-controlled reader is to be capable of scheduled unlock periods to allow for card-free access. The access-controlled reader is to also be capable of requiring one valid access event before beginning a scheduled unlock period.

Any access control point is to be capable of requiring a valid card as well as a PIN code via keypad on a scheduled basis for high security areas. The use of PIN via keypad functions must not reduce the number of card readers or alarm points available in the ACU(s). Any designated alarm input must be able to be scheduled Secured and Accessed. Any relay output must be capable of scheduled ON and OFF periods to allow for automatic input and output system control.

2.4.1.5 Maximum User Capability

Up to 64,000 individual users may be given access cards or codes and have their access controlled and recorded.

2.4.1.6 Access Groups

Each system user must be assignable to a maximum of 4 of 256 possible access groups. An access group is defined as one or more people who are allowed access to the same areas at the same days and time periods.

2.4.1.7 Active and Expire Dates

Any card or user may be configured with activation and expiration dates. The card can be assigned to any valid access group and will be activated and expired according to the specified dates.

2.4.1.8 Maximum Use Settings

Any card or user may be configured with maximum number of uses for that card. The card can be assigned to any valid access group and will be expired according to the specified number of card uses.

2.4.1.9 Door Outputs

Provide each access control reader with two dedicated relay outputs. Both relays are to provide Normally Open and Normally Closed contacts. Use the first relay for electric lock control while the second is software configurable to activate for door forced open, door left open too long, duress, passback violations, invalid access attempts and valid unlock conditions. Allow for both relays to be separately programmable for energize times from 1 second to 10 minutes. The second relay must allow a delay time to be specified, causing its activation to be delayed after an activating condition occurs.

2.4.1.10 User List or Who's In (Muster Reports)

Provide the capability to generate dynamic lists of users in certain

access-controlled areas, based either upon selected users or selected areas. The lists must have the option of automatically refreshing after a user-selected interval of time.

2.4.1.11 Crisis Mode

Provide support for a "crisis mode", in which user-selected alarm point activations cause changes to user access privileges. The changes to user access privileges must be configurable to restrict normal access to no access or limited access.

2.4.1.12 Door Groups

Allow up to 256 door groups to be configured. Doors belonging to the same group are capable of being locked, unlocked, disabled, and enabled on command from the ACS.

2.4.1.13 Door Interlocking

Allow a group of doors to be software configured so that if any door in the group is unsecure, all other doors are automatically disabled. This feature is also known as a "mantrap" configuration. The interlocking features must not require the ACS to be on-line for proper operation.

2.4.1.14 PIN Required

Provide support for the required use of a keypad code, in addition to a valid credential during user-selected schedules.

2.4.1.15 Remote Door Control

Provide the ESS operator the capability of manually controlling any access point by issuing a simple command from the ACS. Provide the operator the ability to lock, unlock, enable, and disable any door or Door Group in this manner. This activity is to cause an entry to be logged displaying the door name, number and time that it was performed.

2.4.1.16 Key Control

When interfaced with an approved key-control system, the system is to allow users to deny access to certain doors for any users who have keys in their possession.

2.4.1.17 Disable Event Messages

Allow users to disable user-selected event messages (Door Forced Open, Door Open Too Long, Door Closed, Request to Exit) for user-selected doors. Allow users to disable certain messages (Door Forced Open, Door Open Too Long) according to a user-selected schedule.

2.4.1.18 Input and Output Groups

Allow for up to 256 user-defined (input and output) groups to be defined. Each Input device is to be able to be linked to these groups for arming, disarming, shunting and unshunted as well as output control.

2.4.1.19 Delays

Each alarm device must allow a delay to be specified which is either an

entry type or a dwell type. An entry-type delay is to prevent the input from issuing an alarm event until the delay elapses. If unarmed during the delay period, the alarm is to be ignored. A dwell-type delay requires the input to remain in the alarm state for the full delay duration before issuing an alarm.

2.4.1.20 Output Configuration

Allow each output relay to be software configurable as:

(1) Follows

(2) Latch

(3) Timeout

(4) Scheduled

(5) Timeout Re-triggerable

(6) Limit

(7) Counter

Allow for a time schedule to automatically control the activation and de-activation of the Scheduled type with all other types configured to activate based on input and output group conditions. Additionally, a time schedule must be specified to configure when the output is to actively monitor the input and output groups.

2.4.1.21 Remote Output Control

Provide the operator the capability of manually controlling any output point by issuing a simple command from the SCC. Based upon the output type, provide the ESS operator the ability to ENABLE, DISABLE, turn ON and turn OFF any output in this manner. A FOLLOWS type output must not be capable of being turned OFF or ON. Log an entry when this activity is performed displaying the output name and time performed. Manual control of outputs are not permissible in ICS 705-1 applications.

2.4.1.22 Remote Reset Command

Provide the capability for any ACU to reset manually or by command issued from the ACS with the option of simulating the ACU reset settings or forcing a reset type as specified by the user. The remote reset command is not to cause the ACU to degrade its level of protection to any access points defined.

2.4.1.23 Time Zone

Allow the user to select the time zone in which the ACU is located, so that event times displayed for that ACU will match the local time where the ACU is located.

2.4.1.24 User-Selected LED Behavior

Allow the user to select different behaviors for the LEDs of each access-controlled reader.

2.4.1.25 Traced Cards

Provide the capability of selecting any number of cardholders for the purpose of limiting reports to only traced users displaying all traced cardholder events in a user-selected alternate color.

2.4.2 Error and Throughput Rates

Rates must be portal to portal performance averages obtained when processing individuals one at a time. Features are not to reduce capability to meet throughput requirements when serial verification techniques or multiple attempts are required to satisfy error performance requirements.

A Type I error denies access to an authorized enrolled individual. A Type II error grants access to an unauthorized individual. Subsystem Type I and Type II error rates must both be less than 0.1 percent. At the error rates, subsystem access throughput rate must be minimum of 12 individuals per minute through one card reader and keypad access control device.

2.4.3 Access Control System Central Processing

a. Provide serial management and control of system processing. Provide a microprocessor control device able to monitor and control units and up to 32 card reader and keypad access control devices. Central processor must interrogate and receive responses from each ACU within 100 milliseconds. Failure to respond to an interrogation is to cause an alarm.

b. Provide the central processor with a Ethernet interface port to communicate with the printer. Provide an operator interface to control system operating functions. Provide the central processor with a facility-tailorable data base for a minimum of 1000 cardholders with by-name alphanumeric printout, and for automated IDS monitoring, management, and control functions.

c. Provide enrollment equipment as required in paragraph ENROLLMENT CENTER EQUIPMENT.

d. Provide system configuration controls and electronic diagnostic aids for subsystem setup and troubleshooting with the central processor. Components are not to be accessible to operations personnel and must be tamper alarmed.

2.4.4 Access Control Unit(ACU)

Provide micro-processor based ACU with all access and input and output decisions to be made by the individual ACU(s). Provide modular solution which will allow for present security requirements and the capability to expand. Configure all field ACU panels to intercommunicate via RS-422/485 or RS-232 hardwired or TCP/IP. Equip all field ACU(s) with a tamper contact.

Designate one ACU as "Primary", responsible for all ACS-to-ACU communications. All other ACU(s) up to a maximum of 256 are to be designated as "Secondary" and communicate with the "Primary" via an RS-422/485 hardwire, TCP/IP network or fiber-optic configuration. Provide ACU capable of, but not limited to, the following:

a. Built-in surge suppression circuitry on plug-in modular circuit boards with surge suppression, configured as an integral component of the system and self-sacrificing in the event of extreme surges or spikes.

b. Capable of supporting at least 2 ports and be expandable in increments of two ports up to a maximum of 16 ports per ACU.

c. Each port configured by ACS to support any one of the following peripheral devices:

(1) Card reader

(2) Alarm Monitoring Module

(3) Output Relay Module

(4) Elevator Reader

(5) Elevator Output Module

Any device combination can be supported on each ACU, up to a total of 16 devices per ACU.

d. Capability of supporting multiple card reader technologies simultaneously, including:

(1) Keypad

(2) Card and Keypad

(3) CAC compatible

(4) Biometrics

This capability must be an integral part of the ACU and will not require special external equipment. See NIST SP 800-116.

e. Built-in battery back-up of programmed information sustainable for a period of at least 90 days.

f. Powered by a 12 or 24VDC power source rated at a minimum of 2 amperes with a battery back-up for complete system operation in the event of power failure. Provide battery backup for all ACU(s) to sufficiently power the ACU for 8 hours continuous service.

g. Electric strikes, other locking devices and ancillary peripherals on a separate power supply with battery back-up for continued operation in the event of power failure as specified in paragraph BACKUP POWER.

h. A minimum of a 10,300 event log buffer per ACU to record and hold access and alarm activity information until the ACS is connected and receives the information. Provide a software-configurable warning log buffer filling notification for ACU(s) configured with network switch capabilities.

2.4.5 Access Control Devices

UL 294. The card, card reader, and panels must meet encryption requirements that are specified in paragraph DATA ENCRYPTION. Devices are

to be tamper alarmed, tamper and vandal resistant, and solid state, containing no electronics which could compromise the access control subsystem should the subsystem be attacked.

2.4.5.1 Card Readers

Provide surface, weatherproof mountable card readers as indicated for each individual location. Provide contactless w/keypad type card readers capable of reading CAC and Keypad CAC cards type of access control cards.

Keypads must contain an alphanumeric and special symbols keyboard with symbols arranged in ascending ASCII code ordinal sequence . Provide keypad integrated into the card reader.

2.4.5.1.1 Contact Card Readers

Provide contact card readers that can read credential CAC cards whose characteristics of size and technology meet those defined by ANSI ISO/IEC 7816 and meet NDAA Compliance and NIST FIPS 201-2 Approval Letter for ACS Products.

Provide readers with "flash" download capability to accommodate card format changes and the capability of reading the card data and transmitting the data, or a portion thereof, to the ESS control panel.

2.4.5.1.2 Contactless Card Readers

Provide contactless card readers that can read credential CAC cards whose characteristics of size and technology meet those defined by ANSI ISO/IEC 7816 in close proximity to the card reader and meet NDAA Compliance and NIST FIPS 201-2 Approval Letter for ACS Products.

Provide readers with "flash" download capability to accommodate card format changes and the capability of reading the card data and transmitting the data, or a portion thereof, to the ESS control panel.

2.4.5.1.3 Card Readers With Integral Keypad and Biometric Reader

Equip contact and contactless card readers with integral keypads and biometric readers as specified in paragraph KEYPADS and as in FINGERPRINT ANALYSIS SCANNER.

2.4.5.1.4 Card Readers with Integral Keypad

Equip contact and contactless card readers with integral keypads as specified in paragraph KEYPADS.

2.4.5.1.5 Card Reader Display

Provide card readers with an LED or other visual indicator display which indicate power ON and OFF and whether user passage requests have been accepted or rejected.

2.4.5.1.6 Card Reader Response Time

The card reader is to respond to passage requests by generating a signal to the local processor.

2.4.5.1.7 Card Reader Power

Power the card reader from the source as shown on the drawings. The card reader must not dissipate more than 5 Watts.

2.4.5.1.8 Card Reader Mounting Method

Provide card readers suitable for surface, or weatherproof mounting as required.

2.4.5.2 Keypads

Entry control keypads are to use unique alphanumeric and other symbol combinations as an identifier. Keypads must contain an integral alphanumeric and special symbols keyboard with symbols arranged in ascending ASCII code ordinal sequence . Communications protocol is to be compatible with the local processor.

2.4.5.2.1 Keypad Display

Keypads are to include an LED or other type of visual indicator display and provide visual status indications indicating power ON and OFF and whether user passage requests have been accepted or rejected.

The maximum horizontal and vertical viewing angles are to be limited by the keypad display or enclosure. The maximum horizontal viewing angle must be no more than plus and minus 5 degrees off a vertical plane perpendicular to the plane of the face of the keypad display. The maximum vertical viewing angle must be no more than plus and minus 15 degrees off a horizontal plane perpendicular to the plane of the face of the keypad display.

2.4.5.2.2 Keypad Response Time

The keypad is to respond to passage requests by generating a signal to the local processor.

2.4.5.2.3 Keypad Power

Power the keypad from the source as shown on the drawings. The keypad must not dissipate more than 5 Watts.

2.4.5.2.4 Keypad Mounting Method

Provide keypads suitable for surface mounting as required.

2.4.5.2.5 Keypad Duress Codes

Provide a means for users to indicate a duress situation by entering a special code into the keypad.

2.4.5.3 Access Control Cards

Provide cards with the capability of modification and lamination during enrollment process without readability reduction for use as a picture and identification badge. Cards must contain binary coded data arranged in a scrambled pattern as a unique identification code stored on or within the card and of the type readable by the subsystem card readers. Include a non-duplicated unique facility access control subsystem identification

code common to access control cards within the card binary data. Configure cards for use as a photo identification card suitable for lamination.

PIV cards must be be listed on the "FIPS 201 Approved Products List - PIV Card" found on the www.idmanagement.gov website.

2.4.5.3.1 Credential Card Modification

Provide entry control cards that can be modified by lamination or direct print process during the enrollment process for use as a picture and identification badge as needed for the site without readability reduction. Credential cards must allow adding at least one slot or hole for a clip affixing the credential card to the type of badge holder used at the site.

2.4.5.3.2 Card Size and Dimensional Stability

Provide credential cards that are 2-1/8 x 3-3/8 inches. The credential card material must be dimensionally stable so that an undamaged card with deformations resulting from normal use is readable by the card reader.

2.4.5.3.3 Card Materials and Physical Characteristics

Provide credential cards that are abrasion resistant, non-flammable, and present no toxic hazard to humans when used in accordance with manufacturer's instructions. The credential card is to be impervious to solar radiation and the effects of ultra-violet light.

2.4.5.3.4 Card Construction

Provide credential cards of core and laminate or monolithic construction. Hot stamp into material or direct print onto lettering, logos and other markings.

2.4.5.3.5 Card Durability and Maintainability

The credential cards must yield a useful lifetime of at least 5 years. The credential card must be able to be cleaned by wiping the credential card with a sponge or cloth wet with a soap and water solution.

2.4.5.3.6 Warranty

Include a minimum 3-year warranty.

2.4.5.4 Personal Identity Verification Equipment

Entry control personnel identity verification equipment must use a unique personal characteristic or unique personal physiological measurement to establish the identity of authorized, enrolled personnel. Provide a means to construct individual templates or profiles based upon measurements taken from the person to be enrolled. This template is to be stored as part of the System Reference Database Files. The stored template is to be used as a comparative base by the personnel identity verification equipment to generate appropriate signals to the associated local processors.

2.4.5.4.1 Template Update and Acceptance Tolerances

Hand geometry devices are not to automatically update a user's profile. Significant changes in an individual's hand geometry are to require re-enrollment. Provide an adjustable acceptance tolerance or template match criteria under the system manager or operator control. The hand geometry device is to determine when multiple attempts are needed for hand geometry verification, and automatically prompt the user for additional attempts up to a maximum of three. Three failed attempts are to generate an entry control alarm.

2.4.5.4.2 Average Verification Time

The hand geometry device is to respond to passage requests by generating signals to the local processor. The verification time must be 1.5 seconds or less from the moment the hand geometry device initiates the scan process until the hand geometry device generates a response signal.

2.4.5.4.3 Modes

a. Provide an enrollment mode, recognition mode, and code or credential verification mode that is selectable by the system manager or operator from the SCC.

b. The enrollment mode is to create a hand template for new personnel and enter the template into the entry control database file created for that person. Template information must be compatible with the system application software.

c. The hand geometry device allows passage when the hand scan data from the verification attempt matches a hand geometry template stored in the database files when operating in recognition mode.

d. The hand geometry device allows passage when the hand scan data from the verification attempt matches the hand geometry template associated with the identification code entered into a keypad or matches the hand geometry template associated with credential card data read by a card reader when operating in code or credential verification mode.

2.4.5.4.4 Reports

The hand geometry device is to create and store template match scores for all transactions involving hand geometry scans. The template match scores are to be stored in the matching personnel data file in a file format compatible with the system application software and be used for report generation.

2.4.5.4.5 Electrical

The hand geometry device must not dissipate more than 45 Watts from the source indicated.

2.4.5.4.6 Mounting Method

Provide hand geometry devices suitable for surface mounting as required.

2.4.5.4.7 Communications Protocol

The communications protocol between the hand geometry device and the local

processor must be compatible.

2.4.5.4.8 Fingerprint Analysis Scanner

a. Fingerprint analysis scanners are to use a unique human fingerprint pattern to identify authorized, enrolled personnel. The device is to incorporate positive measures to establish that the fingers being measured by the device belong to a living human being. Provide alignment system which allows the user's fingers to always remain in full view of the user.

b. The fingerprint analysis scanner is to perform an optical or other type of scan of the user's fingers during the scan process. The fingerprint analysis scanner is to automatically initiate the scan process provided the user's fingers are properly positioned. Each user fingerprint template must not require more than 1250 eight-bit bytes of storage media space.

c. Include an LED or other type of visual indicator display and provide visual status indications and user prompts. The display is to indicate power ON and OFF, and whether user passage requests have been accepted or rejected.

2.4.5.4.8.1 Template Update and Acceptance Tolerances

Fingerprint analysis scanners are not to automatically update an user's profile. Significant changes in an individual's fingerprints require re-enrollment. Provide an adjustable acceptance tolerance or template match criteria under system manager or operator control. The fingerprint analysis scanner is to determine when multiple attempts are needed for fingerprint verification, and automatically prompt the enrollee for additional attempts up to a maximum of 3. Three failed attempts are to generate an entry control alarm.

2.4.5.4.8.2 Average Verification Time

The fingerprint analysis scanner is to respond to passage requests by generating signals to the local processor. The verification time must be 2.0 seconds or less from the moment the fingerprint analysis scanner initiates the scan process until the fingerprint analysis scanner generates a response signal.

2.4.5.4.8.3 Modes

a. Provide an enrollment mode, recognition mode, and code or credential verification mode that is selectable by the system manager or operator from the SCC.

b. The enrollment mode is to create a fingerprint template for new personnel and enter the template into the system database file created for that person. Template information must be compatible with the system application software.

c. The fingerprint analysis scanner is to allow passage when the fingerprint data from the verification attempt matches a fingerprint template stored in the database files when operating in recognition mode.

d. The fingerprint analysis scanner allows passage when the fingerprint

data from the verification attempt matches the fingerprint template associated with the identification code entered into a keypad or matches the fingerprint template associated with credential card data read by a card reader when operating in code or credential verification mode.

2.4.5.4.8.4 Reports

The fingerprint analysis scanner is to store template transactions involving fingerprint scans. The template match scores are to be stored in the matching personnel data file in a file format compatible with the system application software, and to be used for report generation.

2.4.5.4.8.5 Electrical

The fingerprint analysis scanner must not dissipate more than 45 Watts from the source indicated.

2.4.5.4.8.6 Mounting Method

Provide fingerprint analysis scanners suitable for surface mounting.

2.4.5.4.8.7 Communications Protocol

The communications protocol between the fingerprint analysis scanner and its associated local processor must be compatible.

2.4.5.4.9 Iris Scan Device

The iris scan identification device is to use the unique patterns found in the iris of the human eye to identify authorized, enrolled personnel. The device is to use ambient light to capture an image of the iris of a person presenting themselves for identification. The resulting video image is to be compared against a stored template that was captured during the enrollment process. The device authenticates the presenting individual as identified when the presented image is sufficiently similar to the stored image template. Provide the ability to adjust the threshold of similarity.

Users who wear contact lenses or eyeglasses are not to adversely affect the efficiency and accuracy of the device. Facial contact with the device is not to be required for identification. Provide a manual push-button to initiate the scan process when the user has aligned their eye in front of the device. Provide adjustments to accommodate differences in user height.

2.4.5.4.9.1 Display Type

Include an LED or other type of visual indicator display and provide visual status indications and user prompts. The display is to indicate power ON and OFF and whether user passage requests have been accepted or rejected.

2.4.5.4.9.2 Template Update and Acceptance Tolerances

Iris scanners are not to automatically update a user's template. Significant changes in an individual's eye requires re-enrollment. Provide an adjustable acceptance tolerance or template match criteria under system manager or operator control. The iris scanner is to determine when multiple attempts are needed to verify the iris being scanned, and automatically prompt the enrollee for additional attempts up to a maximum of three. Three failed attempts generates an entry control

alarm.

2.4.5.4.9.3 Average Verification Time

The iris scanner is to respond to passage requests by generating signals to the local processor. The verification time must be 1.5 seconds or less from the moment the eye scanner initiates the scan process until the eye scanner generates a response signal.

2.4.5.4.9.4 Modes

a. Provide an enrollment mode, recognition mode, and code or credential verification mode that is selectable by the system manager or operator from the Security Command Center.

b. The enrollment mode is to create an iris template for new personnel and enter the template into the system database file created for that person. Template information must be compatible with the system application software.

c. The iris scanner is to allow passage when the iris scan data from the verification attempt matches the iris scan template stored in the database files when operating in recognition mode.

d. The iris scanner allows passage when the iris scan data from the verification attempt matches the iris scan template associated with the identification code entered into a keypad or matches the iris scan template associated with credential card data read by a card reader when operating in code or credential verification mode.

2.4.5.4.9.5 Reports

The iris scanner is to store template transactions involving iris scans. The template match scores are to be stored in the matching personnel data file in a file format compatible with the system application software and be used for report generation.

2.4.5.4.9.6 Electrical

The eye scanner must not dissipate more than 45 Watts from the voltage source indicated.

2.4.5.4.9.7 Mounting Method

Provide eye scanners suitable for surface mounting.

2.4.5.4.10 Facial Scanner

a. Facial recognition scanners are to use a unique human facial patterns to identify authorized, enrolled personnel. The device is to incorporate positive measures to establish that the face being measured by the device belong to a living human being. Provide alignment system which allows the user's face to always remain in full view of the user.

b. The facial recognition scanner is to perform an optical or other type of scan of the user's face during the scan process. The facial recognition scanner is to automatically initiate the scan process provided the user's face is properly positioned.

c. Include an LED or other type of visual indicator display and provide visual status indications and user prompts. The display is to indicate power ON and OFF, and whether user passage requests have been accepted or rejected.

2.4.5.4.10.1 Template Update and Acceptance Tolerances

Facial recognition scanners are not to automatically update an user's profile. Significant changes in an individual's face require re-enrollment. Provide an adjustable acceptance tolerance or template match criteria under system manager or operator control. The facial recognition scanner is to determine when multiple attempts are needed for data verification, and automatically prompt the enrollee for additional attempts up to a maximum of 3. Three failed attempts are to generate an entry control alarm.

2.4.5.4.10.2 Average Verification Time

The facial recognition scanner is to respond to passage requests by generating signals to the local processor. The verification time must be 2.0 seconds or less from the moment the facial recognition scanner initiates the scan process until the facial recognition scanner generates a response signal.

2.4.5.4.10.3 Modes

a. Provide an enrollment mode, recognition mode, and code or credential verification mode that is selectable by the system manager or operator from the SCC.

b. The enrollment mode is to create a facial template for new personnel and enter the template into the system database file created for that person. Template information must be compatible with the system application software.

c. The facial recognition scanner is to allow passage when the facial data from the verification attempt matches a facial template stored in the database files when operating in recognition mode.

d. The facial recognition scanner allows passage when the facial data from the verification attempt matches the facial template associated with the identification code entered into a keypad or matches the facial template associated with credential card data read by a card reader when operating in code or credential verification mode.

2.4.5.4.10.4 Reports

The facial recognition scanner is to store template transactions involving facial scans. The template match scores are to be stored in the matching personnel data file in a file format compatible with the system application software, and to be used for report generation.

2.4.5.4.10.5 Electrical

The facial recognition scanner must not dissipate more than 45 Watts from the source indicated.

2.4.5.4.10.6 Mounting Method

Provide facial recognition scanners suitable for surface mounting.

2.4.5.4.10.7 Communications Protocol

The communications protocol between the facial recognition scanner and its associated local processor must be compatible.

2.4.5.4.11 Palm Scanner

a. Palm scanners are to use a unique human hand pattern to identify authorized, enrolled personnel. The device is to incorporate positive measures to establish that the palm being scanned by the device belongs to a living human being. Provide alignment system which allows the user's hand to always remain in full view of the user.

b. The palm scanner is to perform an optical or other type of scan of the user's hand during the scan process. The palm scanner is to automatically initiate the scan process provided the user's hand is properly positioned. Each user's hand template must not require more than 1250 eight-bit bytes of storage media space.

c. Include an LED or other type of visual indicator display and provide visual status indications and user prompts. The display is to indicate power ON and OFF, and whether user passage requests have been accepted or rejected.

2.4.5.4.11.1 Template Update and Acceptance Tolerances

Palm scanners are not to automatically update a user's profile. Significant changes in an individual's hand requires re-enrollment. Provide an adjustable acceptance tolerance or template match criteria under system manager or operator control. The palm scanner is to determine when multiple attempts are needed for data verification, and automatically prompt the enrollee for additional attempts up to a maximum of 3. Three failed attempts are to generate an entry control alarm.

2.4.5.4.11.2 Average Verification Time

The palm scanner is to respond to passage requests by generating signals to the local processor. The verification time must be 2.0 seconds or less from the moment the palm scanner initiates the scan process until the palm scanner generates a response signal.

2.4.5.4.11.3 Modes

a. Provide an enrollment mode, recognition mode, and code or credential verification mode that is selectable by the system manager or operator from the SCC.

b. The enrollment mode is to create a hand template for new personnel and enter the template into the system database file created for that person. Template information must be compatible with the system application software.

c. The palm scanner is to allow passage when the hand data from the verification attempt matches a hand template stored in the database files when operating in recognition mode.

d. The palm scanner allows passage when the hand data from the verification attempt matches the hand template associated with the identification code entered into a keypad or matches the hand template associated with credential card data read by a card reader when operating in code or credential verification mode.

2.4.5.4.11.4 Reports

The palm scanner is to store template transactions involving hand scans. The template match scores are to be stored in the matching personnel data file in a file format compatible with the system application software, and to be used for report generation.

2.4.5.4.11.5 Electrical

The palm scanner must not dissipate more than 45 Watts from the source indicated.

2.4.5.4.11.6 Mounting Method

Provide palm scanners suitable for surface mounting.

2.4.5.4.11.7 Communications Protocol

The communications protocol between the palm scanner and its associated local processor must be compatible.

2.4.5.5 Portal Control Devices

Portal control devices must meet the requirements in Section 08 71 00 DOOR HARDWARE.

2.4.5.5.1 Push-Button Switches

a. Provide momentary contact, back lit push buttons and stainless-steel switch enclosures for each push button. Provide switch enclosures suitable for surface mounting as required and push buttons suitable for flush mount in the switch enclosures. The push button switches are to meet the requirements of NEMA 250 for the area in which they are to be installed.

b. Where multiple pushbuttons are housed within a single switch enclosure stack vertically with each push button switch labeled with 1/4 inch high text and symbols. The push button switches are to be connected to the local processor associated with the portal to which they are applied and operate the appropriate electric strike, electric bolt or other facility release device.

c. The continuous current of the IDS circuit is to be no more than 50 percent of the continuous current rating of the device supplied. Provide push button switches with double-break silver contacts that will make 720 VA at 60 amperes and break 720 VA at 10 amperes.

2.4.5.5.2 Panic Bar

Include panic bar emergency exit hardware on emergency exit doors as indicated. Provide an alarm shunt signal from the panic bar emergency exit hardware to the appropriate local processor. Provide panic bar

compatible with mortise- mount door hardware and operate by retracting the bolt.

2.4.5.5.2.1 Emergency Egress With Alarm

Include a conspicuous warning sign with 1 inch high, red lettering notifying personnel that an alarm will be annunciated if the panic bar is operated.

Panic bar hardware operation is to generate an intrusion alarm and local alarm annunciation. The panic bar must depend upon a mechanical connection only and not depend upon electric power for operation, except for local alarm annunciation and alarm communications.

2.4.5.5.2.2 Normal Egress

Panic bar hardware operation is not to generate an intrusion alarm. The panic bar must depend upon a mechanical connection only when exiting. Provide the exterior, non-secure side of the door with an electrified thumb latch or lever to provide access after the credential I.D. authentication by the ESS.

Signal Switches: Strikes/bolts are to include signal switches indicating to the system when the bolt is not engaged, or the strike mechanism is unlocked. The signal switches are to report a forced entry to the system.

2.4.5.5.3 Electric Door Strikes and Bolts

Configure electric door strikes and bolts to remain secure in case of power failure using DC power to energize the solenoids. Incorporate end-of-line resistors to facilitate line supervision by the system. Install metal-oxide varistors (MOVs) to protect the controller from reverse current surges if not incorporated into the electric strike or local controller. Electric strikes must have a minimum forcing strength of 2300 pounds.

2.4.5.5.3.1 Solenoid

The actuating solenoid for the strikes and bolts furnished must not dissipate more than 12 Watts and operate on 12 VDC. The inrush current must not exceed 1 ampere and the holding current must not be greater than 500 milli-amperes. The actuating solenoid must move from the fully secure to fully open positions in not more than 500 milliseconds.

2.4.5.5.3.2 Signal Switches

Strikes and bolts are to include signal switches indicating to the system when the bolt is not engaged . The signal switches are to report a forced entry to the system.

2.4.5.5.3.3 Tamper Resistance

The electric strike and bolt mechanism is to be encased in hardened guard barriers to deter forced entry.

2.4.5.5.3.4 Size and Weight

Electric strikes and bolts are to be compatible with standard door frame preparations.

2.4.5.5.3.5 Mounting Method

Provide electric strikes and bolts suitable for use with single and double door installations, with mortise- type hardware as indicated, and compatible with right- or left-hand mounting.

2.4.5.5.3.6 Astragals

See Section 08 71 00 DOOR HARDWARE for Astragal lock guards.

2.4.5.5.4 Electrified Mortise Lock

Configure electrified mortise locks to remain secure in case of power failure using DC power to energize the solenoids. Provide solenoids rated for continuous duty. Incorporate end-of-line resistors to facilitate line supervision by the system. Install metal-oxide varistors (MOVs) to protect the controller from reverse current surges if not incorporated into the electric strike or local controller.

2.4.5.5.4.1 Solenoid

The actuating solenoid for the mortise locks furnished must not dissipate more than 12 Watts and operate on 12 VDC. The inrush current must not exceed 1 ampere and the holding current must not be greater than 500 milli-amperes. The actuating solenoid must move from the fully secure to fully open positions in not more than 500 milliseconds.

2.4.5.5.4.2 Signal Switches

The mortise locks are to include signal switches indicating to the system when the locks are not engaged. The signal switches are to report a forced entry to the system.

2.4.5.5.4.3 Power Transfer

Provide an electric power transfer with each mortise lock to get power and monitoring signals from the lockset to the door frame.

2.4.5.5.4.4 Size and Weight

Electrified mortise locks are to be compatible with standard door preparations.

2.4.5.5.4.5 Mounting Method

Provide electrified mortise locks suitable for use with single and double door installations. The lock would be in the active leaf and the fixed leaf would be monitored in double door installations.

2.4.5.5.5 Electromagnetic Lock

Electromagnetic locks are to contain no moving parts and depend solely upon electromagnetism to secure a portal by generating at least 1200 pounds of holding force. Interface the lock with the local processors without external, internal, or functional local processor alteration. Incorporate an end-of-line resistor to facilitate line supervision by the system. Install MOVs to protect the controller from reverse current surges if not incorporated into the electromagnetic lock or local controller. Provide

in accordance with ANSI/BHMA A156.23.

2.4.5.5.5.1 Armature

The electromagnetic lock is to contain internal circuitry to eliminate residual magnetism and inductive kickback. The actuating armature must operate on 12 VDC and not dissipate more than 12 Watts. The holding current must be not greater than 500 milli-amperes. The actuating armature must take not more than 300 milli-seconds to change the status of the lock from fully secure to fully open or fully open to fully secure.

2.4.5.5.5.2 Tamper Resistance

The electromagnetic lock mechanism is to be encased in hardened guard barriers to deter forced entry.

2.4.5.5.5.3 Mounting Method

Provide electromagnetic lock suitable for use with single and double door installations with mortise- type hardware as indicated, and compatible with right- or left-hand mounting.

2.4.5.5.6 Entry Booth

2.4.5.5.6.1 Local Alarm Annunciation

Provide local alarm annunciation for all system equipment located within the entry booth itself and its associated portals or zones and terminal devices and a means to enable and disable this feature from the SCC under operator control.

2.4.5.5.6.2 Terminal and Facility Interface Device Support

The entry booth local processor subsystem is to support the full range of system terminal and facility interface devices as specified.

2.4.5.5.6.3 Response Times

The entry booth local processor subsystem must respond to a SCC interrogation within 100 milliseconds. The entry booth local processor is to respond to valid passage requests from its associated terminal devices by generating a signal to the appropriate electric strike and bolt, electrified mortise lock, or electromagnetic lock within 100 milliseconds after verification.

2.4.5.5.6.4 Autonomous Local Control

In the event of a communication loss, the entry booth local processor subsystem must automatically convert to autonomous local control and monitoring of its associated card readers, keypads, electric strike and bolt, electrified mortise lock, or electromagnetic lock and automatically revert to central control upon communication restoration. Transactions occurring during the communications outage are to be recorded and retained in local memory and reported to the central database files upon communication restoration within 10 seconds.

2.4.5.5.6.5 Diagnostics

Provide built-in diagnostics implemented in software, firmware, or

hardware. The booth is to automatically execute a series of built-in tests and report equipment malfunctions, configuration errors, and inaccuracies to the SCC each time the entry booth local processor subsystem is started up or re-booted. The system must annunciate a fail-safe alarm if the local processor fails the built-in diagnostics. Provide diagnostic aids within the entry booth local processor subsystem to aid in system set-up, maintenance, and troubleshooting.

2.4.5.5.6.6 Memory Type and Size

Data entered is to be stored for a minimum of 1 year in the absence of power from external source to the entry booth.

2.4.5.5.6.7 Tamper Protection

The local processor subsystem is to monitor all service entry panels for tamper. Tamper lines must not be accessible except through tamper protected entry panels. Provide entry panels with key locks. Provide the capability to take the booth off-line for service.

2.4.5.5.6.8 Entry Booth Configuration

Provide a closed-in structures suitable for occupancy by 1 person with a personnel passage area, equipment storage, a low security entry or exit door and a high security entry or exit door. Configure with paired card readers, or keypads, 1 each, on the high security entry or exit door and low security entry or exit door; a key release switch outside the low security door; a glass break type emergency release switch. Both doors to the entry booth are to be normally secured.

2.4.5.5.6.9 Entry Booth Operation

a. Configure to allow passage requests to be initiated from only 1 door at a time. During emergency situations both doors must have the capability to able to be opened at the same time. The person is to be allowed entry to the booth by presenting valid credential card to the card reader or keypad identification code data to the keypad device. An unsuccessful attempt to enter the booth are to generate an entry denial alarm.

b. Incorporate a personal identity verification device as specified and grant the person egress from the booth after successful personal identity verification. The entry booth is to confine the person and generate an entry control alarm if the person fails the personal identity verification test. The local processor is to grant the person's passage request if all provided data is valid.

c. The person is to be confined if a tamper alarm is generated by any of the equipment associated with the subject entry booth while a person is inside. Operating the glass break type emergency release switch is to command the entry door electric strike and bolt, electrified mortise lock, or electromagnetic lock release to the fully open position or with a delay after the egress door has been confirmed secured. The person may exit through the door used for entry once inside the entry booth and prior to personal identity verification test initiation.

2.4.5.5.6.10 Display Type

Include an LED or other type of visual indicator display and provide visual status indications and person prompts. The display is to indicate power on/off, and whether enrollee passage requests have been accepted or rejected. Provide 3 status lights outside each door indicating entry booth status by marking:

a. Green light indicates READY

b. Amber light indicates BUSY

c. Red light indicates INOPERATIVE

2.4.5.5.6.11 Lighting

Provide lights recessed above an acrylic light diffuser in the ceiling of the entry booth. Provide a separate light source within the overhead lighting fixture assembly to provide emergency lighting in case of a power failure.

2.4.5.5.6.12 Heating and Ventilation Equipment

Include built-in heating and cooling equipment to sustain the specific operating temperature range for the electronic equipment installed.

2.4.5.5.6.13 Entry Booth Wall and Frame Construction

Provide a rigid structure with the strength of the walls greater than or equal to 12-gauge steel with 1 inch standing seams. All glass is to be at least 5/16 inch laminated, annealed glass and meeting UL 972 certification requirements. The entry booth must meet flame spread rating 25 or less, fuel contribution of 50 or less, smoke development of 50 or less, in accordance with test method ASTM E84.

Provide entry booths constructed to minimize the heating effects of solar radiation, by using the manufacturer's standard clear, tinted, or bronzed glass with over-hanging roofs or other structural means to shade the windows.

2.4.5.5.6.14 Entry Booth Doors

Doors must be at least 35 inches wide, by 79 inches high with glass panels at least 31 inches wide, by 74 inches high. Provide door hinges and closers with adjustments for vertical, horizontal, and torque. Provide an inside push bar, and an outside mechanical pull handle. Aluminum parts are to be anodized finish.

2.4.5.5.6.15 Entry Booth Floor Construction

Provide entry booth with a rigid floor covered by a rubber mat or indoor or outdoor carpeting. The rubber mat or carpet must be at least 1/16 inch thick and provide a continuous floor covering without seams.

2.4.5.5.6.16 Electrical Requirements

The entry booth, including associated terminal and facility interface and other type of devices housed within the entry booth must not dissipate more than 1500 Watts. Provide booth with an integral battery back-up

system. The battery back-up system must power the entry control devices and electric strike and bolt electrified mortise lock, electromagnetic lock, or for at least 30 minutes. The doors to the booth are to be secured , and the booth must go into an inoperative status if AC power is not restored to the booth within 30 minutes. Upon AC power restoration, the booth is to upload all entry transactions from the local processor subsystem to the SCC.

2.4.5.5.6.17 VSS Camera

Design and configure the VSS camera for continuous operation and transmit video information to the local video recorder as specified and designed.

2.4.5.5.6.18 Weight Check Monitor

Provide a weight check monitor which continuously monitors the weight of the booth plus any occupant. The weight check monitor is to consist of synchronized, matched, electronic load cells located at the base of the entry booth and be connected to the local processor subsystem. The weight check monitor must be accurate to within plus or minus 5 pounds. Configure the entry booth to compensate for side loading to prevent damage to the load cells by the passage of equipment through the booth. Include individual weights for each user in the reference database files as part of the enrollment process. Provide a method to enter a custom, predefined tolerance on valid weights of authorized persons.

Automatically update each person's weight profile based upon the last three uses of entry control booths. Generate an entry control alarm for any passage attempt for which the person's weight does not agree with system reference database file data and confine the person. The weight check monitor is not to increase the portal door threshold height by more than 1/4 inch.

2.4.5.5.6.19 Double Occupancy Sensor

Incorporate a sensor connected to the local processor subsystem which monitors the entire occupant area to detect attempts at double occupancy. A double occupancy sensor activation is to generate a system alarm and confine the enrollees.

2.4.5.5.6.20 Intercom

Provide three combination speaker and microphones to provide 2-way communications at each speaker and microphone location. The speakers must be at least 4 inches in diameter. Locate two of the speakers and microphones at the high and low security entry or exit doors, behind louvered panels, to provide communications for people outside the booth. The third speaker and microphone are to be located inside the booth behind a perforated metal screen above the personal identity verification device to provide communications for people inside the booth. Connect each of the speakers and microphones to the operator console at the SCC and to the voice prompt system as indicated.

2.4.5.5.6.21 Voice Prompts

Include a voice prompt system using human voice commands to speed up the entry control process and improve throughput rate. This audible prompt system is to respond to the next sequential activity requirement as each employee accesses the booth. All commands are to be stored in

electrically programmable read only memory chips located in the local processor subsystem. The voice prompts are to only be directed to the speaker and microphone nearest the employee. Use the voice prompts only if the employee does not perform the next step in the entry booth entry control process within a 5 second time window. The SCC must be able to enable and disable of voice prompts and adjustment of the time window under operator control.

2.4.5.6 Active Barrier Interface

Provide active barrier interface in accordance with Section 34 75 13.13 CRASH RATED ACTIVE VEHICLE BARRIERS AND CONTROLS suitable for connection to, monitoring, and control by the system's local processors and include all additional equipment and wiring to be an operable system.

2.4.6 Elevator Control

2.4.6.1 Control Elevator Operation with Entry Control Terminal Devices

The elevator's standard control equipment, components, and actuators must serve as the facility interface. System components and subsystems must interface with standard elevator control equipment without elevator control equipment modification. The system is to provide a means to define access-controlled floors of a facility, deny access to these floors by unauthorized individuals, and implement all other system functions as specified.

2.4.6.2 Floor Tracking

Deploy the elevator control system in such a manner as to provide "floor tracking" reports where the system records the individual's floor selection when elevator control is in effect.

2.4.7 Access Control System Date and Time

Provide system date and time per paragraph DATE AND TIME GENERATOR.

2.5 VIDEO SURVEILLANCE SYSTEM (VSS)

Select system components that conform to the Open Network Video Interface Forum (ONVIF) specification. Provide compatible UL 62368-1 and UL 2802 listed VSS components to provide visual assessment of ESS alarms automatically upon alarm or upon SCC operator selection. Otherwise, the subsystem is to continuously display the coverage area. Display alphanumeric camera location ID on all monitors. Provide the number of alarm monitors as required. The scene from each camera must appear clear, crisp, and stable on the respective monitor during both daytime and nighttime operation. Provide component equipment that minimizes both preventive and corrective maintenance. Provide components from a single manufacturer or justify mixing manufacturer components and demonstrate compatibility in submittal information.

2.5.1 Cameras

2.5.1.1 VSS Camera

Provide Internet Protocol (IP) cameras of fixed, pan-tilt-zoom (PTZ), or panoramic type as indicated on the drawings.

a. Day-Night Color fixed, PTZ or panoramic cameras are to be used in all outdoor environments. Standard fixed, PTZ, or panoramic cameras are to be used for all indoor applications except when backlighting issues are observed. Use Day-Night cameras or standard cameras with backlighting compensation for backlighting or high contrast applications.

b. Provide PTZ cameras with a direct drive motor assembly. Belt driven PTZ camera units are not acceptable. Equip PTZ cameras with a slip ring assembly having an optical interface and be rated for continuous duty. PTZ cameras must be fully integrated units. The pan-tilt mechanism must be an integral part of the camera. The PTZ control system from the mouse to the camera to the viewed image must operate in real-time with no impact to operational accuracy of pan tile zoom function.

c. Provide cameras that operate over a voltage range of 12 VAC at 60 Hz Power over Ethernet (PoE) IEEE 802.3.

d. All cameras must be constructed to provide rigid support for electrical and optical systems so that unintentional changes in alignment or microphonic effects do not occur during operation, movement, or lens adjustments.

e. Video Frame Rate: 60 frames per second (fps)

f. Cameras without on-board SD card recording may not be used.

g. Cameras with on-board SD card recording must be addressed in the system programming regarding the use of SD card recording. Network outages must be addressed regarding the upload procedure for the SD card data. Audio recording (if used) must be addressed also, including proper signage per all applicable laws.

2.5.1.1.1 Sensitivity

Minimum Illumination: 0.07 foot-candles at F1.4 color mode; 0.009 foot-candles at F1.4 in the B&W mode.

2.5.1.1.2 Signal-To-Noise Ratio

Show a signal-to-noise ratio of not less than 50 decibels (dB) at Automatic Gain Control (AGC) "Off", weight "On".

2.5.1.1.3 Resolution

Provide a minimum of 6 megapixel resolution. The imager must have a minimum of 1080P picture in progressive scan format. Resolution is to be maintained over the specified input voltage and frequency range, and not vary from minimum specification over the specified operating temperature range.

2.5.1.1.4 Synchronization

Provide cameras that have internal and line lock.

2.5.1.1.5 Low Light Level

Provide Day-Night cameras that have a B-W mode that may be automatically

engaged on low light level and permit the use of integrated or external infrared illuminator. Electronic removal of the color signal is not acceptable. The camera must have an infrared cut filter capable of being removed automatically upon low light threshold or manually.

2.5.1.2 Camera Lenses

Camera lenses are to be all glass with coated optics. Provide lens mount that is C or CS mount, compatible with the cameras selected integrated with the cameras. Provide lens with the camera that have a maximum f-stop opening of f/1.2 or the maximum available for the focal length specified. The lens is to have an auto-iris mechanism unless otherwise specified. Lenses having auto iris, manual iris, or zoom and focus functions are to be supplied with connectors, wiring, receiver and driver units, and controls as needed to operate the lens functions. Provide lenses with sufficient circle of illumination to cover the image sensor evenly. Lenses are not to be used on a camera with an image format larger than the lens is configured to cover. Provide lens with focal lengths as indicated or specified in the manufacturer's lens selection tables.

2.5.1.3 Camera Housing and Mounts

The camera and lens are to be enclosed in a tamper resistant housing installed on a camera support. Any ancillary housing mounting hardware needed to install the housing at the camera location is to be provided as part of the housing. The camera support must be capable of supporting the mounted equipment and withstanding wind and ice loads normally encountered at the site.

2.5.1.3.1 Environmentally Sealed Camera Housing

The housing is to provide an environment needed for camera operation and be condensation free; dust and watertight; keep the viewing window free of fog, snow, and ice, and be fully operational in 100 percent condensing humidity. Provide housing equipped with a sunshield. Both the housing and sunshield are to be white in color. Housing must be purged of atmospheric air and pressurized with dry nitrogen, equipped with a fill valve, overpressure valve, and include a humidity indicator visible from the exterior. Housing must not have a leak rate greater than 2 psi at sea level within a 90 day period. Housing must resist influx of rain or snow from vertical to wind driven horizontal directions.

Provide housing equipped with supplementary camera mounting blocks or supports needed to position the camera and lens to maintain the proper optical centerline. All electrical and signal connections required for camera and lens operation are to be supplied. Provide a mounting bracket as part of the housing which allows weight adjustment to center the weight of the assembly.

2.5.1.3.2 Indoor Camera Housing

Provide housing with a tamper resistant enclosure for indoor camera operation and with the proper mounting brackets for the specified camera and lens. The housing and appurtenances color are not to conflict with the building interior color scheme.

2.5.1.3.3 Interior Mount

Provide camera mount suitable for either wall or ceiling mounting and have

an adjustable head for mounting the camera. The wall mount and head must be constructed of aluminum or steel with a corrosion-resistant finish. Provide adjustable head with 360 degrees of pan and plus or minus 90 degrees of tilt.

2.5.1.3.4 Low Profile Ceiling Mount

Provide tamperproof ceiling housing which is low profile and suitable for use in 2- by 2-foot ceiling tiles. The housing must be equipped with a camera mounting bracket and allows a 360-degree viewing setup.

2.5.1.3.5 Interior Dome Housing

The dome housing is to be capable of being mounted by pendant, pole, ceiling, surface, or corner as shown on the drawings. The lower dome is to be black opaque acrylic and have a light attenuation factor of not more than 1 f-stop. Provide housing with:

a. Integral pan-tilt complete with wiring

b. Wiring harnesses

c. Connectors

d. Permanent lubrication

e. Motors that are thermally or impedance protected against overload damage.

f. Any other hardware and equipment as needed to provide a fully functional pan-tilt dome. Provide pan movement of 360 degrees and tilt movement of at least plus or minus 90 degrees. Pan speed must be at least 20 degrees per second and tilt speed be at least 10 degrees per second.

2.5.1.3.6 Exterior Dome Housing

Provide dome housing capable of being mounted by pendant, pole, ceiling, surface, or corner as shown on the drawings and constructed to be dust and watertight, and fully operational in 100 percent condensing humidity. Purge the housing of atmospheric air and pressurize with dry nitrogen. Provide a fill valve and overpressure valve with a pressure indicator visible from the exterior. The housing is to be equipped with supplementary camera mounting blocks or supports as needed to position the specified camera and lens to maintain the proper optical centerline.

Provide all electrical and signal connections required for camera and lens operation. The housing is to provide the environment needed for camera operation. The lower dome is to be black opaque acrylic with a light attenuation factor of not more than 1 f-stop. Provide housing with:

a. Integral pan-tilt complete with wiring

b. Wiring harnesses

c. Connectors

d. Permanent lubrication

e. Motors that are thermally or impedance protected against overload damage.

f. Any other hardware and equipment as needed to provide a fully functional pan-tilt dome. Provide pan movement of 360 degrees and tilt movement of at least plus or minus 90 degrees. Pan speed must be at least 20 degrees per second and tilt speed be at least 10 degrees per second.

2.5.1.3.7 Exterior Wall Mount

Provide exterior camera wall mount that is 24 inches long and has an adjustable head for mounting the camera. The wall mount and head must be constructed of aluminum, stainless steel, or steel with a corrosion-resistant finish. Provide adjustable head for at least plus and minus 90 degrees of pan, and at least plus and minus 45 degrees of tilt. If to be used in conjunction with a pan-tilt, provide bracket without the adjustable mounting head, and a bolt hole pattern to match the pan-tilt base. Wind speeds up to 60 mph must not change alignment of the camera nor affect the PTZ operation.

2.5.1.3.8 Pan-Tilt Mount

a. Provide pan-tilt mount capable of supporting the camera, lens, and housing specified that is weatherproof and sized to accommodate the camera, lens and housing weight plus maximum wind loading encountered at the installation site if the pan-tilt is to be mounted outdoors. Provide pan-tilt with:

(1) Heavy duty bearings

(2) Hardened steel gears

(3) Externally adjustable limit stops for pan and tilt

(4) Mechanical, dynamic, or friction brakes

(5) Permanent lubrication

(6) Motors that are thermally or impedance protected against overload damage.

b. Provide pan movement of 360 degrees pan rotation, a minimum tilt movement of plus and minus 90 degrees. Manual pan speed must be a minimum of 0 to 80 degrees per second , and a minimum tilt speed of 10 degrees per second . A minimum automatic pan speed of 280 degree per second and tilt speed of 160 degree per second .

c. The pan-tilt is to be supplied complete with wiring, wiring harnesses, connectors, receiver-driver, pan-tilt control system, pre-position cards, or any other hardware and equipment as needed to provide a fully functional pan-tilt mount to fulfill the site design requirements.

2.5.2 Video Analytics (VA)

2.5.2.1 Software

Provide capability range from basic activity detection to the search

through databases to pre-empt serious incidents. The VA is to provide graphic identified movement identification, user-selectable monitored areas, compensation for environmental movement, and other features specified when provided as a capability of the NVR. Provide the following features:

2.5.2.1.1 Basic Motion Detection

a. Adaptive Motion

b. Abandoned Object

c. Object Removal

d. Camera Sabotage

e. Directional Motion

f. Object Counting

g. Loitering Detection

h. Stopped Vehicle

2.5.2.1.2 Advanced VA

2.5.2.1.2.1 Intruder Identification

This refers to identifying unauthorized humans in specified areas within the field of view.

2.5.2.1.2.2 Environmental Compensation

Recognizing and ignoring wind-blown debris, animals, background traffic, and so on.

2.5.2.1.2.3 Counting

This refers to recognizing a quantity of a particular object moving or activity performed.

2.5.2.1.2.4 Directional Identification

This refers to the ability to ignore objects moving in one direction, while alarming for objects moving in unauthorized directions.

2.5.2.1.2.5 Item Recognition

This refers to activation when specific user-selected items are removed from, placed in, or passed through the field of view.

2.5.2.1.2.6 Subject Tracking

Highlighting and following a specific person or item as it moves about the field of view, or from the field of view of one camera to another.

2.5.2.1.2.7 Multiple Subject Tracking

Highlighting and following multiple persons or items simultaneously as

they move about the field of view, or from the field of view of one camera to another.

2.5.2.1.2.8 Object Left Behind

This refers to the ability to detect objects left behind or added within the field of view in a scene.

2.5.2.2 Embedded VA

2.5.2.2.1 Intelligent Video Analysis

a. Provide camera capable of processing and analyzing video within the camera itself, with no extra hardware required.

b. The camera is to be capable of detecting and sending alarms for abnormal events.

c. The camera is to be configurable to analyze up to 10 different scenes for one or more of the following events:

(1) Line Crossing

(2) Loitering

(3) Idle Object

(4) Removed Object

(5) Conditional Change

(6) Trajectory Tracking

(7) Filters

d. The camera is to allow users to set up to 10 separate profiles and switch profiles based on a day, night, or holiday schedule.

e. The camera is to support scene tours that automatically reposition the camera to each scene for a specified duration.

f. The camera is to incorporate an Alarm Rule Engine, enabling abnormal events that VA detects to prompt the camera to take one or more actions:

(1) Trigger a relay connected to an alarm siren, strobe, or both.

(2) Trigger a visual alert to be displayed on the operator's screen.

(3) Go to a specified scene (preset position).

g. Camera must provide 100 horizontal and vertical pixels per foot at desired distance for License Plate Recognition. Camera must also provide 24 frames per second for License Plate Recognition.

2.5.2.2.2 Motion Tracking with PTZ Cameras

a. The camera is to offer Intelligent Tracking to continuously track an object using pan, tilt, and zoom actions.

b. The camera is to provide automatic motion tracking using intelligent video analytics.

c. Provide camera with the ability to follow an object continually when passing behind a privacy mask.

d. Provide camera with the ability to restart tracking if a target starts moving in the same area where the initial target stopped moving or if the camera detects an object moving along the last known trajectory.

e. The camera is to allow an operator to select an object to track in the live image view.

2.5.3 Color Computer Monitors

Except as specified, provide computer monitors that:

a. Are rated for continuous operation.

b. LED flat panel computer monitor with HDMI input.

c. Have a 16:9 aspect ratio nominally measures 55 inches for LED displays.

2.5.3.1 Mounting

a. Mount monitors with compatible wall mount or manufacturer provided desk top stand.

2.5.3.2 Video and Signal Input

Monitors are to operate with video input requiring a one HDMI switchable to either loop-through or internal 75-ohm terminating impedance.

Signal input connectors must be HDMI type.

2.5.4 Ancillary Equipment

Equipment is to consist of the items specified below:

2.5.4.1 Video System Date and Time

Provide system date and time per paragraph DATE AND TIME GENERATOR and paragraph VIDEO RECORDING PERFORMANCE.

2.5.4.2 Camera Identifiers

Label video signal from each camera using alphanumeric identifiers. Camera alphanumeric identifiers may originate from either the camera or the video recorder.

2.5.4.3 Video Recording

2.5.4.3.1 Analog to IP Video Converter

For new construction projects or new installation of new cameras on an existing site analog cameras are not allowed. For existing analog cameras that must remain in service, provide an analog (base band video) to IP converter to allow the camera images to be recorded in the IP based system.

2.5.4.3.2 IP Based Video Recording Device/System

a. Provide video recording device/system with an integral video management software (VMS). Dedicated VSS monitors and authorized computers networked to the video recording device/system are to be capable of viewing recorded and live video from the network. The video recording device/system is to be able to record and transmit video with minimum 24 fps at maximum camera resolution. The video recording device/system is to network with and utilize smaller, non-server computers at off-site camera locations as local recorders.

b. Provide video recording device/system with the capability to de-warp live and recorded images.

c. The storage memory capacity of the video recording device/system is to be sufficient to store a minimum of 30 days of video at 15 fps, 6 megapixel resolution and be expandable for an increased capacity of 4 TB and be capable of including Redundant Array of Independent Disc (RAID) arrays 5 or 10 .

d. The video recording device/system must have the capacity to address and process up to 16 dual-streaming cameras. The video recording device/system must record all cameras onto a hard drive and allow remote network viewing via intranet browser. Hard drive capability must be sized to store all cameras recording 24 hours a day 7 days a week at 15 frames per second per camera for 4 weeks.

2.5.4.3.3 Video Recording Performance

The video recording performance is to be as follows:

a. The NVR video server is to use modular hard disk media, with a digital format capacity of 2TB per module.

b. Provide a 1000Base-T connection for record review and camera view and control that is compatible for a PC workstation equipped with latest Microsoft Windows Professional operating system software, Internet Browser Software.

c. PC workstation Viewing: Include direct access from the ESS PC workstations to each NVR video server via a internet web browser. All necessary descriptive bookmarks and shortcuts are to be prepared on each PC workstation to allow this direct access. All functions are to be accessible through HTML commands from a user's web browser interface. Pictures are to be available for attachment via a user-provided SMTP-based e-mail transport system and included capability for 16 users and 3 user access levels (admin, control and user).

d. Include sampling at 720(H) by 480(V) and 320(H) by 240(V) (Pixel Memory) with frames per second and 3-D scan conversion to enable jitter-free stabilized pictures in a single frame. Modes include:

(1) Emergency

(2) Event

(3) Schedule

(4) Manual Recording

e. Each camera is to support individual Recording Rate and Image Quality settings for each mode (Emergency, Event, Schedule, and Manual Recording). This array of Camera Recording Rate and Image Quality settings by the Recording Modes is to form one of four Program Actions. The Program Action is to be assignable to a timetable to form one of 16 Independent Recording Profiles. Allow each Recording Profile to be manually activated, activated via RS-232C interface, automatically activated by timetable, or activated by separate alarm or emergency inputs.

f. Provide system date and time per paragraph DATE AND TIME GENERATOR. System Date and time to be digitally displayed on the monitor and also clearly shown on digitally stored recordings. The following information is to be included as part of the date and time stamps:

(1) Year

(2) Month

(3) Day

(4) Hour

(5) Minute

(6) Second

(7) Alphanumeric camera location ID up to 8 characters. The NVR video server is to feature video loss detection on all channels.

g. Pre-event recording: Pre-event recording should match the configuration in software to record 0.50 second pre-event.

h. Motion-based Recording: Advanced integrated VMD is to be used to detect a specific area, direction and motion duration for each camera channel, independently and simultaneously. Motion Search may be executed for a single camera channel for a selected area on the image.

i. Disk Partitioning: Provide within the NVR video serveran automated disk management and a RTOS (real-time operating system) platform to include a minimum of 4.8 TB of digital video storage on a single partition.

The video recording system is to provide a choice of Physical Partitioning as RAID 5 to provide a redundant array of independent discs to increase performance and redundancy. Raid levels should be coordinated with user requirements. Allow the operator to be able to partition the available recording areas in a Virtual Partition by Regular, Event, and Copy Partitions. Manually and scheduled recorded video information is to be assigned to a Regular Recording Partition, which may be overwritten. Event and Emergency Recording Data is to be assignable to an Event Partition, where image overwriting is be prohibited. Any copied data is to be able to be assigned to the Copy Partition, which may be overwritten or saved as required.

j. Playback: Permit direct camera selection for recording playback of

any of 8 video sources at the same time as multiscreen viewing and multiplexed camera encoding (triplex multiplexer capability).

k. Multiplexer Functions: Include an integral, software based IP switching capability that automatically switches multiple camera images to enable sequential spot monitoring and simultaneous field recording. The unit must have full screen, 10 multiscreen monitoring modes.

l. Outputs

(1) Provide via HDMI female connections outputs for all video source connections to external monitoring systems including multiscreen and spot monitor video outputs.

(2) Provide virtual camera number programming capability to support 64 camera channels on a single system.

m. All camera selection buttons are to have Tri-State Indication, corresponding to Recording, Viewing and Control functions in the NVR video server software. Furnish the following indicators:

(1) Alarm

(2) Alarm Suspend

(3) Operate

(4) HDD1, Hard drive identifier

(5) Timer and Error indicators

(6) Camera Selection

(7) Iris

(8) Preset

(9) Camera Automatic Mode

(10) Pan-Tilt

(11) Set

(12) Jog Dial

(13) Shuttle Dial

(14) Setup-Esc

(15) Record

(16) Search

(17) Play-Pause

(18) Pan-Tilt Slow

(19) Stop

(20) Pan-Tilt Go to Last

(21) Zoom-Focus

(22) A-B

(23) Repeat

(24) Shift

(25) Alarm Reset Buttons

n. Networking: All NVR video server recording, review, playback, camera control and setup are to be available via the internally mounted Network Interface. A 1000Base-T connection for record review and camera view and control will be required on a personal computer equipped with Internet Browser Software and an Ethernet 1000Base-T connection. Permit direct camera selection for recording playback of any of 16 video sources at the same time as multiscreen viewing and multiplexed camera encoding (triplex multiplexer mode). Support a minimum of 8 simultaneous clients viewing and simultaneous FTP sessions.

o. Power: The video recording equipment must have a power source of 120 VAC at 60 Hz.

2.5.4.3.4 Recording Audio With Video

Recording audio with video is acceptable provided all applicable laws are followed. Audio recording is not allowed under any circumstances in certain areas per the law, and if allowed often has strict signage requirements.

2.5.4.4 Camera Control

Provide access to camera functions and real time control for all cameras via the video management software for all camera control, set-up and alarm functions, including preset sequence, digital motion detector mask set, and back light compensation set-up. Controllable camera functions are to be accessible via front panel controls or the optional system controller controls to be accomplished by mouse. These functions are to include:

(1) Direct access of preset position

(2) Zoom (near/far)

(3) Focus (near/far)

(4) Iris (open/close)

(5) Pan (left/right)

2.5.5 Camera Mounting Structures

Provide camera mounting structures designed specifically for VSS cameras. The structure is to accommodate appropriate wiring pathways for power and communication as well as proper grounding and surge protection. Design loads for the camera mounting structure must conform to TIA-222 and all

applicable addendums of the TIA standard. Allowable pole deflection is determined from the point of the camera mount and must not exceed 0.5 percent of the pole height under adjusted maximum wind load conditions. Adjusted maximum wind load conditions for deflection calculations must be 30 miles per hour (mph) or 35 percent of the basic wind speed as determined by TIA-222, whichever is greater. Confirm compliance to TIA standards by structure manufacturer data or by analysis. Provide additional measures as required to stabilize the camera if placed in an environment that is subject to induced vibrations such as heavy winds or excessive traffic.

2.5.6 Video Surveillance System (VSS) Schedule

Provide a spreadsheet describing each individual camera installation location including the following items:

a. Unique camera location identifier.

b. Make/model/type (PTZ, fixed, fixed IR, etc.)/part-number of camera.

c. Make/model/part-number of camera mount.

d. Intended camera field of view.

e. Any additional information pertinent to that unique location.

2.6 SECURITY COMMAND CENTER (SCC)

The SCC must integrate all subsystems and communications and provide operator control interface to the ESS system. The components are as follows:

a. ESS Software

b. Monitoring Display Software

c. Graphical Map Software

d. Printers

e. Controls and Display Integration

f. Enrollment Center Equipment

2.6.1 ESS Software

a. Provide commercial off-the-shelf ESS software that utilizes a single database for the subsystem integrations provided under a single operating environment. The system is to archive all events in a database stored either on a local hard drive or a networked database server. The software has to support configuration and simultaneous monitoring of all subsystems.

b. Allow the networked PC workstation configurations connected via a TCP/IP network. Administrative tasks including configuration, monitoring, schedules, report generation and graphic display are provided from any PC workstation on the network. All system programming data must be instantly accessible to every PC Workstation connected to the network. The system is to utilize a non-proprietary

SQL-based, ODBC-compliant database, managed by Sybase Adaptive Server Anywhere, Microsoft SQL Server, or Oracle.

c. Utilize a preemptive multi-tasking operating system, such as the latest Microsoft Windows Professional environment, that is multitasking, with many processes running at the same time without interference with each other and with higher priority tasks taking precedence over lower priority tasks.

d. Provide capabilities to define visual exclusion areas.

e. Provide de-warping software for panoramic cameras.

2.6.1.1 Alarm Call up

Support responses to alarms entering the system with each alarm capable of initiating one or more of the following actions:

a. Sending alarm commands to a VSS system interface

b. Triggering event recording

c. Activating output devices

d. Playing PC audio files

e. Controlling doors

f. Display graphical maps associated with the alarm device

Provide mode of system operation that requires an operator to acknowledge any alarm. While alarm is still active, the alarm cannot be cleared.

2.6.1.2 Programming

Provide the capability of, but not limited to, the following programming and functionality:

2.6.1.2.1 Daylight Savings Time Adjustment

The ACU(s) and PCU(s) must not need to be connected to the ESS in order for the adjustment to occur.

2.6.1.2.2 Operator Privileges

Support an unlimited number of system operators, each with a unique login and password combination. Operators are to be assigned privileges based on the loops, commands, or programmed features that are available to each individual operator.

2.6.1.2.3 Alarm Priorities

Provide the ability for each alarm device to be user configured to belong to one of 10,000 priority levels which are assigned to an alarm based on alarm importance. These priorities are to define which alarm events to display on individually specified ESS workstations.

2.6.1.2.4 Reports

Include integrated reporting capabilities as well as the ability to run Crystal Report templates.

2.6.1.2.5 User Interface

The ESS programming is to be menu-driven, with "wizards" to assist with software configuration, and include 'Help' information.

2.6.1.2.6 Messages

Permit the use of user-selected colors for event messages.

2.6.1.2.7 Graphics

Provide the capability to display a floor-plan graphic for card activity and alarm events as part of the ESS integration.

2.6.1.2.8 Device Status

Provide the capability to display the dynamic status of a user-selected list of devices, including doors, inputs, and outputs.

2.6.1.2.9 Diagnostics

Include diagnostic software tools that interface and query the hardware for information and to issue commands.

2.6.1.2.10 Mandatory Data Fields

Require any cardholder data field to be selected by the user as mandatory.

2.6.1.2.11 User Defined Data Fields

Provide 20 unassigned data fields for storing user-defined data that support user-defined labels, and are user-configurable as plain text fields or drop-down selection lists.

2.6.1.2.12 Archive Database

Include a connection to an archive database which stores purged events and deleted programming which can be accessed for reporting.

2.6.1.2.13 Programmable Database Backup

Include the capability of performing user-scheduled database backups without the use of third-party backup software.

2.6.1.2.14 Programmable Database Purging

Include the capability of performing user-scheduled database purging, moving selected events to an archive database when the events have aged a user-specified number of days.

2.6.1.2.15 Database Importing

Include the capacity to import user data from an ODBC data source (Access, Excel, text).

2.6.1.2.16 Data Exporting

Include the capacity to export data from any table in the database to either a text, HTML, or Excel file in any user-selected order.

2.6.1.2.17 Event Log Output

Include the capacity to send a continuous stream of user-selected types of event messages to a text file, serial port, or TCP/IP address.

2.6.1.2.18 Data Audit Trail

Record changes to programming, recording the date and time stamp of the change, the name of the operator making the change, and the nature of the change. This data audit is to be available in history for reporting.

2.6.1.2.19 Alarm Forwarding

Provide the capability to forward alarms to cellular telephones via dedicated applications or text message to be utilized by authorized system personnel when they are away from the SCC.

2.6.2 ESS Monitor Display Software

ESS Monitor display software is to provide for text and graphic map displays that include zone and device status integrated into the display. Different colors are to be used for the various components and real time data. Colors must be uniform on all displays. Follow the color coding as follows.

a. FLASHING RED to alert an operator that a zone has gone into an alarm or that primary power has failed.

b. RED to alert an operator that a zone is in alarm and that the alarm has been acknowledged.

c. YELLOW to advise an operator that a zone is in access.

d. GREEN to indicate that a zone is secure or that power is on.

2.6.3 Graphical Interactive Map Software

a. ESS graphical map software is to show the graphic and visual data of all subsystem devices. Use a 42 inches, LED flat screen display with messages displayed in the English language. Provide graphical maps showing a layout of all the protected facilities. Highlight zones corresponding to those monitored by the ESS on the graphical maps. Display status of each zone using graphical icons as required within each designated zone.

b. Provide capability for graphical maps to be linked together using a layered tree structure. For example, a top-level map might be a top view of the site and its buildings, the next level the individual buildings floor, followed by a map of the area on a floor containing the device in alarm. Allow for 3 layers of maps to be defined for any given ESS device. To speed an incident location, each map level contains a clearly visible indicator as to which sub map the operator should select next to find the device that is in alarm.

c. The ESS may also be configured to display a map automatically on a new alarm presentation, providing the operator with prompt visual indication that an alarm has occurred.

d. The status of intrusion devices, access control readers, doors, auxiliary monitor points, and auxiliary outputs is to be able to be requested from any map by simply selecting the icon representing the device and its current state will be displayed. VSS camera control, digital video review, alarm panel transactions and intercom requests are to be available for inclusion on the map with the associated management module installed.

e. Allow for SCC operators to change a current setting by pressing the right mouse button anywhere on the screen or on a specific system device icon. Pressing the right mouse button is to cause the appropriate command options list to appear for selection. Confirmation is provided by reflecting the change in status on the display after a command is selected.

f. The display of intrusion or auxiliary door alarms may be automatically enabled or disabled by the use of timed commands, either by device or by a group of devices. This may be used, for example, to disable all door alarms on internal doors, during normal office hours.

g. Create maps using standard office tools allowing drawings to be imported in Jpeg, Bitmap, Windows metafile, PDF or DXF file formats to provide maximum flexibility.

2.6.4 Printers

2.6.4.1 Report Printer

Provide a laser text printer to generate reports that is a wired network (RJ45) interface dry-type laser process printer. Provide a printer with the capability of holding a minimum of 500 pages. The unit must print a minimum of 30 pages per minute at 600 dpi resolution.

2.6.4.2 Alarm Printer

Provide an alarm printer interconnected to the SCC equipment with a minimum print rate of 30 characters per second to produce hard copy of system events. Printer must meet requirements per paragraph REPORT PRINTER.

2.6.4.3 Badge Printer

Provide a dye-sublimation or resin thermal transfer type image printer for Badge Identification credentials that is capable of printing two sides, edge to edge, directly onto a white-unfinished 0.030 PVC, PVH or PVCH card at a rate of approximately 80 seconds per card. Provide an encoder to be an integral part of the printer with encoding conforming to ABA Track II and ANSI specifications.

2.6.5 Control and Display Integration

Integrate human engineer SCC controls so the entire SCC can be operated by a single or multiple operator(s). Integrate switching and monitoring components of the assessment subsystem with the SCC so that SCC

operator(s) can effectively monitor, assess alarms, and control the ESS. Method of system integration must be as a single console. Provide chassis, and modules required for console SCC configuration.

2.6.6 Enrollment Center Equipment

Provide enrollment stations to enroll personnel into, and disenroll personnel from, the system database. The enrollment equipment is to only be accessible to authorized entry control enrollment personnel. Provide a quantity of credential cards equal to or greater than the number of personnel to be enrolled at the site plus an extra 25 percent for future use. The enrollment equipment is to include subsystem configuration controls and electronic diagnostic aids for subsystem setup and troubleshooting with the SCC. Provide a CAC card reader at the enrollment station. Also provide a keypad at the enrollment station. Provide a printer for the enrollment station which meets the requirements of paragraph REPORT PRINTER.

2.6.6.1 Enrollment Client Accessories

a. Provide a steel desk-type console and equipment racks. The console is to be in accordance with ECIA EIA/ECA 310-E and as indicated.

b. Rack mount all equipment in the console and equipment racks, except for printer. Color coordinate the console and equipment racks and cabinets, obtaining approved by the Contracting Officer.

2.6.6.2 Enrollment Center I.D. Production

a. Equip the enrollment client with a high-resolution digital camera structurally mounted or provided with a reliable tripod. The camera model is to be as recommended by the manufacturer of the ESS. Provide commercial off-the-shelf components.

b. Design and provide a lighting system sufficient for quality, still-video capture.

c. Equip the enrollment client with a dye-sublimation printer capable of printing directly to the access control or I.D. credential. Provide printer toner kits and other printing supplies to complete the initial enrollment by 200 percent.

2.6.6.3 Enrollment Client Software

Provide database management functions for the system and allow an operator to change and modify the data entered in the system as needed. The enrollment station is not to have any alarm response or acknowledgment functions as a programmable system function. Multiple, password-protected access levels are to be provided at the enrollment station. Database management and modification functions are to require a higher operator access level than personnel enrollment functions. Provide a means for disabling the enrollment station when it is unattended to prevent unauthorized use.

Provide a method to enter personnel identifying information into the entry control database files through enrollment stations to include a credential unit in use at the installation. In the case of personnel identity verification subsystems, this data is to include biometric data. Allow entry of this data into the system database files using simple menu

selections and data fields. The data field names are to be customized to suit user and site needs. All personnel identity verification subsystems selected for use with the system are to fully support the enrollment function and be compatible with the entry control database files.

2.7 COMMUNICATIONS

a. Communications are to link together subsystems of the ESS and be in accordance with Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM. Interfaces between subsystems cannot be accomplished by use of an electro-mechanical relay assembly. Communications links must be supervised. Provide common communications interface devices throughout the ESS. Provide the sensor to control unit interface as a dry contact relay that is normally open (NO) or normally closed (NC), except as specified otherwise.

b. Use digital, asynchronous, or multiplexed data control unit for central alarm reporting and display processor interface. Group individual data bits into word format and transmit as coded messages. Implement interface with network switches which function as a communications controller, perform data acquisition and distribution, buffering message handling, error checking, and signal regeneration as required to maintain communications.

c. Provide totally automatic status changes communication, commands, field-initiated interrupts, and any other communications required for proper system operation. Do not require system communication operator initiation or response. System communication is to return to normal after any partial or total network interruption including power loss or transient upset. Automatically annunciate communication failures to the operator with communication link identification that has experienced a partial or total failure.

2.7.1 Link Supervision

2.7.1.1 Hardwire Direct Current Line Supervision

Provide only for the sensor to control unit links which are within the ESS protected area. Supervise circuits by monitoring changes in the current that flows through the detection circuit and a terminating resistor of at least 2.2 K ohms. Supervision circuitry is to initiate an alarm in response to opening, closing, shorting, or grounding of conductors by employing Class C standard line security. Class C circuit supervisor units are to provide an alarm response in the annunciator in not more than one second because of the following changes in normal transmission line current:

a. Five percent or more in normal line signal when it consists of direct current from 0.5 through 30 milliamperes.

b. Ten percent or more in normal line signal when it consists of direct current from 10 microamperes to 0.5 milliamperes.

c. Five percent or more of an element or elements of a complex signal upon which security integrity of the system is dependent. This tolerance will be applied for frequencies up to 100 Hz.

d. Fifteen percent or more of an element or elements of a complex signal upon which the security integrity of the system is dependent. This

tolerance will be applicable for all frequencies above 100 Hz.

2.7.1.2 Hardwire Alternating Current Supervision

Supervision is not to be capable of compromise by use of resistance, voltage, or current substitution techniques. Use this method on circuits which employ a tone modulated frequency-shift keying (FSK), interrogate-and-reply communications method. Supervisory circuit are to be immune to transmission line noise, crosstalk, and transients. Terminate detection circuit by complex impedance. Maintain line supervision by monitoring current amplitude and phase. Size complex impedance so that current leads or lags the driving voltage by 45 plus or minus 5 degrees.

Alarm when rms current changes by more than 5 percent, or phase changes by more than 5 degrees for supervision current of 0.5 to 30 milliamperes rms. Alarm when rms current changes by more than 10 percent, or phase changes by more than 8 degrees for lines with supervision currents of 0.01 to 0.5 milliamperes. Identified line supervision alarm must be communicated within one second of the alarm.

2.7.1.3 Hardwire Digital Supervision

Local processors are to exchange digital data to indicate secure or alarm at least every 2 seconds. Alarm if data is missed for more than one second for passive supervisory circuits. Coding used for data cannot be decipherable by merely viewing data on an oscilloscope. Supervisory circuits are to asynchronously transmit bursts of digital data for transponder schemes. Data pattern is to be random in nature. Remote detectors are to receive data and encode a response based on a proprietary coding scheme.

Provide a unique encoding scheme; an industry-wide or vendor standard is not acceptable. Transmit encoded response back to supervisory circuit. Supervisory circuit is to compare the response to an anticipated response. Alarm on failure of the detector to return a data burst or return an incorrect response.

2.7.2 Hardwire

2.7.2.1 Electrical Conductor Lines

a. Use electrical conductor lines for hardwire that rely on current path except for electrical wires; neutral conductors of electrical distribution systems cannot be used as signal transmitters.

b. Conductors outside the protected area are to be shielded cable installed in Galvanized Rigid Steel Conduit (GRC, RMC) in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Supervision circuitry is not to initiate nuisance alarms in response to normal line noise, transients, crosstalk, or in response to normal parametric changes in the line over a temperature range of minus 30 to 125 degrees F.

c. Ambient current levels chosen for line supervision must be sufficient to detect tampering and be within the normal operating range of electrical components. Report line supervision and tamper alarms regardless of mode of operation.

d. Provide hardwire links in accordance with UL 1076 and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM for interior applications with additions and modifications specified. Conductors are to be copper. Conductors for links which also carry AC voltage, are to be No. 12 AWG minimum; single conductors for low-voltage DC links are to be No. 14 AWG minimum. Conductors are to be color coded. Conceal wiring in finished areas of new construction and wherever practical in existing construction if not otherwise precluded by the Government.

e. Identify conductors within each enclosure where a tap, splice, or termination is made. Identify conductors by plastic-coated, self-sticking, printed markers or by heat-shrink type sleeves. Connect sensors, control units, and communication devices so that removal will cause a tamper alarm to sound. Pigtail or "T" tap connections are not acceptable. Each conductor used for identical functions is to be distinctively color-coded. Each circuit color-coded wire is to remain uniform throughout circuit. Tamper switches meet requirements of paragraph TAMPER SWITCHES.

2.7.2.2 Communication Link

a. Provide a dedicated circuit communication link from sensor to control unit. Opening or closing a relay contact will indicate an alarm. Convert analog signals to digital values or a relay closure or opening within 250 feet of the sensing point. Communications from control unit to central alarm reporting and display processor are to operate in a continuous interrogation and response mode, using time-multiplexed digital communications techniques at a data rate of 5.12 kilobaud.

b. Interrogation and response communications between the control unit and central processor is to be half-duplex and bidirectional on one dual twisted pair cable (one pair for interrogation and one for response), which may have one or more parallel branches. Individual control unit lines are to be at least 22 AWG wire. Connect control wires in parallel to the hardwire link. Communication system is to provide as many as 255 control unit connections.

c. The communication system must maintain specified performance over a link length of 7500 feet when operating without line repeaters or other signal regenerating or amplifying devices. The communications system must maintain specified performance over a link length of 75,000 feet when operating with signal-regenerating line repeaters.

d. Control unit to central alarm reporting and display processor communications link is to also be capable of operating over a maximum of four standard voice grade telephone leased or proprietary lines. Link is to be capable of operating half-duplex over a Type 3002 data transmission pair and be capable of modular expansion. Telephone lines will be provided by the Government. Coordinate and check out system operation. General characteristics and telephone line service are to be as follows:

e.

Connections	Two- or four-wire
Impedance at 1000 Hz	600 ohms
Transmitting level	0 to 12 dBm
Transmitting level adjustment	3 dB increments
Type	Data
Direction	Two-way alternate (half-duplex)
Maximum speed	10.24 kilobaud
Maximum loss at 1000 Hz	33 dB

2.7.3 Radio Frequency Link

a. Provide a full-duplex, supervised RF, polling system specifically used for alarm data communications with components manufactured by one manufacturer operating in the VHF, 134 to 154 MHz band. System is to interface directly with ESS hardwire data link from control unit to central alarm reporting and display location and is to translate (reduce) the data rate for RF transmission, modulate and demodulate the data signal, and transmit and receive ESS data.

b. Provide a factory-tested complete RF link which both automatically and upon operator command transmits a signal with a unique identification from the central alarm monitoring location to the control unit locations. Message receipt at control unit location is to be ignored by all units except the addressee. Unit with the correct address is to decode the interrogation signal and respond to the interrogation with the status of the reporting sensors. Re-interrogate when the addressee fails to respond. Alarm upon failure to respond a second time.

c. Remote units in the RF system are to be individually polled in turn. Polling response time and transmission data rate, data error rate, and equipment reliability is to ensure that overall, ESS alarm annunciation time reliability and Pd is not degraded.

d. Provide RF transmitters, receivers, or transceivers in sufficient quantities to meet specified requirements. RF link transmissions are to be on one or more of the frequencies within the specified band as required to meet specified requirements and neither interfere with other ESS components nor any facility electronic components. Provide transmitters which are in accordance with applicable requirements of 47 CFR 15.

e. Message types and content are to be identical to those transmitted by other portions of the ESS data communications subsystem. ESS alarms sent by RF link are not to fail and are to be transmitted by the RF link due to event occurrence during "off air" periods. RF link is to provide message transmission priority in the following order:

(1) Intrusion alarms

(2) Tamper alarms

(3) Access denial alarms

(4) Other alarms on a first-in, first-out basis including loss of communication signal, fail-safe, low battery, and power loss.

f. Provide omnidirectional, coaxial, half-wave dipole antennas for alarm transmitters and transceivers with a driving point impedance to match transmission output. Provide antennas and antenna mounts that are corrosion resistant and able to withstand wind velocities of 100 mph and physical damage caused by vandalism. Antennas cannot be mounted directly to any facility fence or roofing system.

g. Provide antennas from the same manufacturer as the rest of the RF link. Provide coaxial cable in lengths as required. Cables are to use PL-type fittings or connectors, properly protected against moisture. Cables must match transmitter output impedance.

2.7.4 Data Encryption

Incorporate data encryption equipment on data transmission circuits as shown on the drawings. The algorithm used for encryption must be the Advanced Encryption Standard (AES) algorithm described in NIST FIPS 197 of TDES, ASC/X9 X9.52, as a minimum. Data encryption must be in accordance with NIST FIPS 140-2.

2.7.5 Network Switch

For Department of Defense projects network switches must comply with DISA APL. The small form-factor pluggable (SFP) is to provide full-duplex 1000/100/10-Mbps connectivity between switches over single mode (SM) infrastructures. Provide mounting accessories for a typical field distribution box . Rack requirements as specified in paragraph EQUIPMENT RACK.

2.7.5.1 Inside Plant

Provide a network switch for ESS system with 48 SFP Ethernet ports. Allow dynamic port base security and rapid spanning tree protocol with VLAN assignments for specific users regardless of where the switch is connected. The switch will use AC input voltage nominal of 120 VAC at 60 Hz. The switch is to be less than 2 Rack Units (RU) and Layer 3 capable. The switch is to have the capability of commanding a self-healing ring configuration. 1000Base-LX SFP Fast Ethernet Interface Converter is to be a hot swappable device that plugs into a Gigabit fiber SFP uplink port on the switch. The switch is to be a fully managed power over Ethernet (PoE) to all ports. Provide switch capable of using a Layer 3 (routed) port to connect to a LAN gateway port for Internet and web base access. The Mean Time Between Failure (MTBF) must be greater than 210,000 hours.

2.7.6 Video and ESS Transmission

Transmission is to be by optical fiber dedicated to the associated circuit. Video and ESS transmission cables must conform to the industry standards in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM Section 33 82 00 TELECOMMUNICATIONS OUTSIDE PLANT (OSP).

Install interior cable in Electrical Metallic Tubing (EMT) conduit unless indicated otherwise. Provide conduit and fittings in accordance with Section 26 20 00 INTERIOR DISTRIBUTION. Use only compression fittings for EMT conduit. No set screw fittings allowed. Cable is to be rated for the installation method intended. Install exterior cable underground installed in Schedule 80 Polyvinyl chloride (PVC) conduits.

2.7.7 Wire and Cable

Provide all wire and cable (including copper power cable, UTP data cable, optical fiber cable, and coaxial cable) not indicated as Government-furnished equipment. Wiring must meet NFPA 70 standards and as indicated in the Wire and Cable Data Sheets Attachment at the end of this section. Provide optical fiber test data and UTP test data for field connectorized cable, including any existing optical fiber cable and/or existing UTP which will be used to transmit data for any ESS items provided in the project..

2.7.8 Digital Data Interconnection Wiring

Interconnecting cables carrying digital data between equipment located at the SCC or at a secondary control and monitoring site is to be optical fiber cable. Interconnecting cables conform to the industry standards in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM Section 33 82 00 TELECOMMUNICATIONS OUTSIDE PLANT (OSP).

2.7.9 Aboveground Sensor Wiring

Sensor wiring is to be 20 AWG minimum, twisted and shielded, 2, 3, 4, or 6 pairs to match hardware. Provide multiconductor wire with a PVC outer jacket.

2.7.10 Direct Burial Sensor Wiring

Sensor wiring is to be 20 AWG minimum, twisted and shielded, 2, 3, 4, or 6 pairs to match hardware.

2.7.11 Local Area Network (LAN) Cabling

Category 6 cabling must be in accordance with TIA-568.2. Provide permanent link testing and a test report for all Category 6 cabling.

2.7.12 Cable Construction

Provide all cable components that will withstand the environment in which the cable is installed for a minimum of 20 years.

2.8 BACKUP POWER

a. Intrusion alarms are not to be generated because of power switching; however, Provide a power switching indication and on-line source at the alarm monitor.

b. The system is to automatically switch back to the primary source upon primary power restoration. Detect and report failure of an on-line battery as a fault condition. Power products must be in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

c. Provide backup power to the primary power by backup batteries in each

element or subsystem .

2.9 SURGE SUPPRESSION DEVICES

Comply with requirements in Section 33 82 00 TELECOMMUNICATION OUTSIDE PLANT (OSP).

2.9.1 Powerline Surge Protection

Power Line Surge Protection Equipment connected to alternating current circuits must be protected from power line surges. Equipment protection must withstand surge test waveforms described in IEEE C62.41.1 and IEEE C62.41.2. Fuses must not be used for surge protection.

2.9.2 Powerline Sensor Device Wiring and Communication Circuit Surge Protection

Sensor Device Wiring and Communication Circuit Surge Protection Inputs must be protected against surges induced on device wiring. Outputs must be protected against surges induced on control and device wiring installed outdoors and as shown. Communications equipment must be protected against surges induced on any communications circuit. Cables and conductors, except fiber optics, which serve as communications circuits from console to field equipment, and between field equipment, must have surge protection circuits installed at each end. Protection must be furnished at equipment, and additional triple electrode gas surge protectors rated for the application on each wire line circuit must be installed within 3 feet of the building cable entrance. Fuses must not be used for surge protection. The inputs and outputs must be tested in both normal mode and common mode using the following two waveforms:

a. A 10-microsecond rise time by 1000 microsecond pulse width waveform with a peak voltage of 1500 Volts and a peak current of 60 Amperes.

b. An 8-microsecond rise time by 20-microsecond pulse width waveform with a peak voltage of 1000 Volts and a peak current of 500 Amperes.

2.10 COMPONENT ENCLOSURE

Alarm enclosures with a tamper switch(es). Refer to paragraph TAMPER SWITCHES. Enclosures is to be formed and assembled to be sturdy and rigid. These include:

a. Consoles

b. Annunciator housings

c. Power supply enclosures

d. Sensor control and terminal cabinets

e. Control units

f. Wiring gutters

g. Other component housings

2.10.1 Interior Sensor

Provide sensors to be used in an interior environment with a housing that provides protection against dust, falling dirt, and dripping noncorrosive liquids. Refer to paragraph INTERIOR ENCLOSURES for enclosure ratings.

2.10.2 Exterior Sensor

Provide sensors to be used in an exterior environment with a housing that provides protection against windblown dust, rain and splashing water, and hose directed water. Sensors are not to be damaged by the ice formation on the enclosure. Refer to paragraph "Exposed-to-Weather Enclosures" and "Corrosion-Resistant Enclosures" for enclosure ratings.

2.10.3 Interior Enclosures

Enclosures to house equipment in an interior environment must be housed in a metallic enclosure and meet the requirements of NEMA 250 Type.

2.10.4 Exposed-to-Weather Enclosures

Enclosures to house equipment in an outdoor environment must be housed in a metallic enclosure and meet the requirements of NEMA 250 Type 4 .

2.10.5 Metal Thickness

Thicknesses of metal in cast and sheet metal enclosures of all types must be not less than those listed in Tables 8.1, 8.2, and 8.3 of UL 1610 for alarm components, and NEMA ICS 2 and NEMA ICS 6 for other enclosures. Sheet steel used in enclosure fabrication is to be at least 16 gauge; consoles are to be at least 18 gauge.

2.10.6 Doors and Covers

a. Doors and covers are to be flanged. Provide tight pin hinges or the ends of hinge pins are to be tack welded to prevent ready removal where doors are mounted on hinges with exposed pins.

b. Provide doors having a latch edge length of less than 24 inches with a single lock. Provide the door with a three-point latching device with lock where latch edge of a hinged door is 24 inches or more in length; or alternatively with two locks, one located near each end.

c. Covers of pull and junction boxes provided to facilitate initial installation of the system need not be provided with tamper switches if they contain no splices or connections, but must be protected by permanently affixing the covers in place or by tamper resistant security fasteners. Labels must be affixed to such boxes indicating they contain no connections.

2.10.7 Ventilation

Ventilation openings in enclosures and cabinets must conform to requirements of UL 1610.

2.10.8 Mounting

Sheet metal enclosures are to be rated for wall mounting with top hole slotted, unless otherwise indicated. Mounting holes are to be in

positions which remain accessible when major operating components are in place and door is open and be inaccessible when door is closed.

2.10.9 Labels

Junction Boxes utilized for ESS and ESS system connections must be labeled with "ESS".

2.10.10 Test Points

Provide readily visible and accessible with minimum disassembly of equipment to test points, controls, and other adjustments inside enclosures. Test points and other maintenance controls must be readily accessible to operator personnel.

2.11 EQUIPMENT RACK

Provide standard 19 inch electronic rack cabinets conforming to UL 50 for the ESS system at the SCC and remote control and monitoring sites as shown on the drawings. Equipment rack must be in accordance with Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

2.11.1 Labels

Provide a labeling system for cabling as required by TIA-606 and UL 969. Provide stenciled lettering for voice and data circuits using thermal ink transfer process .

2.12 LOCKS AND KEY LOCK

2.12.1 Lock

Provide locks on system enclosures for maintenance purposes that meet UL 437 and are round-key type, with three dual, one mushroom, and three plain pin tumblers . Keys must be stamped "U.S. GOVT. DO NOT DUP.". Keys are only to be withdrawn when in the locked position. Key all maintenance locks alike and furnish only two keys for all of these locks.

2.12.2 Key-Lock Operated Switches

All key-lock-operated switches required to be installed on system components are to be UL 437, with three dual, one mushroom, and three plain pin tumblers, . Keys must be stamped "U.S. GOVT. DO NOT DUP.". Key-lock-operated switches are to have two positions, with the key removable in either position. Key all key-lock-operated switches differently and furnish only two keys for each key-lock-operated-switch.

2.12.3 Construction Locks

Use a set of temporary locks during installation and construction. Do not include any of the temporary locks in the final set of locks installed and delivered to the Government.

2.13 FIELD FABRICATED NAMEPLATES

Nameplates must comply with ASTM D709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device as specified or as indicated on the drawings. Each nameplate inscription is to identify the function and, when applicable, the position.

Nameplates are to be melamine plastic, 0.125 inch thick, white with black center core. Surface is to be matte finish. Corners are to be square. Accurately align lettering and engrave into the core. Minimum size of nameplates must be 1 by 2.5 inches. Provide lettering a minimum of 0.25 inch high normal block style. Nameplates are not required for devices smaller than 1 x 3 inches.

2.13.1 Manufacturer's Nameplate

Each item of equipment is to have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.14 FACTORY APPLIED FINISH

Electrical equipment is to have factory-applied painting systems which meets the requirements of the NEMA 250 corrosion-resistance test as a minimum.

PART 3 EXECUTION

3.1 INSTALLATION

Install the system in accordance with safety and technical standards NFPA 70, UL 681, UL 1037, and UL 1076. Configure components within the system with appropriate service points to pinpoint system trouble in less than 20 minutes.

Install all system components, including any equipment that is furnished by the Government, and appurtenances in accordance with the manufacturer's instructions, NFPA 70 and as shown on the drawings, and furnish all necessary connectors, terminators, interconnections, services, and adjustments required for a complete and operable system.

3.1.1 Existing Equipment

Connect to and utilize existing equipment, control signal transmission lines, and devices as shown on the drawings. Any equipment and signal lines that are usable in their original configuration without modification may be reused with Government approval.

Make written requests and obtain approval prior to disconnecting any signal lines and equipment that creates equipment outage. Such work can proceed only after receiving Government approval of these requests. If any device fails after work has commenced on that device, signal, or control line, diagnose the failure and perform any necessary corrections to the equipment. The Government is responsible for maintenance and repair of Government equipment. The Contractor will be held responsible for repair costs due to negligence or abuse of Government equipment on their part.

3.1.2 Software Installation

Load software as specified and required for an operational system, including databases and specified programs. Provide original and backup copies on optic discs of all accepted software, including diagnostics, upon successful endurance test completion.

3.1.3 Enclosure Penetrations

Enclosures are to be penetrated from the bottom unless shown otherwise. Penetrations of interior enclosures having transitions of conduit from interior to exterior, and penetrations of exterior enclosures are to be sealed with rubber silicone sealant to preclude the entry of water. Terminate conduit risers in a hot-dipped galvanized metal cable terminator that is filled with a sealant as recommended by the cable manufacturer, and in a manner that does not damage the cable.

3.1.4 Cable and Wire Runs

Perform required cable and wire routings per NFPA 70 and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, ICS 705-1, and as specified. Terminate conduits including flexible metal and armored cable in the sensor or device enclosure. Fit ends of conduit with insulated bushings. Exposed conductors at ends of conduits external to sensors and devices are not acceptable.

3.1.5 Soldering

Soldered electrical connections must use composition Sn60, Type AR or S, for general purposes; use composition Sn62 or Sn63, Type AR or S, for special purposes. Flux must conform to ASTM B32 when Type S solder is used for soldering electrical connections.

3.1.6 Galvanizing

Ferrous metal is to be hot-dip galvanized in accordance with ASTM A123/A123M. Provide screws, bolts, nuts, and other fastenings and supports that are corrosion resistant.

Field welds or brazing on factory galvanized boxes, enclosures, conduits, and so on, are to be coated with a cold galvanized paint containing at least 95 percent zinc by weight.

3.1.7 Conduits

Install interior conduits in accordance with NFPA 70, Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM and ICS 705-1. Install exterior conduits in accordance with NFPA 70, Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION and ICS 705-1.

3.1.8 Underground Cable Installation

Install underground conductors connecting protected structures and objects to the central alarm updating and display unit as direct burial or in conduit in accordance with Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Coaxial cable cannot be spliced.

3.1.9 Field Applied Painting

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting must be in accordance with Section 09 90 00 PAINTS AND COATINGS.

3.1.10 Bonding, Grounding, and Shielding

Provide in accordance with TIA-607 and NFPA 70. Provide ground rods, bonding conductors, and grounding busbars in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.1.10.1 Grounding

Provide a ground system that consists of the earth electrode and lightning protection, surge protection, fault protection and signal reference subsystems.

3.1.10.1.1 Earth Electrode Subsystem

Provide an earth electrode subsystem that provides a path of low resistance to earth for lightning and power fault currents.

3.1.10.1.1.1 Ground Rod

Provide ground rods as needed. Ground rods must be copper clad galvanized , a minimum of 10 foot in length and not less than 3/4 inch in diameter. Install ground rods vertically with the top at least 12 inches below grade. The resistance to earth should not exceed 10 ohms for any ground rod location supporting an electronic sensor. Consider alternate methods for reducing the resistance to earth where 10 ohms cannot be obtained due to high soil resistivity, rock formations, etc.

3.1.10.1.1.2 Perimeter Fence

Ground perimeter animal control or security fences for personnel safety and to minimize the potential for equipment damage caused by lightning strikes. Ground sensored fences with ground rods at every sensor post supporting an electronic sensor. Ground fences with no electronic security equipment with ground rods at intervals of 650 feet. Ground all fences on each side of all gates, at each corner, or change in fence direction, at points 150 feet on each side of high tension wiring crossings, and at the closest approach to any building located within 50 feet of the fence. For all fences, bond a #2 AWG copper wire to the fence post, bottom steel tension wire, and ground rod. Bonding will be in accordance with MIL-HDBK-419. Bond ground straps to posts and ground rods by exothermic welding or brazing. Bond hinged gates to gate posts. Ensure each bend in the copper cable is gradual and does not exceed a radius of 8 inches. The angle of any bend will not be less than 90 degrees. The fence to earth ground will not exceed 10 ohms. Non-electronic, sensored fences may be grounded to 25 ohms.

3.1.10.1.1.3 Field Distribution Boxes (FDBs)

Ground each FDB with a grounding rod, which will be commonly bonded with power and sensor ground in the FDB on a common ground bus. Verify that all paint and or foreign substance that would preclude continuity of the signal path has been removed when securing a ground bus/strip. Attach the FDB ground wire to the grounding rod by exothermic welding.

3.1.10.1.1.4 Towers and Structures

Provide security alarm monitoring facilities that contain major concentrations of security equipment such as consoles with a lightning protection system including air terminals, down conductors, surge

arrestors and station grounds, all connected to a common counterpoise system.

3.1.10.2 Surge Protection Subsystem

3.1.10.2.1 Exterior Equipment

Provide lightning surge protection for exterior sensor equipment, Field Distribution Boxes, and camera equipment. Provide surge protection on input and output circuits of field equipment boxes to protect transponders and power supplies.

3.1.10.2.2 Interior Equipment

Ground interior sensor surge protection devices to an existing facility ground provided the ground is thoroughly checked for integrity. If a proper facility ground is not available, install a code compliant ground in accordance with the National Electric Code.

3.1.10.2.3 Fault Protection Subsystem

Install a fault protection subsystem that provides a conductive path between the earth electrode subsystem and all exposed metal parts of electrical enclosures. Provide fault protection for exterior and interior equipment by means of an equipment-grounding conductor routed from the equipment to the AC power distribution panel.

3.1.10.2.4 Signal Reference Subsystem

Install a proper Signal Reference Subsystem for security systems in accordance with MIL-HDBK-419. Bond all security equipment cases or cabinets to the equipotential planes by the shortest and most direct route.

3.1.10.3 Bonding

Provide bonding by welding in accordance with MIL-STD-188-124 and MIL-HDBK-419.

3.1.10.4 Shielding

Provide shielding in accordance with the standards in MIL-HDBK-419.

3.1.11 Nameplate Mounting

Provide nameplate number, location, and letter designation as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or rivets.

3.2 ADJUSTMENT, ALIGNMENT, SYNCHRONIZATION, AND CLEANING

a. Clean each system component of dust, dirt, grease, or oil incurred during and after installation or accrued subsequent to installation from other project activities subsequent to installation.

b. Prepare for system activation by manufacturer's recommended procedures for adjustment, alignment, or synchronization.

c. Prepare each component in accordance with appropriate provisions of component installation, operations, and maintenance manuals.

d. Remove large vegetation that may sway in the wind and touch fencing.

e. Adjust sensors so that coverage is overlapping and maximized without mutual interference.

3.3 SYSTEM STARTUP

Do not apply power to the system until after:

a. Set up system equipment items and communications in accordance with manufacturer's instructions.

b. Conduct a system visual inspection to ensure that defective equipment items have not been installed and that there are no loose connections.

c. Test and verify system wiring as correctly connected.

d. Verify system grounding and transient protection systems as properly installed.

e. Verify the correct voltage, phasing, and frequency of the system power supplies.

Satisfaction of the requirements above does not relieve the contractor of responsibility for incorrect installations, defective equipment items, or collateral damage as result of Contractor work or equipment.

3.4 SUPPLEMENTAL CONTRACTOR QUALITY CONTROL

Provide the services of technical representatives who are familiar with all components and installation procedures of the installed system; and are approved by the Contracting Officer. These representatives are to be present on the job site during the preparatory and initial phases of quality control to provide technical assistance. These representatives are also to be available on an as needed basis to aid with follow-up phases of quality control. These technical representatives are to participate in the system testing and validation and provide certification that their respective system portions meet the contractual requirements.

The above requirements supplement the quality control requirements specified elsewhere in the contract.

3.5 ESS SYSTEM TESTING

All ESS Testing requirements are specified in Section 28 08 10 ELECTRONIC SECURITY SYSTEM ACCEPTANCE TESTING.

3.6 ESS TRAINING

Conduct training courses for 10 designated personnel in system maintenance and operation. Coordinate training with the Government. The training is to be oriented to the specific system being installed. Training content is to include training manuals and audio-visual materials. Deliver training manuals for each trainee with 2 additional copies delivered for archiving at the project site. The manuals are to include an agenda, defined objectives for each lesson, and a detailed subject matter

description for each lesson.

Furnish audio-visual equipment and other training materials and supplies. Deliver copies of the audio-visual materials to the Government either as a part of the printed training manuals or on the same media as that used during the training sessions when course portions are presented using audio-visual material.

3.6.1 ESS Training Outline

Submit a training plan for the training phases, including type of training to be provided, outline of training manuals, training course agendas, and a list of reference material, for Government approval.

3.6.2 Typical Training Day

A training day is defined as:

a. Eight hours of classroom instruction, with

(1) Two 15-minute breaks

(2) One hour lunch break

b. Conducted:

(1) Monday through Friday

(2) During the daytime shift in effect at a government-provided training facility

For guidance in planning the required instruction, assume that attendees will have a high school education or equivalent, and are familiar with ESS. Approval of the planned training schedule is to be obtained from the Government at least 30 days prior to the training.

3.6.3 ESS Administrator Training

a. ACS and IDS Administrator Training includes:

(1) Two eight-hour on-site training sessions

(2) Operating system procedures and configuration

(3) Operator functions

(4) Database functions and setup

(5) Card holder input and deletion procedures

(6) Report generation

(7) Applications programs (as applicable)

(8) Graphics generation and manipulation

(9) Items unique to the ACS and IDS interfaces with other systems

(10) System backup and restore

b. VSS Administrator Training includes:

(1) One eight-hour session on site

(2) Training is to include all administrator and operator functions, and items unique to the installed VSS, and interfaces with other systems.

3.6.4 ESS Operator Training

Coordinate the operator training syllabus with the Government prior to conducting operator training.

a. ACS and IDS Operator Training includes:

(1) Four (one-day) 8 hour on-site training sessions

(2) System operating procedures

(3) System configuration orientation

(4) Alarm acknowledgment

(5) Alarm response logging

(6) Graphics functionality

(7) Items unique to the ACS and IDS interfaces with other systems

b. VSS Operator Training includes:

(1) Two (one-day) 8 hour on-site training sessions

(2) System operating procedures

(3) System configuration

(4) Video call-up

(5) Camera and monitor control

(6) Graphics functionality

(7) Basic device terminology and troubleshooting

3.6.5 Maintenance Personnel Training

The system maintenance course is to be taught at the project site after endurance test completion for a period of five training days. A maximum of five personnel, designated by the Government, will attend the course. The training includes:

a. Physical layout of each piece of hardware.

b. Troubleshooting and diagnostics procedures of each piece of hardware.

c. Component repair and replacement procedures of each piece of hardware.

d. Maintenance procedures and schedules to include system testing after repair of each piece of hardware.

e. Calibration procedures of each piece of hardware. Upon course completion, the students are to be proficient in system maintenance.

f. Review of site-specific drawing package, device location, communication, topology, and flow.

3.6.6 Follow-up Training

a. Provide One hour training session each month for two months after initial training.

b. Follow-up training is to begin one month after initial training.

c. Training is to include testing for system competence.

-- End of Section --

SECTION 28 31 76

INTERIOR FIRE ALARM AND MASS NOTIFICATION SYSTEM, ADDRESSABLE
08/20

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S3.2	(2020) American National Standard Method for Measuring the Intelligibility of Speech Over Communication Systems (ASA 85)

ASTM INTERNATIONAL (ASTM)

ASTM F402	(2018) Standard Practice for Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide https://www.approvalguide.com/

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 4	(2018) Standard for Integrated Fire Protection and Life Safety System Testing
NFPA 70	(2026; TIA 26-1; ERTA 26-1; TIA 26-2; TIA 26-3; TIA 26-4; TIA 26-5; TIA 26-6; TIA 26-7; ERTA 26-2; ERTA 26-3) National Electrical Code
NFPA 72	(2025; TIA 25-1; TIA 25-2; TIA 25-3; TIA 25-4; ERTA 25-1; ERTA 25-2) National Fire Alarm and Signaling Code
NFPA 90A	(2024) Standard for the Installation of Air Conditioning and Ventilating Systems

NFPA 170	(2024; ERTA 1 2023) Standard for Fire Safety and Emergency Symbols

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-601-02	(2021) Fire Protection Systems Inspection, Testing, and Maintenance
UFC 4-010-06	(2023) Cybersecurity of Facility-Related Control Systems

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 15	Radio Frequency Devices
47 CFR 90	Private Land Mobile Radio Services

UL SOLUTIONS (UL)

UL 268	(2023) UL Standard for Safety Smoke Detectors for Fire Alarm Systems
UL 268A	(2008; Reprint Aug 2023) Smoke Detectors for Duct Application
UL 464	(2023) UL Standard for Safety Audible Signaling Devices for Fire Alarm and Signaling Systems, Including Accessories
UL 497B	(2004; Reprint Feb 2022) UL Standard for Safety Protectors for Data Communications and Fire Alarm Circuits
UL 864	(2023; Reprint Oct 2024) UL Standard for Safety Control Units and Accessories for Fire Alarm Systems
UL 1283	(2017; Reprint Feb 2024) UL Standard for Safety Electromagnetic Interference Filters
UL 1449	(2021; Reprint Oct 2025) UL Standard for Safety Surge Protective Devices
UL 1480	(2023) UL Standard for Safety Speakers for Fire Alarm and Signaling Systems, Including Accessories
UL 1638	(2023) UL Standard for Safety Visible Signaling Devices for Fire Alarm and Signaling Systems, Including Accessories
UL 1971	(2002; Reprint Feb 2024) UL Standard for Safety Signaling Devices for the Deaf and Hard of Hearing
UL 2017	(2008; Reprint Jan 2024) UL Standard for Safety General-Purpose Signaling Devices and Systems

UL 2572	(2016; Bul. 2018) UL Standard for Safety Mass Notification Systems
UL Fire Prot Dir	UL Product IQ (updated online) at https://productiq.ulpropsector.com/en

1.2 RELATED SECTIONS

Section 25 05 11.21 CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS FIRE & LIFE SAFETY, applies to this section, with the additions and modifications specified herein. In addition, refer to the following sections for related work and coordination:

Section 21 13 13 WET PIPE SPRINKLER SYSTEM, FIRE PROTECTION
Section 08 71 00 DOOR HARDWARE for door unlocking and additional work related to finish hardware.
Section 07 84 00 FIRESTOPPING for additional work related to firestopping.

1.3 SUMMARY

1.3.1 Scope

a. This work includes designing and providing a new, complete, fire alarm and mass notification (MNS) system as described herein and on the contract drawings. Include system wiring, raceways, pull boxes, terminal cabinets, outlet and mounting boxes, control equipment, initiating devices, notification appliances, supervising station fire alarm transmitters/mass notification transceiver, and other accessories and miscellaneous items required for a complete operational system even though each item is not specifically mentioned or described. Provide system complete and ready for operation. Design and installation must comply with UFC 4-010-06.

b. Provide equipment, materials, installation, workmanship, inspection, and testing in strict accordance with NFPA 72, except as modified herein. The system layout on the drawings show the intent of coverage and suggested locations. Final quantity, system layout, and coordination are the responsibility of the Contractor.

c. Each remote fire alarm control unit must be powered from a wiring riser specifically for that use or from a local emergency power panel located on the same floor as the remote fire alarm control unit. Where remote fire control units are provided, equipment for notification appliances may be located in the remote fire alarm control units.

d. The fire alarm and mass notification system must be independent of the building security, building management, and energy/utility monitoring systems other than for control functions.

1.3.2 Qualified Fire Protection Engineer (QFPE)

Services of the QFPE must include:

a. Reviewing SD-02, SD-03, and SD-05 submittal packages for completeness and compliance with the provisions of this specification. Construction (shop) drawings and calculations must be prepared by, or prepared under the immediate supervision of, the QFPE. The QFPE must

affix their professional engineering stamp with signature to the shop drawings, calculations, and material data sheets, indicating approval prior to submitting the shop drawings to the DFPE.

b. Providing a letter documenting that the SD-02, SD-03, and SD-05 submittal package has been reviewed and noting any outstanding comments.

c. Performing in-progress construction surveillance prior to installation of ceilings (rough-in inspection).

d. Witnessing pre-Government functional performance testing and performing a final installation review.

e. Signing applicable certificates under SD-07.

1.4 DEFINITIONS

Wherever mentioned in this specification or on the drawings, the equipment, devices, and functions must be defined as follows:

1.4.1 Interface Device

An addressable device that interconnects hard wired systems or devices to an analog/addressable system.

1.4.2 Fire Alarm and Mass Notification Control Unit (FMCU)

A master control unit having the features of a fire alarm control unit (FACU) and an autonomous control unit (ACU) where these units are interconnected to function as a combined fire alarm/mass notification system. The FACU and ACU functions may be contained in a single cabinet or in independent, interconnected, and co-located cabinets.

1.4.3 Remote Fire Alarm and Mass Notification Control Unit

A control unit, physically remote from the fire alarm and mass notification control unit, that receives inputs from automatic and manual fire alarm devices; may supply power to detection devices and interface devices; may provide transfer of power to the notification appliances; may provide transfer of condition to relays or devices connected to the control unit; and reports to and receives signals from the fire alarm and mass notification control unit.

1.4.4 Local Operating Console (LOC)

A unit designed to allow emergency responders or building occupants to operate the MNS including delivery of recorded messages or live voice announcements, initiate visual, textual visual, and audible appliance operation and other relayed functions.

1.4.5 Terminal Cabinet

A steel cabinet with locking, hinge-mounted door where terminal strips are securely mounted inside the cabinet.

1.4.6 Control Module and Relay Module

Terms utilized to describe emergency control function interface devices as

defined by NFPA 72.

1.4.7 Designated Fire Protection Engineer (DFPE)

The DoD fire protection engineer that oversees that Area of Responsibility for that project. This is sometimes referred to as the "cognizant" fire protection engineer. Interpret reference to "authority having jurisdiction" and AHJ in referenced standards to mean the Designated Fire Protection Engineer (DFPE). The DFPE may be responsible for review of the contractor submittals having a "G" designation, and for witnessing final inspection and testing.

1.4.8 Qualified Fire Protection Engineer (QFPE)

A QFPE is an individual who is a licensed professional engineer (P.E.), who has passed the fire protection engineering written examination administered by the National Council of Examiners for Engineering and Surveying (NCEES) and has relevant fire protection engineering experience.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval.

Shop drawings (SD-02), product data (SD-03) and calculations (SD-05) must be prepared by the fire alarm designer and combined and submitted as one complete package. The QFPE must review the SD-02/SD-03/SD-05 submittal package for completeness and compliance with the Contract provisions prior to submission to the Government. The QFPE must provide a Letter of Confirmation that they have reviewed the submittal package for compliance with the contract provisions. This letter must include their registered professional engineer stamp and signature. Partial submittals and submittals not reviewed by the QFPE will be returned by the Government disapproved without review.

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Qualified Fire Protection Engineer (QFPE); G

Fire alarm system designer; G

Supervisor; G

Technician; G

Installer; G

Test Technician; G

Fire Alarm System Site-Specific Software Acknowledgement; G

SD-02 Shop Drawings

Nameplates; G

Instructions; G

Wiring Diagrams; G

System Layout; G

Notification Appliances; G

Initiating devices; G

Amplifiers; G

Battery Power; G

Voltage Drop Calculations; G

SD-03 Product Data

Fire Alarm and Mass Notification Control Unit (FMCU); G

Local Operating Console (LOC); G

Amplifiers; G

Tone Generators; G

Digitalized voice generators; G

Manual Stations; G

Smoke Detectors; G

Duct Smoke Detectors; G

Air sampling smoke detectors; G

Addressable Interface Devices; G

Addressable Control Modules; G

Isolation Modules; G

Notification Appliances; G

Low Temperature Sensor; G

Textual Display Signs; G

Batteries; G

Battery Chargers; G

Supplemental Notification Appliance Circuit Panels; G

Auxiliary Power Supply Panels; G

Surge Protective Devices; G

Alarm Wiring; G

Back Boxes and Conduit; G

Ceiling Bridges for Ceiling-Mounted Appliances; G

Terminal Cabinets; G

Automatic Fire Alarm Transmitters (including housing); G

Radio Transmitter and Interface Panels; G

Document Storage Cabinet; G

SD-05 Design Data

Air Sampling Smoke Detection System Calculations; G

SD-06 Test Reports

Test Procedures; G

SD-07 Certificates

Verification of Compliant Installation; G

Request for Government Final Test; G

SD-10 Operation and Maintenance Data

Operation and Maintenance (O&M) Instructions; G

Instruction of Government Employees; G

SD-11 Closeout Submittals

As-Built Drawings

Spare Parts

1.6 SYSTEM OPERATION

Fire alarm system/mass notification system including textual display sign control panel(s), components requiring power, except for the FMCU(s) power supply, must operate on 24 volts DC unless noted otherwise in this section.

The interior fire alarm and mass notification system must be a complete, supervised, noncoded, analog/addressable fire alarm and mass notification system conforming to NFPA 72, UL 864, and UL 2572. Systems meeting UL 2017 only are not acceptable. The system must be activated into the alarm mode by actuation of an alarm initiating device. The system must remain in the alarm mode until the initiating device is reset and the control unit is reset and restored to normal. The system may be placed in the alarm mode by local microphones, LOC, FMCU, or remotely from authorized locations/users.

1.6.1 Alarm Initiating Devices and Notification Appliances (Visual, Voice, Textual)

a. Connect alarm initiating devices to initiating device circuits (IDC) Class "B", or to signaling line circuits (SLC) Class "B" and installed in accordance with NFPA 72.

b. Connect notification appliances to notification appliance circuits (NAC) Class "B".

1.6.2 Functions and Operating Features

The system must provide the following functions and operating features:

a. Power, annunciation, supervision, and control for the system. Addressable systems must be microcomputer (microprocessor or microcontroller) based with a minimum word size of eight bits with sufficient memory to perform as specified.

b. Visual alarm notification appliances must be synchronized as required by NFPA 72.

c. Electrical supervision of the primary power (AC) supply, presence of the battery, battery voltage, and placement of system modules within the control unit.

d. An audible and visual trouble signal to activate upon a single break or open condition, or ground fault. The trouble signal must also operate upon loss of primary power (AC) supply, absence of a battery supply, low battery voltage, or removal of alarm or supervisory control unit modules. After the system returns to normal operating conditions, the trouble signal must again sound until the trouble is acknowledged. A smoke detector in the process of being verified for the actual presence of smoke must not initiate a trouble condition.

e. A trouble signal silence feature that must silence the audible trouble signal, without affecting the visual indicator.

f. Program capability via switches in a locked portion of the FMCU to bypass the automatic notification appliance circuits, air handler shutdown, smoke control operation, and door unlocking features. Operation of this programmed action must indicate on the FMCU display as a supervisory or trouble condition.

g. Alarm functions must override trouble or supervisory functions. Supervisory functions must override trouble functions.

h. The system must be capable of being programmed from the control unit keyboard. Programmed information must be stored in non-volatile memory.

i. The system must be capable of operating, supervising, and monitoring non-addressable alarm and supervisory devices.

j. There must be no limit, other than maximum system capacity, as to the number of addressable devices that may be in alarm simultaneously.

k. Where the fire alarm/mass notification system is responsible for initiating an action in another emergency control device or system,

such as HVAC, smoke control, the addressable fire alarm relay must be located in the vicinity of the emergency control device.

l. An alarm signal must automatically initiate the following functions:

(1) Transmission of an alarm signal to the fire department.

(2) Visual indication of the device operated on the FMCU.
(3) Actuation of alarm notification appliances.

(4) Recording of the event electronically in the history log of the FMCU.

(5) Operation of the smoke control system (smoke detection or waterflow in the associated zone only).

m. A supervisory signal must automatically initiate the following functions:

(1) Visual indication of the device operated on the FMCU.

(2) Transmission of a supervisory signal to the fire department.

(3) Operation of a duct smoke detector must shut down the appropriate air handler in accordance with NFPA 90A in addition to other requirements of this paragraph and as allowed by NFPA 72.

(4) Recording of the event electronically in the history log of the FMCU.

n. A trouble condition must automatically initiate the following functions:

(1) Visual indication of the device operated on the FMCU.

(2) Transmission of a trouble signal to the fire department.

(3) Recording of the event electronically in the history log of the FMCU.

o. System control equipment must be programmed to provide a 60-minute to 180-minute delay in transmission of trouble signals resulting from primary power failure.

1.7 TECHNICAL DATA AND SITE-SPECIFIC SOFTWARE

Technical data and site-specific software (meaning technical data that relates to computer software) that are specifically identified in this project, and may be required in other specifications, must be delivered, strictly in accordance with the CONTRACT CLAUSES. The fire alarm system manufacturer must submit written confirmation of this contract provision as "Fire Alarm System Site-Specific Software Acknowledgement". Identify data delivered by reference to the specification paragraph against which it is furnished. Data to be submitted must include complete system, equipment, and software descriptions. Descriptions must show how the equipment will operate as a system to meet the performance requirements of this contract. The site-specific software data package must also include the following:

a. Items identified in NFPA 72, titled "Site-Specific Software".

b. Identification of programmable portions of the system equipment and capabilities.

c. Description of system revision and expansion capabilities and methods of implementation detailing both equipment and software requirements.

d. Provision of operational software data on all modes of programmable portions for fire alarm and mass notification.

e. Description of Fire Alarm and Mass Notification Control Unit equipment operation.

f. Description of auxiliary and remote equipment operations.

g. Library of application software.

h. Operation and maintenance manuals.

1.8 QUALITY ASSURANCE

1.8.1 Submittal Documents

1.8.1.1 Preconstruction Submittals

Within 36 days of contract award but not less than 14 days prior to commencing any work on site, the Contractor must submit the following for review and approval. SD-02, SD-03 and SD-05 submittals received prior to the review and approval of the qualifications of the fire alarm subcontractor and QFPE must be returned disapproved without review. All resultant delays must be the sole responsibility of the Contractor.

1.8.1.2 Shop Drawings

Shop drawings must not be smaller than the Contract Drawings. Drawings must comply with the requirements of NFPA 72 and NFPA 170. Minimum scale for floor plans must be 1/8"=1'.

1.8.1.3 Nameplates

Nameplate illustrations and data to obtain approval by the Contracting Officer before installation.

1.8.1.4 Wiring Diagrams

Two copies of point-to-point wiring diagrams showing the points of connection and terminals used for electrical field connections in the system, including interconnections between the equipment or systems that are supervised or controlled by the system. Diagrams must show connections from field devices to the FMCU and remote FMCU, initiating circuits, switches, relays and terminals, including pathway diagrams between the control unit and shared communications equipment within the protected premises. Point-to-point wiring diagrams must be job specific and must not indicate connections or circuits not being utilized. Provide complete riser diagrams indicating the wiring sequence of all devices and their connections to the control equipment. Include a color-code schedule for the wiring.

1.8.1.5 System Layout

Two copies of plan view drawing showing device locations, terminal cabinet locations, junction boxes, other related equipment, conduit routing, conduit sizes, wire counts, conduit fill calculations, wire color-coding, circuit identification in each conduit, and circuit layouts for all floors. Indicate candela rating of each visual notification appliance. Indicate the wattage of each speaker. Clearly identify the locations of isolation modules. Indicate the addresses of all devices, modules, relays, and similar. Show/identify all acoustically similar spaces. Indicate if the environment for the FMCU is within its environmental listing (e.g. temperature/humidity).

Provide a complete description of the system operation in matrix format similar to the "Typical Input/Output Matrix" included in the Annex of NFPA 72.

For air sampling smoke detection systems, provide floor plan layouts indicating location of fire alarm control unit, air sampling piping (lengths of pipe) and sampling ports (sizes and locations). Floor plan must also indicate geographic monitor zone boundaries, location of display control unit, bar level annunciation panels if separate, and all other associated equipment that is required to provide a complete operational system.

1.8.1.6 Notification Appliances

Calculations and supporting data on each circuit to indicate that there is at least 25 percent spare capacity for notification appliances. Annotate data for each circuit on the drawings.

1.8.1.7 Initiating Devices

Calculations and supporting data on each circuit to indicate that there is at least 25 percent spare capacity for initiating devices. Annotate data for each circuit on the drawings.

1.8.1.8 Amplifiers

Calculations and supporting data to indicate that amplifiers have sufficient capacity to simultaneously drive all notification speakers at tapped settings plus 25 percent spare capacity. Annotate data for each circuit on the drawings.

1.8.1.9 Battery Power

Calculations and supporting data as required in paragraph Battery Power Calculations for alarm, alert, and supervisory power requirements. Calculations including ampere-hour requirements for each system component and each control unit component, and the battery recharging period, must be included on the drawings.

1.8.1.10 Voltage Drop Calculations

Voltage drop calculations for each notification circuit indicating that sufficient voltage is available for proper operation of the system and all components, at a minimum rated voltage of the system operating on batteries. Include the calculations on the system layout drawings.

1.8.1.11 Product Data

Two copies of annotated descriptive data to show the specific model, type, and size of each item. Catalog cuts must also indicate the NRTL listing. The data must be highlighted to show model, size, and options that are intended for consideration. Data must be adequate to demonstrate compliance with all contract requirements. Product data for all equipment must be combined into a single submittal.

Provide an equipment list identifying the type, quantity, make, and model number of each piece of equipment to be provided under this submittal. The equipment list must include the type, quantity, make and model of spare equipment. Types and quantities of equipment submitted must coincide with the types and quantities of equipment used in the battery calculations and those shown on the shop drawings.

1.8.1.12 Air Sampling Smoke Detection System Calculations

Submit air sampling detection system design analysis calculations consisting of battery capacity, loading calculations, and fan speed and air flow/transport calculations. Include schematic diagrams showing pipe segments, pipe diameters, lengths of pipe, node numbers, and sample port diameters to verify the requirements are met.

1.8.1.13 Operation and Maintenance (O&M) Instructions

Six copies of the Operation and Maintenance Instructions. The O&M Instructions must be prepared in a single volume or in multiple volumes, with each volume indexed, and may be submitted as a Technical Data Package. Manuals must be approved prior to training. The Interior Fire Alarm And Mass Notification System Operation and Maintenance Instructions must include the following:

a. "Manufacturer Data Package five" as specified in Section 01 78 23 OPERATION AND MAINTENANCE DATA.

b. Operating manual outlining step-by-step procedures required for system startup, operation, and shutdown. The manual must include the manufacturer's name, model number, service manual, parts list, and preliminary equipment list complete with description of equipment and their basic operating features.

c. Maintenance manual listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guide. The manuals must include conduit layout, equipment layout and simplified wiring, and control diagrams of the system as installed.

d. Complete procedures for system revision and expansion, detailing both equipment and software requirements.

e. Software submitted for this project on CD/DVD media utilized.

f. Printouts of configuration settings for all devices.

g. Routine maintenance checklist. The routine maintenance checklist must be arranged in a columnar format. The first column must list all installed devices, the second column must state the maintenance activity or state no maintenance required, the third column must state the frequency of the maintenance activity, and the fourth column

provided for additional comments or reference. All data (devices, testing frequencies, and similar) must comply with UFC 3-601-02.

h. A final Equipment List must be submitted with the Operating and Maintenance (O&M) manual.

1.8.1.14 As-Built Drawings

The drawings must show the system as installed, including deviations from both the project drawings and the approved shop drawings. These drawings must be submitted within two weeks after the final Government test of the system. At least one set of the as-built (marked-up) drawings must be provided at the time of, or prior to the final Government test.

1.8.2 Qualifications

1.8.2.1 Fire Alarm System Designer

The fire alarm system designer must be certified as a Level IV (minimum) Technician by National Institute for Certification in Engineering Technologies (NICET) in the Fire Alarm Systems subfield of Fire Protection Engineering Technology or meet the qualifications for a QFPE.

1.8.2.2 Supervisor

A NICET Level IV fire alarm technician must supervise the installation of the fire alarm/mass notification system, including the air sampling smoke detection system. The fire alarm technicians supervising the installation of equipment must be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.

1.8.2.3 Technician

Fire alarm technicians with a minimum of four years of experience must be utilized to install and terminate fire alarm/mass notification devices, cabinets and control units. The fire alarm technicians installing the equipment must be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings, and must be thoroughly experienced in the installation of air sampling detection systems.

1.8.2.4 Installer

Fire alarm installer with a minimum of two years of experience utilized to assist in the installation of fire alarm/mass notification devices, cabinets and control units . A licensed electrician must be allowed to install wire, cable, conduit and backboxes for the fire alarm system/mass notification system. The fire alarm installer must be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.

1.8.2.5 Test Technician

Fire alarm technicians with a minimum of eight years of experience and NICET Level IV utilized in testing and certification of the installation of the fire alarm/mass notification devices, cabinets and control units. The fire alarm technicians testing the equipment must be factory trained in the installation, adjustment, testing, and operation of the equipment

installed as part of this project.

1.8.2.6 Manufacturer

Components must be of current design and must be in regular and recurrent production at the time of installation. Provide design, materials, and devices for a protected premises fire alarm system, complete, conforming to NFPA 72, except as specified herein.

1.8.3 Regulatory Requirements

Equipment and material must be listed or approved. Listed or approved, as used in this section, means listed, labeled or approved by a Nationally Recognized Testing Laboratory (NRTL) such as UL Fire Prot Dir or FM APP GUIDE. The omission of these terms under the description of any item of equipment described must not be construed as waiving this requirement. All listings or approvals by testing laboratories must be from an existing ANSI or UL published standard. The recommended practices stated in the manufacturer's literature or documentation must be considered as mandatory requirements.

1.9 DELIVERY, STORAGE, AND HANDLING

Protect equipment delivered and placed in storage from the weather, humidity, and temperature variation, dirt and dust, and other contaminants.

1.10 MAINTENANCE

1.10.1 Spare Parts

Furnish the following spare parts in the manufacturers original unopened containers:

a. Five complete sets of system keys.

b. Two of each type of fuse required by the system.

c. One manual stations.

d. Two of each type of detector installed.

e. Two of each type of detector base and head installed.

f. Two air sampling smoke detection system filter assemblies.

g. Two of each type of audible and visual alarm device installed.

h. One textual visual notification appliance.

i. Two of each type of addressable monitor module installed.

j. Two of each type of addressable control module installed.

k. Two low voltage, one , and one 120 VAC surge protective device.

1.10.2 Special Tools

Software, connecting cables and proprietary equipment, necessary for the maintenance, testing, and reprogramming of the equipment must be furnished

to the Contracting Officer, prior to the instruction of Government employees.

PART 2 PRODUCTS

2.1 GENERAL PRODUCT REQUIREMENT

All fire alarm and mass notification equipment must be listed for use under the applicable reference standards. Interfacing of UL 864 or similar approved industry listing with Mass Notification equipment listed to UL 2572 must be done in a laboratory listed configuration, if the software programming features cannot provide a listed interface control.

2.2 MATERIALS AND EQUIPMENT

2.2.1 Standard Products

Provide materials, equipment, and devices that have been tested by a nationally recognized testing laboratory and listed for fire protection service when so required by NFPA 72 or this specification. Select material from one manufacturer, where possible, and not a combination of manufacturers, for any particular classification of materials. Material and equipment must be the standard products of a manufacturer regularly engaged in the manufacture of the products for at least 2 years prior to bid opening.

2.2.2 Nameplates

Major components of equipment must have the manufacturer's name, address, type or style, model or serial number, catalog number, date of installation, installing Contractor's name and address, and the contract number provided on a new name plate permanently affixed to the item or equipment. Major components include, but are not limited to, the following:

a. FMCU

Nameplates must be etched metal or plastic, permanently attached by screws to control units or adjacent walls.

2.2.3 Keys

Keys and locks for equipment, control units and devices must be identical. .

2.2.4 Instructions

Provide a typeset printed or typewritten instruction card mounted behind a Lexan plastic or glass cover in a stainless steel or aluminum frame. Install the frame in a conspicuous location observable from the FMCU. The card must show those steps to be taken by an operator when a signal is received as well as the functional operation of the system under all conditions, normal, alarm, supervisory, and trouble. The instructions must also include procedures for operating live voice microphones. The instructions and their mounting location must be approved by the Contracting Officer before being posted.

2.3 FIRE ALARM AND MASS NOTIFICATION CONTROL UNIT

Provide a complete fire alarm and mass notification control unit (FMCU) fully enclosed in a lockable steel cabinet as specified herein. Operations required for testing or for normal care, maintenance, and use of the system must be performed from the front of the enclosure. The nonsecure and secure area control units must match exactly. The system must be capable of defining any module as an alarm module and report alarm trouble, loss of polling, or as a supervisory module, and reporting supervisory short, supervisory open or loss of polling such as waterflow switches, valve supervisory switches, fire pump monitoring, independent smoke detection systems, relays for output function actuation.

a. Each control unit must provide power, supervision, control, and logic for the entire system, utilizing modular components, internally mounted and arranged for easy access. Each control unit must be suitable for operation on a 120 volt, 60 hertz, normal building power supply. Provide each control unit with supervisory functions for power failure, internal component placement, and operation.

b. Visual indication of alarm, supervisory, or trouble initiation on the FMCU must be by liquid crystal display or similar means with a minimum of 80 characters. The mass notification control unit must have the capability of temporarily deactivate the fire alarm audible notification appliances while delivering voice messages.

c. Provide secure operator console for initiating recorded messages, strobes and displays; and for delivering live voice messages. Provide capacity for at least eight prerecorded messages. Provide the ability to automatically repeat prerecorded messages. Provide a secure microphone for delivering live messages. Provide adequate discrete outputs to temporarily deactivate fire alarm audible notification, initiate/synchronize strobes and initiate textual visual notification appliances. Provide a complete set of self-diagnostics for controller and appliance network. Provide local diagnostic information display and local diagnostic information and system event log file.

2.3.1 Cabinet

Install control unit components in cabinets large enough to accommodate all components and also to allow ample gutter space for interconnection of control units as well as field wiring. The cabinet must be a sturdy steel housing, complete with back box, hinged steel door with cylinder lock, and surface mounting provisions. The enclosure must be identified by an engraved phenolic resin nameplate. Lettering on the nameplate must say "Fire Alarm and Mass Notification control unit" and must not be less than 1-inch high. Provide prominent rigid plastic or metal identification plates for lamps, circuits, meters, fuses, and switches.

2.3.2 Silencing Switches

2.3.2.1 Alarm Silencing Switch

Provide an alarm silencing switch at the FMCU that must silence the audible and visual notification appliances. Subsequent activation of initiating devices must cause the notification appliances to re-activate.

2.3.2.2 Supervisory/Trouble Silencing Switch

Provide supervisory and trouble silencing switch(es) that must silence the audible trouble and supervisory signal(s), but not extinguish the visual indicator. This switch must be overridden upon activation of a subsequent supervisory or trouble condition. Audible trouble indication must resound automatically every 24 hours after the silencing feature has been operated if the supervisory or trouble condition still exists.

2.3.3 Non-Interfering

Power and supervise each circuit such that a signal from one device does not prevent the receipt of signals from any other device. Initiating devices must be manually reset by switch from the FMCU after the initiating device or devices have been restored to normal.

2.3.4 Audible Notification System

The Audible Notification System must comply with the requirements of NFPA 72 for Emergency Voice/Alarm Communications System requirements, except as specified herein. The system must be a one-way, multi-channel voice notification system incorporating user selectability of a minimum eight distinct sounds for tone signaling, and the incorporation of a voice module for delivery of recorded messages. Audible appliances must produce a three-pulse temporal pattern for three cycles followed by a voice message that is repeated until the control unit is reset or silenced. Automatic messages must be broadcast through speakers throughout the building/facility but not in stairs or elevator cabs. A live voice message must override the automatic audible output through use of a microphone input at the control unit or the LOC.

a. When using the microphone, live messages must be broadcast all call. The system must be capable of operating all speakers at the same time.

b. The microprocessor must actively interrogate circuitry, field wiring, and digital coding necessary for the immediate and accurate rebroadcasting of the stored voice data into the appropriate amplifier input. Loss of operating power, supervisory power, or any other malfunction that could render the digitalized voice module inoperative must automatically cause the three-pulse temporal pattern to take over all functions assigned to the failed unit in the event an alarm is activated.

2.3.4.1 Outputs and Operational Modules

All outputs and operational modules must be fully supervised with on-board diagnostics and trouble reporting circuits. Provide form "C" contacts for system alarm and trouble conditions. Provide circuits for operation of auxiliary appliance during trouble conditions. During a Mass Notification event, the control unit must not generate nor cause any trouble alarms to be generated with the Fire Alarm system.

2.3.4.2 Mass Notification

a. The system must have the capability of utilizing an LOC with redundant controls of the FMCU. Notification Appliance Circuits (NAC) must be provided for the activation of strobe appliances. Audio output must be selectable for line level. A hand-held microphone must be provided and, upon activation, must take priority over any tone signal,

recorded message or PA microphone operation in progress, while maintaining the strobe NAC circuit activation.

b. The Mass Notification functions must override the manual or automatic fire alarm notification. Other fire alarm functions including transmission of a signal(s) to the fire department must remain operational. When a mass notification announcement is disengaged and a fire alarm condition still exists, the audible and visual notification appliances must resume activation for alarm conditions. The fire alarm message must be of lower priority that all other messages (except any "test" messages) and must not override any other messages. If not manually ended, any mass notification announcement will automatically end after 10 minutes.

c. Messages must be recorded professionally utilizing standard industry methods, in a professional voice. Message and tone volumes must both be at the same decibel level. Messages recorded from the system microphone must not be accepted. A 1000 Hz tone (as required by NFPA 72) must precede messages and be similar to the following unless Installation or Facility specific messages are required:

(1) Fire: "May I have your attention please. May I have your attention please. A fire emergency has been reported in the building. Please leave the building by the nearest exit" (Provide a 2 second pause.) "May I have your attention please, (repeat the tones and message on a continuous loop)."

(2) Test: "May I have your attention please. May I have your attention please. This is a test of the building mass notification system. Please continue your normal duties. This is only a test." (Provide a 2 second pause.)

(3) All Clear: "May I have your attention please. May I have your attention please. An all clear has been issued, resume normal activities." (Provide a 2 second pause.)

(4) Additional installation-specific messages, as required by the COR.

d. Auxiliary Input Module must be designed to be an outboard expansion module to either expand the number of optional LOC's, or allow a telephone interface.

2.3.4.3 Installation-Wide Control

If an installation-wide control system for mass notification exists on the Base, the autonomous control unit must communicate with the central control unit of the Installation-wide system. The autonomous control unit must receive commands/messages from the central control unit and provide status information. Provide complete MNS system designed to allow interface with a wide area MNS.

2.3.5 Memory

Provide each control unit with non-volatile memory and logic for all functions. The use of long life batteries, capacitors, or other age-dependent devices must not be considered as equal to non-volatile processors, PROMS, or EPROMS.

2.3.6 Field Programmability

Provide control units and control units that are fully field programmable for both input and output of control, initiation, notification, supervisory, and trouble functions. The system program configuration must be menu driven. System changes must be password protected. Any proprietary equipment and proprietary software needed by qualified technicians to implement future changes to the fire alarm system must be provided as part of this contract.

2.3.7 Input/Output Modifications

The FMCU must contain features that allow the bypassing of input devices from the system or the modification of system outputs. These control features must consist of a control unit mounted keypad. Any bypass or modification to the system must indicate a trouble condition on the FMCU.

2.3.8 Resetting

Provide the necessary controls to prevent the resetting of any alarm, supervisory, or trouble signal while the alarm, supervisory or trouble condition on the system still exists.

2.3.9 Walk Test

The FMCU must have a walk test feature. When using this feature, operation of initiating devices must result in limited system outputs, so that the notification appliances operate for only a few seconds and the event is indicated in the history log and on the system printer, but no other outputs occur.

2.3.10 History Logging

The control unit must have the ability to store a minimum of 400 events in a log. These events must be stored in a battery-protected memory and must remain in the memory until the memory is downloaded or cleared manually. Resetting of the control unit must not clear the memory.

2.3.11 Manual Access

An operator at the control unit, having a proper access level, must have the capability to manually access the following information for each initiating device.

a. Primary status.

b. Device type.

c. Present average value.

d. Present sensitivity selected.

e. Detector range (normal, dirty).

2.4 LOCAL OPERATING CONSOLES (LOC)

2.4.1 General

The LOC must consist of a remote microphone station incorporating a

push-to-talk (PTT) hand-held microphone and system status indicators. The LOC must have the capability of being utilized to activate prerecorded messages. The unit must incorporate microphone override of any tone generation or recorded messages. The unit must be fully supervised from the FMCU. The housing for the LOC must not be lockable.

2.4.2 Multiple LOCs

When an installation has more than one LOC, the LOCs must be programmed to allow only one LOC to be available for paging or messaging at a time. Once one LOC becomes active, all other LOC's will have an indication that the system is busy (Amber Busy Light) and cannot be used at that time. This is to avoid two messages being given at the same time. It must be possible to override or lockout the LOC's from the FMCU.

2.5 AMPLIFIERS, PREAMPLIFIERS, TONE GENERATORS

Any amplifiers, preamplifiers, tone generators, digitalized voice generators, and other hardware necessary for a complete, operational, textual audible circuit conforming to NFPA 72 must be housed in a remote FMCU, terminal cabinet, or in the FMCU. Individual amplifiers must be 100 watts maximum.

2.5.1 Operation

The system must automatically operate and control all building speakers.

2.5.2 Construction

Amplifiers must utilize computer grade components and must be provided with output protection devices sufficient to protect the amplifier against any transient up to 10 times the highest rated voltage in the system.

2.5.3 Inputs

Equip each system with separate inputs for the tone generator, digitalized voice driver and control unit mounted microphone . Microphone inputs must be of the low impedance, balanced line type. Both microphone and tone generator input must be operational on any amplifier.

2.5.4 Tone Generator

The tone generator must produce a three-pulse temporal pattern and must be constantly repeated until interrupted by either the digitalized voice message, the microphone input, or the alarm silence mode as specified. The tone generator must be single channel with an automatic backup generator per channel such that failure of the primary tone generator causes the backup generator to automatically take over the functions of the failed unit and also causes transfer of the common trouble relay. The tone generator must be provided with securely attached labels to identify the component as a tone generator and to identify the specific tone it produces. Systems that integrate the temporal-three pattern into the pre-recorded mass notification messages are acceptable and do not require the use of a tone generator.

2.5.5 Protection Circuits

Each amplifier must be constantly supervised for any condition that could render the amplifier inoperable at its maximum output. Failure of any

component must cause illumination of a visual "amplifier trouble" indicator on the control unit, appropriate logging of the condition in the history log, and other actions for trouble conditions as specified.

2.6 MANUAL STATIONS

Provide metal or plastic, surface mounted,double-action, addressable manual stations, that are not subject to operation by jarring or vibration. Stations must be equipped with screw terminals for each conductor. Stations that require the replacement of any portion of the device after activation are not permitted. Stations must be finished in red with molded raised lettering operating instructions of contrasting color. The use of a key must be required to reset the station.

2.7 SMOKE DETECTORS

2.7.1 Spot Type Detectors

Provide addressable photoelectric smoke detectors as follows:

a. Provide analog/addressable photoelectric smoke detectors utilizing the photoelectric light scattering principle for operation in accordance with UL 268. Smoke detectors must be listed for use with the FMCU.

b. Provide self-restoring type detectors that do not require any readjustment after actuation at the FMCU to restore them to normal operation. The detector must have a visual indicator to show actuation.

c. Vibration must have no effect on the detector's operation. Protect the detection chamber with a fine mesh metallic screen that prevents the entrance of insects or airborne materials. The screen must not inhibit the movement of smoke particles into the chamber.

d. Provide twist lock bases with screw terminals for each conductor. The detectors must maintain contact with their bases without the use of springs.

e. The detector address must identify the particular unit, its location within the system. Detectors must be of the low voltage type rated for use on a 24 VDC system.

2.7.2 Duct Smoke Detectors

Duct-mounted addressable photoelectric smoke detectors must consist of a smoke detector, as specified in paragraph Spot Type Detectors, mounted in a special housing fitted with duct sampling tubes. Detector circuitry must be mounted in a metallic or plastic enclosure exterior to the duct. Detectors must be listed for operation over the complete range of air velocities, temperature and humidity expected at the detector when the air-handling system is operating. Detectors must be powered from the FMCU.

a. Sampling tubes must run the full width of the duct. The duct detector package must conform to the requirements of NFPA 90A, UL 268A, and must be listed for use in air-handling systems. The control functions, operation, reset, and bypass must be controlled from the FMCU.

b. Lights to indicate the operation and alarm condition must be visible

and accessible with the unit installed and the cover in place. Remote indicators must be provided where required by NFPA 72. Remote indicators as well as the affected fan units must be properly identified in etched plastic placards.

c. Detectors must provide for control of auxiliary contacts that provide control, interlock, and shutdown functions specified in Section 23 09 00 to INSTRUMENTATION AND CONTROL FOR HVAC. Auxiliary contacts provide for this function must be located within 3 feet of the controlled circuit or appliance. The auxiliary contacts must be supplied by the fire alarm system manufacturer to ensure complete system compatibility.

2.8 AIR SAMPLING SMOKE DETECTION SYSTEM

The air sampling smoke system must consist of a detector assembly housing an integral aspiration fan, filter, laser-based detection chamber and control, output and supervision circuitry. The system must consist of a piping or tubing distribution network that runs from the detector assembly(s) to the protected area(s) and is supported by air sampling smoke detection system calculations from a computer-based design modeling tool. The system must include configurable alarm and trouble relay outputs for interface to other systems where required.

a. System must be complete in all ways. It must include all engineering, and electrical installation, all detection and control equipment, auxiliary devices and controls, alarm interface, functional checkout and testing, training and all other operations necessary for a functional system.

b. System base detectors and modules must each accommodate up to 40 addressable microbore sampling tubes where each tube has a sampling point at the end. Additional modules may be used to provide up to 20 addressable sampling holes per system.

c. Program alarm thresholds to the following values unless the results of the pre-Government system tests indicate a clear need to change them. In the event that such a need is indicated, notify the Contracting Officer and provide complete documentation concerning the need to deviate from these values. Include within the deviation documentation request, information that complies with the paragraph entitled "Sensitivity Verification Test". Ensure initial threshold levels are approved prior to the Government test.

(1) Alert Level 1: set ALERT at 0.20 percent obscuration/foot

(2) Alarm Level 2: set ALARM at 1.000 percent obscuration/foot

d. All air sampling smoke detection devices and associated components must be new, standard products or the manufacturer's latest design and suitable to perform the functions intended.

e. The laser detection chamber must be of the mass light scattering type and capable of detecting a wide range of smoke particle types of varying size. A particle counting method must be employed for the purposes of:

(1) Preventing large particles from affecting the true smoke reading.

(2) Monitoring contamination of the filter (for example, dust and dirt) to automatically notify when maintenance is required. The particle counting method must not be used for the purpose of smoke density measurement.

f. Detector(s) must be self-monitoring for filter contamination and provide indication through system fault when replacement is necessary. Detectors which allow automatic reset of filter status upon removal and re-insertion are not permitted.

g. Detector(s) must contain relays for alarm and fault conditions. The relays must be software programmable to the required functions.

h. Detector(s) must permit configuration by programmers that are either integral to the system, portable or PC based.

i. Detector(s) must allow programming of:

(1) Smoke threshold alarm levels; ALERT, ALARM.

(2) Faults, including airflow, detector, power, filter and network, as well as an indication of the urgency of the fault.

(3) Configuration of relay outputs for remote indication of alarm and fault conditions.

(4) General purpose input functionality.

2.9 LOW TEMPERATURE SENSOR

Provide listed supervisory air temperature switch for sprinkler riser room. Switch must cause a supervisory signal to be transmitted to the FMCU whenever the temperature in the room drops to below 40 degrees F. Device must reset when temperature rises above 40 degrees F.

2.10 ADDRESSABLE INTERFACE DEVICES

The initiating device being monitored must be configured as a Class "B" initiating device circuits. The module must be listed as compatible with the control unit. The module must provide address setting means compatible with the control unit's SLC supervision and store an internal identifying code. Monitor module must contain an integral LED that flashes each time the monitor module is polled and is visible through the device cover plate. Pull stations with a monitor module in a common backbox are not required to have an LED. Modules must be listed for the environmental conditions in which they will be installed.

2.11 ADDRESSABLE CONTROL MODULES

The control module must be capable of operating as a relay (dry contact form C) for interfacing the control unit with other systems, and to control door holders or initiate elevator fire service. The module must be listed as compatible with the control unit. The indicating device or the external load being controlled must be configured as Class B notification appliance circuits. The system must be capable of supervising, audible, visual and dry contact circuits. The control module must have both an input and output address. The supervision must detect a short on the supervised circuit and must prevent power from being applied to the circuit. The control module must provide address setting means

compatible with the control unit's SLC supervision and store an internal identifying code. The control module must contain an integral LED that flashes each time the control module is polled and is visible through the device cover plate. Control Modules must be listed for the environmental conditions in which they will be installed.

2.12 ISOLATION MODULES

a. Provide isolation modules to subdivide each signaling line circuit in accordance with NFPA 72 between adjacent isolation modules.

b. Isolation modules must provide short circuit isolation for signaling line circuit wiring.

c. Power and communications must be supplied by the SLC and must report faults to the FMCU.

d. After the wiring fault is repaired, the fault isolation modules must test the lines and automatically restore the connection.

2.13 NOTIFICATION APPLIANCES

2.13.1 Audible Notification Appliances

Audible appliances must conform to the applicable requirements of UL 464. Appliances must be connected into notification appliance circuits. Surface mounted audible appliances must be painted white. Recessed audible appliances must be installed with a grill and faceplate that is painted white.

2.13.1.1 Speakers

a. Speakers must conform to the applicable requirements of UL 1480. Speakers must have six different sound output levels and operate with audio line input levels of 70.7 VRMs and 25 VRMs, by means of selectable tap settings. Interior speaker tap settings must include taps of 1/4, 1/2, 1, and 2 watt, at a minimum. Exterior speakers must also be multi-tapped with no more than 15 watt maximum setting. Speakers must incorporate a high efficiency speaker for maximum output at minimum power across a frequency range of 400 Hz to 4,000 Hz, and must have a sealed back construction. Speakers must be capable of installation on standard 4-inch square electrical boxes. Where speakers and strobes are provided in the same location, they may be combined into a single unit. All inputs must be polarized for compatibility with standard reverse polarity supervision of circuit wiring via the FMCU.

b. Provide speaker mounting plates constructed of cold rolled steel having a minimum thickness of 16 gage or molded high impact plastic and equipped with mounting holes and other openings as needed for a complete installation. Fabrication marks and holes must be ground and finished to provide a smooth and neat appearance for each plate. Each plate must be primed and painted.

c. Speakers must utilize screw terminals for termination of all field wiring.

2.13.2 Visual Notification Appliances

Visual notification appliances must conform to the applicable requirements of UL 1638, UL 1971 and conform to the Architectural Barriers Act (ABA). Visual Notification Appliances must have clear high intensity optic lens, xenon flash tubes, or light emitting diode (LED) and be marked "Alert" in red letters. The light pattern must be dispersed so that it is visible above and below the strobe and from a 90 degree angle on both sides of the strobe. Strobe flash rate must be 1 flash per second. Strobe must be surface mounted.

2.13.3 Textual Display Signs

Textual display signs must be LED and must not exceed 38 inches long by 8 inches high by 4 inches deep with a height necessary to meet the requirements of NFPA 72. The text display must be compatible with the FMCU to display messaging to match audible notification without the need for an external controller.

2.14 ELECTRIC POWER

2.14.1 Primary Power

Power must be 120 VAC 60 Hz service for the FMCU from the AC service to the building in accordance with NFPA 72.

2.15 SECONDARY POWER SUPPLY

Provide for system operation in the event of primary power source failure. Transfer from normal to auxiliary (secondary) power or restoration from auxiliary to normal power must be automatic and must not cause transmission of a false alarm.

2.15.1 Batteries

Provide sealed, maintenance-free, sealed lead acid batteries as the source for emergency power to the FMCU. Batteries must contain suspended electrolyte. The battery system must be maintained in a fully charged condition by means of a battery charger. Provide an automatic transfer switch to transfer the load to the batteries in the event of the failure of primary power.

2.15.1.1 Capacity

Battery size must be the greater of the following two capacities. This capacity applies to every control unit associated with this system, including supplemental notification appliance circuit panels, auxiliary power supply panels, fire alarm transmitters, and Base-wide mass notification transceivers. When determining the required capacity under alarm condition, visual notification appliances must include both textual and non-textual type appliances.

a. Sufficient capacity to operate the fire alarm system under supervisory and trouble conditions, including audible trouble signal devices for 48 hours and audible and visual signal devices under alarm conditions for an additional 15 minutes.

b. Sufficient capacity to operate the mass notification for 60 minutes after loss of AC power.

2.15.1.2 Battery Power Calculations

a. Verify that battery capacity exceeds supervisory and alarm power requirements for the criteria noted in the paragraph "Capacity" above.

(1) Substantiate the battery calculations for alarm and supervisory power requirements. Include ampere-hour requirements for each system component and each control unit component, and compliance with UL 864.

(2) Provide complete battery calculations for both the alarm and supervisory power requirements. Submit ampere-hour requirements for each system component with the calculations.

(3) Provide voltage drop calculations to indicate that sufficient voltage is available for proper operation of the system and all components. Calculations must be performed using the minimum rated voltage of each component.

b. For battery calculations assume a starting voltage of 24 VDC for starting the calculations to size the batteries. Calculate the required Amp-Hours for the specified standby time, and then calculate the required Amp-Hours for the specified alarm time. Using 20.4 VDC as starting voltage, perform a voltage drop calculation for circuits containing devices or appliances remote from the power sources.

2.15.2 Battery Chargers

Provide a fully automatic, variable charging rate battery charger. The charger must be capable of providing 120 percent of the connected system load and must maintain the batteries at full charge. In the event the batteries are fully discharged (20.4 Volts dc), the charger must recharge the batteries back to 95 percent of full charge within 48 hours after a single discharge cycle as described in paragraph CAPACITY above. Provide pilot light to indicate when batteries are manually placed on a high rate of charge as part of the unit assembly if a high rate switch is provided.

2.16 SURGE PROTECTIVE DEVICES

Surge protective devices must be provided to suppress all voltage transients which might damage fire alarm control unit components. Systems having circuits located outdoors, communications equipment must be protected against surges induced on any signaling line circuit. Cables and conductors, that serve as communications links, must have surge protection circuits installed at each end. The surge protective device must wire in series to the power supply of the protected equipment with screw terminations. Line voltage surge arrestor must be installed directly adjacent to the power panel where the FMCU breaker is located.

a. Surge protective devices for nominal 120 VAC must be UL 1449 listed with a maximum 500 volt suppression level and have a maximum response time of 5 nanoseconds. The surge protective device must also meet IEEE C62.41.1 and IEEE C62.41.2 category B tests for surge capacity. The surge protective device must feature multi-stage construction and be provided with a long-life indicator lamp (either light emitting diode or neon) which extinguishes upon failure of protected components. Any unit fusing must be externally accessible.

b. Surge protective devices for nominal 24 VAC, fire alarm telephone dialer, or ethernet connection must be UL 497B listed, meet IEEE C62.41.1 and have a maximum response time of 1-nanosecond. The surge protective device must feature multi-stage construction and be self-resetting. The surge protective device must be a base and plug style. The base assembly must have screw terminals for fire alarm wiring. The base assembly must accept "plug-in" surge protective module.

c. All surge protective devices (SPD) must be the standard product of a single manufacturer and be equal or better than the following:

(1) For 120 VAC nominal line voltage: UL 1449 and UL 1283 listed, series connected 120 VAC, 20A rated, surge protective device in a NEMA 4x enclosure. Minimum 50,000 amp surge current rating with EMI/RFI filtering and a dry contact circuit for remote monitoring of surge protection status.

(2) For 24-volt nominal line voltage: UL 497B listed, series connected low voltage, 24-volt, 5A rated, loop circuit protector, base and replaceable module.

2.17 WIRING

Provide wiring materials under this section as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM with the additions and modifications specified herein.

2.17.1 Alarm Wiring

IDC and SLC wiring must be fiber optic or solid copper cable as indicated on the drawings and in accordance with the manufacturers requirements. Copper signaling line circuits and initiating device circuit field wiring must be No. 16 AWG size conductors at a minimum. Visual notification appliance circuit conductors, that contain audible alarm appliances, must be copper No. 16 AWG size conductors at a minimum. Speaker circuits must be copper No. 16 AWG size twisted and shielded conductors at a minimum. Wiring for textual notification appliance circuits must be in accordance with manufacturer's requirements but must be supervised by the FMCU. Wire size must be sufficient to prevent voltage drop problems. Circuits operating at 24 VDC must not operate at less than the listed voltages for the detectors and appliances. Power wiring, operating at 120 VAC minimum, must be a minimum No. 12 AWG solid copper having similar insulation. Acceptable power-limited cables are FPL, FPLR or FPLP as appropriate with red colored covering. Nonpower-limited cables must comply with NFPA 70.

2.18 INTERFACE TO THE BASE-WIDE MASS NOTIFICATION NETWORK

Provide fire alarm/mass notification control unit designed to allow for interface with a wide area MNS.2.19 AUTOMATIC FIRE ALARM TRANSMITTERS

2.19.1 Radio Transmitter and Interface Panels

Transmitters must be compatible with the existing proprietary supervising station receiving equipment. Each radio alarm transmitter must be the manufacturer's recognized commercial product, completely assembled, wired, factory tested, and delivered ready for installation and operation. Transmitters must be provided in accordance with applicable portions of

NFPA 72, Federal Communications Commission (FCC) 47 CFR 90 and Federal Communications Commission (FCC) 47 CFR 15. Transmitter electronics module must be contained within the physical housing as an integral, removable assembly. The proprietary supervising station receiving equipment is Monaco and the transmitter must be fully compatible with this equipment. At the contractors option, and if listed, the transmitter may be housed in the same control unit as the FMCU. The transmitter must be narrowband radio, with FCC certification for narrowband operation and meets the requirements of the NTIA (National Telecommunications and Information Administration) Manual of Regulations and Procedures for Federal Frequency Management.

2.19.1.1 Operation

Operate each transmitter from 120-volt ac power. In the event of 120-volt ac power loss, the transmitter must automatically switch to battery operation. Switchover must be accomplished with no interruption of protective service, and must automatically transmit a trouble message. Upon restoration of ac power, transfer back to normal ac power supply must also be automatic.

2.19.1.2 Battery Power

Transmitter standby battery capacity must provide sufficient power to operate the transmitter in a normal standby status for a minimum of 72 hours and be capable of transmitting alarms during that period.

2.19.1.3 Transmitter Housing

Use NEMA Type 1 for housing. The housing must contain a lock that is keyed identical to radio alarm transmitter housings on the Installation. Radio alarm transmitter housing must be factory painted with a suitable priming coat and not less than two coats of a hard, durable weatherproof enamel.

2.19.1.4 Antenna

Antenna must be omnidirectional, coaxial, halfwave dipole antennas for radio alarm transmitters with a driving point impedance to match transmitter output. The antenna and antenna mounts must be corrosion resistant and designed to withstand wind velocities of 100 mph. Do not mount antennas to any portion of the building roofing system. Protect the antenna from physical damage.

2.19.2 Signals to Be Transmitted to the Base Receiving Station

The following signals must be sent to the base receiving station:

a. Sprinkler waterflow

b. Manual pull stations

c. Smoke detectors

d. Duct smoke detectors

e. Common supervisory

f. Common trouble

2.20 SYSTEM MONITORING

2.20.1 Valves

Each valve affecting the proper operation of a fire protection system, including automatic sprinkler control valves, sprinkler service entrance valve, isolating valves for pressure type waterflow or supervision switches, and valves at backflow preventers, whether supplied under this contract or existing, must be electrically monitored to ensure its proper position. Provide each tamper switch with a separate address.

PART 3 EXECUTION

3.1 VERIFYING ACTUAL FIELD CONDITIONS

Before commencing work, examine all adjoining work on which the contractor's work is in any way dependent for perfect workmanship according to the intent of this specification section, and report to the Contracting Officer's Representative any condition which prevents performance of first class work. No "waiver of responsibility" for incomplete, inadequate or defective adjoining work will be considered unless notice has been filed before submittal of a proposal.

3.2 INSTALLATION

3.2.1 Fire Alarm and Mass Notification Control Unit (FMCU)

Locate the FMCU where indicated on the drawings. Surface mount the enclosure with the top of the cabinet 6 feet above the finished floor or center the cabinet at 5 feet, whichever is lower. Conductor terminations must be labeled and a drawing containing conductors, their labels, their circuits, and their interconnection must be permanently mounted in the FMCU. Locate the document storage cabinet adjacent to the FMCU unless the Contracting Officer directs otherwise.

3.2.2 Battery Cabinets

When batteries will not fit in the FMCU, locate battery cabinets below or adjacent to the FMCU. Battery cabinets must be installed at an accessible location when standing at floor level. Battery cabinets must not be installed lower than 12 inches above finished floor, measured to the bottom of the cabinet, nor higher than 36 inches above the floor, measured to the top of the cabinet. Installing batteries above drop ceilings or in inaccessible locations is prohibited. Battery cabinets must be large enough to accommodate batteries and also to allow ample gutter space for interconnection of control units as well as field wiring. The cabinet must be provided in a sturdy steel housing, complete with back box, hinged steel door with cylinder lock, and surface mounting provisions.The cabinet must be identified by an engraved phenolic resin nameplate. Lettering on the nameplate must indicate the control unit(s) the batteries power and must not be less than 1-inch high.

3.2.3 Manual Stations

Locate manual stations as required by NFPA 72 and as indicated on the drawings. Mount stations so they are located no farther than 5 feet from the exit door they serve, measured horizontally. Manual stations must be mounted at 42 inches measured to the operating handle.

3.2.4 Notification Appliances

a. Locate notification appliance devices as required by NFPA 72 and to meet the intelligibility requirements. Where two or more visual notification appliances are located in the same room or corridor or field of view, provide synchronized operation. Devices must use screw terminals for all field wiring. Audible and visual notification appliances mounted in acoustical ceiling tiles must be centered in the tiles plus or minus 2 inches.

b. Audible and visual notification appliances mounted on the exterior of the building, within unconditioned spaces, or in the vicinity of showers must be listed weatherproof appliances installed on weatherproof backboxes.

c. Speakers must not be located in close proximity to the FMCU or LOC so as to cause feedback when the microphone is in use.

3.2.5 Smoke and Heat Detectors

Locate detectors as required by NFPA 72 and their listing on a 4-inch mounting box. Install heat detectors not less than 4 inches from a side wall to the near edge. Heat detectors located on the wall must have the top of the detector at least 4 inches below the ceiling, but not more than 12 inches below the ceiling. Smoke detectors are permitted to be on the wall no lower than 12 inches from the ceiling with no minimum distance from the ceiling. Install smoke detectors no closer than 3 feet from air handling supply diffusers. Detectors installed in acoustical ceiling tiles must be centered in the tiles plus or minus 2 inches.

3.2.6 Air Sampling Smoke Detector

Locate air sampling smoke detectors in accordance with the manufacturer's instructions. Air sampling smoke detectors must be installed as follows:

a. Air Sampling Smoke Detector Assembly:

(1) Detector assembly must be mounted to a wall at a height between 48 to 60 inches to top of detector measured above the finished floor.

(2) Mounting must be in a fully accessible and visible location.

(3) Mounting or attachment to site equipment, cable trays, movable walls, other equipment or equipment supports is not permitted.

(4) Piping network insertion into the detector inlet must not be glued.

(5) Air sampling smoke detector assembly must be installed in accordance with this specification section and the manufacturer's installation and instruction manuals.

(6) Flexible tubing for termination of the sampling pipe network into detector inlet is not permitted unless allowed by its listing.

(7) Provide red background with white lettering labels that are plastic or phenolic type with a minimum of 0.25-inch block

lettering to indicate detector and zone. For example: "AIR SAMPLING SOME DETECTOR No. 1-1 No. 5".

(8) Provide a typeset printed or typewritten instruction card mounted behind a Lexan plastic or glass cover in a stainless steel or aluminum frame. Install the frame in a conspicuous location observable from the ASD panel. The card must show those steps to be taken by an operator when a signal is received as well as the functional operation of the system under all conditions, normal, alarm, supervisory, and trouble. The instructions must be approved by the Contracting Officer before being posted.

b. Pipe and Sampling Tube Mounting:

(1) The pipe and sampling tubing detection network must be mounted as per the design and manufacturer's specification. The hardware used for mounting will depend upon the design and site requirements.

(2) To minimize flexing, pipes must be secured every 5 feet.

(3) Pipes must be suspended between 1 and 4 inches below the ceiling. In areas with a suspended ceiling, the pipe network must be installed above the ceiling utilizing the manufacturer's capillary sample port supported by the ceiling.

(4) The sampling tubes must be of the same length or use the manufacturer's guidelines to run tubes of the required lengths.

(5) When installing a pipe network in areas subject to high temperature fluctuations allow for the contraction and expansion of pipes.

(6) Where expansion or contraction of pipes is likely either after installation or on a continuous basis, do not place pipe clips adjacent to couplings and socket unions as these may interfere with the movement of the pipe.

(7) No bends are permitted within the first 18 inches from the detector inlet.

(8) The routing of the piping and sample tube network must be coordinated with potential obstructions, including cable trays, grounding bars, and HVAC ductwork.

(9) All changes in direction must be made with standard elbows or tees.

(10) All joints must be air-tight and made by using solvent cement, except at the entry to the detector assembly. Refer to ASTM F402.

(11) All pipes must be supported by mechanical hangers attached to the structure of the building. Not more than 1-foot of pipe must extend beyond the last hanger of each sampling pipe. The final installation must result in no noticeable deflection in the piping network.

(12) Attachment of air sampling pipes to cable trays, "gray iron", and telecommunications equipment is prohibited.

(13) Clearly label pipe network to distinguish the pipe from other facility pipe work or protective cabling enclosures. For example: "SMOKE DETECTION SAMPLING TUBE - DO NOT DISTURB". In open rooms and exposed areas, provide labels at no greater than 20-foot intervals. Provide labels every 10 feet where piping is installed above suspended ceilings and every 2 feet, centered in the floor panels, where piping is installed within the raised floor cavity.

(14) Placement of the sampling tube must take into consideration appropriate sampling point locations and spacing.

c. Air Sampling Points:

(1) Open area ceiling sampling points must be oriented downward and must be within 1 to 4 inches below the underside of the ceiling above where the ceiling is smooth.

(2) Label all air sampling points with a round red label, each with a center hole to match the diameter of the drilled sampling point. For example: "AIR SAMPLING POINT DIA 0.125 INCHES". Indicate fractional dimensions in decimal format with a minimum of three decimal places.

(3) Additional air sampling points must be provided at the return side of the in row CRAC units and return side of AHUs leaving the space as recommended by the manufacturer.

3.2.7 Local Operating Console (LOC)

Locate the LOC(s) as required by NFPA 72 and as indicated. Mount the console so that the top message button and microphone is no higher than 4 feet above the floor and the bottom (lowest) message button and microphone is at least 3 feet above the finished floor.

3.2.8 Ceiling Bridges

Provide ceiling bridges for ceiling-mounted appliances. Ceiling bridges must be as recommended/required by the manufacturer of the ceiling-mounted notification appliance.

3.3 SYSTEM FIELD WIRING

3.3.1 Wiring within Cabinets, Enclosures, and Boxes

Provide wiring installed in a neat and professional manner and installed parallel with or at right angles to the sides and back of any box, enclosure, or cabinet. Conductors that are terminated, spliced, or otherwise interrupted in any enclosure, cabinet, mounting, or junction box must be connected to screw-type terminal blocks. Mark each terminal in accordance with the wiring diagrams of the system. The use of wire nuts or similar devices is prohibited. Wiring to conform with NFPA 70.

Indicate the following in the wiring diagrams:

a. Point-to-point wiring diagrams showing the points of connection and terminals used for electrical field connections in the system, including interconnections between the equipment or systems that are

supervised or controlled by the system. Diagrams must show connections from field devices to the FMCU and remote fire alarm/mass notification control units, initiating circuits, switches, relays and terminals.

b. Complete riser diagrams indicating the wiring sequence of devices and their connections to the control equipment. Include a color code schedule for the wiring. Include floor plans showing the locations of devices and equipment.

3.3.2 Terminal Cabinets

Provide a terminal cabinet at the base of any circuit riser, on each floor at each riser, and where indicated on the drawings. Terminal size must be appropriate for the size of the wiring to be connected. Conductor terminations must be labeled and a drawing containing conductors, their labels, their circuits, and their interconnection must be permanently mounted in the terminal cabinet. Minimum size is 8 inches by 8 inches. Only screw-type terminals are permitted. Provide an identification label, that displays "FIRE ALARM TERMINAL CABINET" with 2-inch lettering, on the front of the terminal cabinet.

3.3.3 Alarm Wiring

a. Voltages must not be mixed in any junction box, housing or device, except those containing power supplies and control relays.

b. Utilize shielded wiring where recommended by the manufacturer. For shielded wiring, ground the shield at only one point, in or adjacent to the FMCU.

c. T-tapping using screw terminal blocks is allowed for Class "B" signaling line circuits.

d. Color coding is required for circuits and must be maintained throughout the circuit. Conductors used for the same functions must be similarly color coded. Conform wiring to NFPA 70.

e. Pull all conductors splice free. The use of wire nuts, crimped connectors, or twisting of conductors is prohibited. Where splices are unavoidable, the location of the junction box or pull box where they occur must be identified on the as-built drawings. The number and location of splices must be subject to approval by the Designated Fire Protection Engineer (DFPE).

3.3.4 Back Boxes and Conduit

In addition to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, provide all wiring in rigid metal conduit or intermediate metal conduit unless specifically indicated otherwise. Minimum conduit size must be 3/4-inch in diameter. Do not use electrical non-metallic tubing (ENT) or flexible non-metallic tubing and associated fittings.

a. Galvanized rigid steel (GRS) conduit must be utilized where exposed to weather, where subject to physical damage, and where exposed on exterior of buildings. Intermediate metal conduit (IMC) may be used in lieu of GRS as allowed by NFPA 70. GRS or IMC must be used for fiber optic cable between FMCUs.

b. Electrical metallic tubing (EMT) is permitted above suspended ceilings or exposed where not subject to physical damage. Do not use EMT underground, encased in concrete, mortar, or grout, in hazardous locations, where exposed to physical damage, outdoors or in fire pump rooms. Use die-cast compression connectors.

c. For rigid metallic conduit (RMC), only threaded type fitting are permitted for wet or damp locations.

d. Flexible metal conduit is permitted for initiating device circuits, notification appliance circuits and signaling line circuits 6 feet in length or less. Use liquid tight flexible metal conduit in damp and wet locations.

e. Schedule 40 (minimum) polyvinyl chloride (PVC) is permitted where conduit is routed underground or underground below floor slabs. Convert non-metallic conduit, other than PVC Schedule 40 or 80, to plastic-coated rigid, or IMC, steel conduit before turning up through floor slab.

f. Exterior wall penetrations must be weathertight. Conduit must be sealed to prevent the infiltration of moisture.

3.3.5 Conductor Terminations

Labeling of conductors at terminal blocks in terminal cabinets, FMCU, and remote FMCU and the LOC must be provided at each conductor connection. Each conductor or cable must have a shrink-wrap label to provide a unique and specific designation. Each terminal cabinet, FMCU, and remote FMCU must contain a laminated drawing that indicates each conductor, its label, circuit, and terminal. The laminated drawing must be neat, using 12 point lettering minimum size, and mounted within each cabinet, control unit, or unit so that it does not interfere with the wiring or terminals. Maintain existing color code scheme where connecting to existing equipment.

3.4 FIRESTOPPING

Provide firestopping for holes at conduit penetrations through floor slabs, fire-rated walls, partitions with fire-rated doors, corridor walls, and vertical service shafts in accordance with Section 07 84 00 FIRESTOPPING.

3.5 PAINTING

a. In unfinished areas (including areas above drop ceilings), paint all exposed electrical conduit (serving fire alarm equipment), fire alarm conduit, surface metal raceway, junction boxes and covers red. In lieu of painting conduit, the contractor may utilize red conduit with a factory applied finish.

b. In finished areas, paint exposed electrical conduit (serving fire alarm equipment), fire alarm conduit, surface metal raceways, junction boxes, and electrical boxes to match adjacent finishes. The inside cover of the junction box must be identified as "Fire Alarm" and the conduit must have painted red bands 3/4-inch wide at 10-foot centers and at each side of a floor, wall, or ceiling penetration.

c. Painting must comply with Section 09 90 00 PAINTS AND COATINGS.

3.6 FIELD QUALITY CONTROL

3.6.1 Test Procedures

Submit detailed test procedures, prepared and signed by the NICET Level IV Fire Alarm Technician, and the representative of the installing company, 60 days prior to performing system tests. Detailed test procedures must list all components of the installed system such as initiating devices and circuits, notification appliances and circuits, signaling line devices and circuits, control devices/equipment, batteries, transmitting and receiving equipment, power sources/supply, annunciators, special hazard equipment, emergency communication equipment, interface equipment, and surge protective devices. Test procedures must include sequence of testing, time estimate for each test, and sample test data forms. The test data forms must be in a check-off format (pass/fail with space to add applicable test data; similar to the forms in NFPA 72 and NFPA 4.) The test procedures and accompanying test data forms must be used for the pre-Government testing and the Government testing. The test data forms must record the test results and must:

a. Identify the NFPA Class of all Initiating Device Circuits (IDC), and Notification Appliance Circuits (NAC), Voice Notification System Circuits (NAC Audio), and Signaling Line Circuits (SLC).

b. Identify each test required by NFPA 72 Test Methods and required test herein to be performed on each component, and describe how these tests must be performed.

c. Identify each component and circuit as to type, location within the facility, and unique identity within the installed system. Provide necessary floor plan sheets showing each component location, test location, and alphanumeric identity.

d. Identify all test equipment and personnel required to perform each test including equipment necessary for smoke detector testing. The use of magnets is not permitted.

e. Provide space to identify the date and time of each test. Provide space to identify the names and signatures of the individuals conducting and witnessing each test.

3.6.2 Pre-Government Testing

3.6.2.1 Verification of Compliant Installation

Conduct inspections and tests to ensure that devices and circuits are functioning properly. Tests must meet the requirements of paragraph entitled "Minimum System Tests" as required by NFPA 72. The contractor and an authorized representative from each supplier of equipment must be in attendance at the pre-Government testing to make necessary adjustments. After inspection and testing is complete, provide a signed Verification of Compliant Installation letter by the QFPE that the installation is complete, compliant with the specification and fully operable. The letter must include the names and titles of the witnesses to the pre-Government tests. Provide all completion documentation as required by NFPA 72 including all referenced annex sections and the test reports noted below.

a. NFPA 72 Record of Completion.

b. NFPA 72 Record of Inspection and Testing.

c. Fire Alarm and Emergency Communication System Inspection and Testing Form.

d. Audibility test results with marked-up test floor plans.

e. Intelligibility test results with marked-up floor plans.

f. Documentation that all tests identified in the paragraph "Minimum System Tests" are complete.

3.6.2.2 Request for Government Final Test

When the verification of compliant installation has been completed, submit a formal request for Government final test to the Designated Fire Protection Engineer (DFPE). Government final testing will not be scheduled until the DFPE has received copies of the request for Government final testing and Verification of Compliant Installation letter with all required reports. Government final testing will not be performed until after the connections to the installation-wide fire reporting system and the installation-wide mass notification system have been completed and tested to confirm communications are fully functional. Submit request for test at least 15 calendar days prior to the requested test date.

3.6.3 Correction of Deficiencies

If equipment was found to be defective or non-compliant with contract requirements, perform corrective actions and repeat the tests. Tests must be conducted and repeated if necessary until the system has been demonstrated to comply with all contract requirements.

3.6.4 Government Final Tests

The tests must be performed in accordance with the approved test procedures in the presence of the DFPE. Furnish instruments and personnel required for the tests. The following must be provided at the job site for Government Final Testing:

a. The manufacturer's technical representative.

b. The contractor's Qualified Fire Protection Engineer (QFPE).

c. Marked-up red line drawings of the system as actually installed.

d. Loop resistance test results.

e. Complete program printout including input/output addresses.

f. Copy of pre-Government Test Certificate, test procedures and completed test data forms.

g. Audibility test results with marked-up floor plans.

h. Intelligibility test results with marked-up floor plans.

Government Final Tests will be witnessed by the Qualified Fire Protection Engineer (QFPE). At this time, any and all required tests noted in the

paragraph "Minimum System Tests" must be repeated at their discretion.

3.7 MINIMUM SYSTEM TESTS

3.7.1 System Tests

Test the system in accordance with the procedures outlined in NFPA 72. The required tests are as follows:

a. Loop Resistance Tests: Measure and record the resistance of each circuit with each pair of conductors in the circuit short-circuited at the farthest point from the circuit origin. The tests must be witnessed by the Contracting Officer and test results recorded for use at the final Government test.

b. Verify the absence of unwanted voltages between circuit conductors and ground. The tests must be accomplished at the pre-Government test with results available at the final system test.

c. Verify that the control unit is in the normal condition as detailed in the manufacturer's O&M manual.

d. Test each initiating device and notification appliance and circuit for proper operation and response at the control unit. Smoke detectors must be tested in accordance with manufacturer's recommended calibrated test method. Use of magnets is prohibited. Testing of duct smoke detectors must comply with the requirements of NFPA 72 except disconnect at least 20 percent of devices. If there is a failure at these devices, then supervision must be tested at each device.

e. Test the system for specified functions in accordance with the contract drawings and specifications and the manufacturer's O&M manual.

f. Test both primary power and secondary power. Verify, by test, the secondary power system is capable of operating the system for the time period and in the manner specified.

g. Determine that the system is operable under trouble conditions as specified.

h. Visually inspect wiring.

i. Test the battery charger and batteries.

j. Verify that software control and data files have been entered or programmed into the FMCU. Hard copy records of the software must be provided to the Contracting Officer.

k. Verify that red-line drawings are accurate.

l. Measure the current in circuits to ensure there is the calculated spare capacity for the circuits.

m. Measure voltage readings for circuits to ensure that voltage drop is not excessive.

n. Disconnect the verification feature for smoke detectors during tests to minimize the amount of smoke needed to activate the sensor. Testing of smoke detectors must be conducted using real smoke or the

use of canned smoke which is permitted.

o. Measure the voltage drop at the most remote appliance (based on wire length) on each notification appliance circuit.

p. Verify the documentation cabinet is installed and contains all as-built shop drawings, product data sheets, design calculations, site-specific software data package, and all documentation required by paragraph titled "Test Reports".

3.7.2 Audibility Tests

Sound pressure levels from audible notification appliances must be a minimum of 15 dBa over ambient with a maximum of 110 dBa in any occupiable area. The provisions for audible notification (audibility and intelligibility) must be met with doors, fire shutters, movable partitions, and similar devices closed.

3.7.3 Intelligibility Tests

Intelligibility testing of the System must be accomplished in accordance with NFPA 72 for Voice Evacuation Systems, and ASA S3.2. Following are the specific requirements for intelligibility tests:

a. Intelligibility Requirements: Verify intelligibility by measurement after installation.

b. Ensure that a CIS value greater than the required minimum value is provided in each area where building occupants typically could be found. The minimum required value for CIS is .8. Rounding of values is permitted such that a value of 0.75 meets the requirement for 0.80.

c. Areas of the building provided with hard wall and ceiling surfaces (such as metal or concrete) that are found to cause excessive sound reflections may be permitted to have a CIS score less than the minimum required value if approved by the DFPE, and if building occupants in these areas can determine that a voice signal is being broadcast and they must walk no more than 33 feet to find a location with at least the minimum required CIS value within the same area.

d. Areas of the building where occupants are not expected to be normally present are permitted to have a CIS score less than the minimum required value if personnel can determine that a voice signal is being broadcast and they must walk no more than 50 feet to a location with at least the minimum required CIS value within the same area.

e. Take measurements near the head level applicable for most personnel in the space under normal conditions (e.g., standing, sitting, sleeping, as appropriate).

f. The distance the occupant must walk to the location meeting the minimum required CIS value must be measured on the floor or other walking surface as follows:

(1) Along the centerline of the natural path of travel, starting from any point subject to occupancy with less than the minimum required CIS value.

(2) Curving around any corners or obstructions, with a 12 inches

clearance there from.

(3) Terminating directly below the location where the minimum required CIS value has been obtained.

Use commercially available test instrumentation to measure intelligibility as specified by NFPA 72 as applicable. Use the mean value of at least three readings to compute the intelligibility score at each test location.

3.8 SYSTEM ACCEPTANCE

Following acceptance of the system, as-built drawings and O&M manuals must be delivered to the Contracting Officer for review and acceptance. The drawings must show the system as installed, including deviations from both the project drawings and the approved shop drawings. These drawings must be submitted within two weeks after the final Government test of the system. At least one set of as-built (marked-up) drawings must be provided at the time of, or prior to the Final Government Test.

a. The drawings must be prepared electronically and sized no less than the contract drawings.

b. Include complete wiring diagrams showing connections between devices and equipment, both factory and field wired.

c. Include a riser diagram and drawings showing the as-built location of devices and equipment.

d. Provide Operation and Maintenance (O&M) Instructions.

3.9 INSTRUCTION OF GOVERNMENT EMPLOYEES

3.9.1 Instructor

Provide the services of an instructor, who has received specific training from the manufacturer for the training of other persons regarding the operation, inspection, testing, and maintenance of the system provided. The instructor must train the Government employees designated by the Contracting Officer, in the care, adjustment, maintenance, and operation of the fire alarm system. The instructor must be thoroughly familiar with all parts of this installation. The instructor must be trained in operating theory as well as in practical O&M work. Submit the instructors information and qualifications including the training history.

3.9.2 Required Instruction Time

Provide 8 hours of instruction after final acceptance of the system. The instruction must be given during regular working hours on such dates and times selected by the Contracting Officer. The instruction may be divided into two or more periods at the discretion of the Contracting Officer. The training must allow for rescheduling for unforeseen maintenance and fire department responses.

3.9.2.1 Technical Training

Equipment manufacturer or a factory representative must provide 1 days of on site. Training must allow for classroom instruction as well as individual hands on programming, troubleshooting and diagnostics exercises.

3.9.3 Technical Training Manual

Provide, in manual format, lesson plans, operating instructions, maintenance procedures, and training data for the training courses. The operations training must familiarize designated government personnel with proper operation of the installed system. The maintenance training course must provide the designated government personnel adequate knowledge required to diagnose, repair, maintain, and expand functions inherent to the system.

3.10 EXTRA MATERIALS

3.10.1 Repair Service/Replacement Parts

Repair services and replacement parts for the system must be available for a period of 10 years after the date of final acceptance of this work by the Contracting Officer. During the warranty period, the service technician must be on-site within 24 hours after notification. All repairs must be completed within 24 hours of arrival on-site.

During the warranty period, the installing fire alarm contractor is responsible for conducting all required testing and maintenance in accordance with the requirements and recommended practices of NFPA 72 and the system manufacturers. Installing fire alarm contractor is NOT responsible for any damage resulting from abuse, misuse, or neglect of equipment by the end user.

3.10.2 Spare Parts

Spare parts furnished must be directly interchangeable with the corresponding components of the installed systems. Spare parts must be suitably packaged and identified by nameplate, tagging, or stamping. Spare parts must be delivered to the Contracting Officer at the time of the Government testing and must be accompanied by an inventory list.

3.10.3 Document Storage Cabinet

Upon completion of the project, but prior to project close-out, place in the document storage cabinet copies of the following record documentation:

a. As-built shop drawings

b. Product data sheets

c. Design calculations

d. Site-specific software data package

e. All documentation required by SD-06.

-- End of Section --

SECTION 31 00 00

EARTHWORK
08/23

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO T 180	(2025) Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C600	(2023) Installation of Ductile-Iron Mains and Their Appurtenances

ASTM INTERNATIONAL (ASTM)

ASTM C33/C33M	(2024a) Standard Specification for Concrete Aggregates
ASTM C117	(2023) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C136/C136M	(2025) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C150/C150M	(2024) Standard Specification for Portland Cement
ASTM C260/C260M	(2024) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C618	(2025a) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C989/C989M	(2025) Standard Specification for Slag Cement for Use in Concrete and Mortars
ASTM D698	(2012; R 2021) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft. (600 kN-m/cu. m.))
ASTM D1140	(2017) Standard Test Methods for Determining the Amount of Material Finer

	than 75-µm (No. 200) Sieve in Soils by Washing
ASTM D1556/D1556M	(2015; E 2016) Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
ASTM D1557	(2012; E 2015) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D2216	(2019) Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D2487	(2017; R 2025) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D4253	(2016; E 2019) Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table
ASTM D4254	(2016) Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density
ASTM D4318	(2017; E 2018) Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D4829	(2021) Standard Test Method for Expansion Index of Soils
ASTM D4832	(2016; E 2018) Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders
ASTM D6023	(2016) Standard Test Method for Density (Unit Weight), Yield, Cement Content, and Air Content (Gravimetric) of Controlled Low-Strength Material (CLSM)
ASTM D6103/D6103M	(2017; E 2021) Standard Test Method for Flow Consistency of Controlled Low Strength Material (CLSM)

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1	(2024) Safety -- Safety and Occupational Health (SOH) Requirements

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA SW-846.3-3	(1999, Third Edition, Update III-A) Test Methods for Evaluating Solid Waste: Physical/Chemical Methods

1.2 DEFINITIONS

1.2.1 Structural Fill

Soil material placed to support buildings, walls, pads, and other similar facilities.

1.2.2 Topsoil

Surface layer of primarily organic soil capable of supporting vegetation growth.

1.2.3 Utility Bedding Material

Fill placed to directly support pipes, conduits, cables, and appurtenant structures. Bedding may also be used to provide a cushion between utilities and bedrock, obstacles, obstructions and other unyielding materials.

1.2.4 Flowable Fill

Fill placed in a plastic or liquid form that flows to near its final placement location with limited assistance and subsequently cures or solidifies to provide a stable or impermeable barrier.

1.2.5 Satisfactory Materials

Satisfactory materials for fill, backfill, and/or any in-situ soils to remain in place comprise any materials classified by ASTM D2487 as GW, GP, GM, GC, SW, SP, SM, SC,ML or combination of these such as SP-SM. Maximum particle size to be no less than 1 inch except for fill material placed outside the influence or footprint of structures, slabs, footings and pavements.

1.2.6 Unsatisfactory Materials

Materials which do not comply with the requirements for satisfactory materials are unsatisfactory. Unsatisfactory materials also include man-made fills; trash; refuse; backfills from previous construction; roots and other organic matter or frozen material. Notify the Contracting Officer when encountering any contaminated materials.

1.2.7 Cohesionless Materials

Cohesionless materials include materials classified in ASTM D2487 as GW, GP, SW, and SP. Materials classified as GM and SM will be identified as cohesionless only when the fines are nonplastic. Perform testing, required for classifying materials, in accordance with ASTM D4318, ASTM C117, ASTM C136/C136M and ASTM D1140.

1.2.8 Cohesive Materials

Cohesive materials include materials classified as GC, SC, ML, CL, MH, and CH. Materials classified as GM and SM will be identified as cohesive only when the fines are plastic. Perform testing, required for classifying materials, in accordance with ASTM D4318, ASTM C117, ASTM C136/C136M and ASTM D1140.

1.2.9 Unstable Material

Unstable materials are too weak to adequately support the utility pipe, conduit, equipment, or appurtenant structure. Satisfactory material may become unstable due to ineffective drainage, dewatering, becoming frozen, excessive loading.

1.2.10 Expansive Soils

Expansive soils are defined as soils that have an expansion index greater than 20 when tested in accordance with ASTM D4829.

1.2.11 Capillary Water Barrier

A layer of clean, poorly graded crushed rock, stone, or natural sand or gravel having a high porosity which is placed beneath a building slab with or without a vapor barrier to cut off the capillary flow of pore water to the area immediately below a slab.

1.2.12 Degree of Compaction (Proctor)

Degree of compaction required, except as noted in the second sentence, is expressed as a percentage of the maximum dry density obtained by the test procedure presented in ASTM D1557 abbreviated as a percent of laboratory maximum dry density. Since ASTM D1557 applies only to soils that have 30 percent or less by weight of their particles retained on the 3/4 inch sieve, express the degree of compaction for material having more than 30 percent by weight of their particles retained on the 3/4 inch sieve as a percentage of the maximum dry density in accordance with AASHTO T 180-21 paragraph 1.5, Note 1.

1.2.13 Degree of Compaction (Relative Density)

Degree of compaction required for soils with less than 5 percent passing the No. 200 sieve, is expressed as a relative percentage of the maximum index density/dry unit weight and minimum index density/dry unit weight, obtained by the test procedures in accordance with ASTM D4253 and ASTM D4254, respectively, abbreviated as a percent of laboratory relative density.

1.2.14 Borrow

Soil brought to the project site from an external location for the purposes of project construction.

1.2.15 Subgrade

Earth materials directly below foundations and directly below granular base materials in building slab and pavement areas including shoulders.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Excavation and Trenching Plan; G

Dewatering Work Plan; G

Disposition of Surplus Materials; G

Preconstruction Meeting; G

SD-03 Product Data

Flowable Fill Mix Design; G

SD-06 Test Reports

Material Test Report; G

Borrow Site Testing; G

Pipe Inspection Report; G

1.4 QUALITY CONTROL

1.4.1 Geotechnical Engineer

Provide a Professional Geotechnical Engineer to provide inspection of excavations and soil/groundwater conditions throughout construction. The Geotechnical Engineer is responsible for performing pre-construction and periodic site visits throughout construction to assess site conditions. The Geotechnical Engineer is responsible for preparing and updating the Excavation and Trenching Plan and Dewatering Work Plan as construction progresses to reflect changing conditions and submit an updated plan if necessary.

1.4.2 Qualified Technician

Provide a Qualified Technician to inspect, monitor, sample, and performing field testing. The technician qualifications need to be one of the following: a current National Institute for Certification in Engineering Technologies (NICET) Level II minimum certification in Construction Materials Testing Soils; a Geologist-in-Training with minimum one-year experience; an Engineer-in-Training with minimum one-year experience; a Registered Geologist; or a Professional Engineer.

1.4.3 Lab Validation

Perform testing by a Corps validated commercial testing laboratory or Contractor established testing laboratory meeting the requirements of Section 01 45 00 (or similar number) entitled QUALITY CONTROL and approved by the Contracting Officer. Submit testing laboratory validation for the testing to be performed. Do not permit work requiring testing until testing facilities have been inspected, Corps validated and approved by the Contracting Officer.

1.4.4 Preconstruction Meeting

Conduct a preconstruction meeting at the jobsite at least five business days prior to the start of earthwork operations on the project. The preconstruction meeting is to be arranged by the Contractor and is to follow the written agenda submitted prior to the meeting. The purpose of

this meeting is to review the requirements of this specification and the associated plans. The following individuals must be in attendance at this meeting: Contractor's Project Manager and Project Superintendent, earthwork subcontractor's Project Manager and Site Foreman, Contractor's Geotechnical Engineer and Testing Agency, Government Geotechnical Engineer and Civil Engineer, and Government Construction Manager and Engineering Technician.

The minutes of this meeting are to be recorded by the Contractor and published via email within 48 hours to all attendees. The minutes must be re-published within 48 hours via email pending any subsequent comments from the attendees.

PART 2 PRODUCTS

2.1 SOIL MATERIALS

2.1.1 Structural Non-Frost Susceptible Fill

Materials classified as clean, coarse gravel, GW or GP in accordance with ASTM D2487 with less than 6 percent passing #200 sieve to ensure a non-frost susceptible fill material. Select material type appropriate for the intended purpose.

2.1.2 Porous Fill

Materials containing less than 5 percent passing the No. 200 sieve. Provide the gradation as appropriate for the intended purpose.

2.1.3 Topsoil

Material suitable for topsoil obtained from offsite areas is defined as: Natural, friable soil representative of productive, well-drained soils in the area, free of subsoil, stumps, rocks larger than one inch diameter, brush, weeds, toxic substances, and other material detrimental to plant growth. Amend topsoil pH range to obtain a pH of 5.5 to 7.

2.1.4 Capillary Water Barrier

Conform to ASTM C33/C33M for fine aggregate grading with a maximum of 3 percent by weight passing ASTM D1140, No. 200 sieve, or 1-1/2 inch and no more than 2 percent by weight passing the No. 4 size sieve.

2.1.5 Utility Bedding Material

Except as specified otherwise in the individual piping section, provide bedding for buried piping in accordance with AWWA C600. Install bedding for plastic piping to spring line of pipe. Utility bedding material may include the following:

2.1.5.1 Sand

Clean, coarse-grained sand classified as SW or SP by ASTM D2487 for bedding and backfill as indicated.

2.2 FLOWABLE FILL

Design and submit flowable fill mix design to consist of Portland cement, fly ash, and/or slag cement and fine aggregate. Include the dry weights

of cementitious material(s); quality and gradation of aggregates in the saturated surface-dry weights along with gradation tests; quantities, types, and names of admixtures; and quantity of water per cubic yard. The unconfined compressive strength to be 50 to 150 psi at 28 days in accordance with ASTM D4832. The aggregates in accordance with ASTM C33/C33M Fine Aggregates. Air-entrain fill in accordance with ASTM C260/C260M. The air content to be between 8 and 15 percent in accordance with ASTM D6023. The flow to be between 8 and 12 inches in accordance with ASTM D6103/D6103M. Portland cement to be Type I or II in accordance with ASTM C150/C150M. Fly ash to be Class C in accordance with ASTM C618. Provide slag cement in Grade 100 or 120 in accordance with ASTM C989/C989M.

2.3 BURIED WARNING AND IDENTIFICATION MARKERS

Provide metallic core or metallic-faced, acid- and alkali-resistant, polyethylene plastic warning tape manufactured specifically for warning and identification of buried utility lines. Provide tape on rolls, 3 inches minimum width, color coded as specified below for the intended utility with warning and identification imprinted in bold black letters continuously over the entire tape length. Warning and identification to read, "CAUTION, BURIED (intended service) LINE BELOW" or similar wording. Provide permanent color and printing, unaffected by moisture or soil.

Warning Tape Color Codes	
Red	Electric
Yellow	Gas, Oil; Dangerous Materials
Orange	Telephone and Other Communications
Blue	Water Systems
Green	Sewer Systems
White	Steam Systems
Gray	Compressed Air

2.3.1 Warning Tape for Metallic Piping

Provide acid and alkali-resistant polyethylene plastic tape conforming to the width, color, and printing requirements specified above, with a minimum thickness of 0.003 inch and a minimum strength of 1500 psi lengthwise, and 1250 psi crosswise, with a maximum 350 percent elongation.

2.3.2 Detectable Warning Tape for Non-Metallic Piping

Provide polyethylene plastic tape conforming to the width, color, and printing requirements specified above, with a minimum thickness of 0.004 inch, and a minimum strength of 1500 psi lengthwise and 1250 psi crosswise. Manufacture tape with integral wires, foil backing, or other means of enabling detection by a metal detector when tape is buried up to 3 feet deep. Encase metallic element of the tape in a protective jacket or provide with other means of corrosion protection.

2.3.3 Detection Wire for Non-Metallic Piping

Insulate a single strand, solid copper detection wire with a minimum of 12 AWG.

2.4 BORROW

Provide borrow materials from sources located outside of Government property meeting the requirements of paragraph STRUCTURAL FILL.

PART 3 EXECUTION

3.1 PROTECTION

Perform all work specified in accordance with applicable requirements of the Corps of Engineers publication EM 385-1-1 Safety and Health Requirements Manual.

Use equipment of type and size appropriate for the site conditions (soil character and moisture content). Maintenance of exposed subgrades and fills is the responsibility of the Contractor. The Contractor is required to prevent damage by ineffective drainage, dewatering, and heavy loads and equipment by implementing precautionary measures. Repair or replace any defects or damage.

3.1.1 Underground Utilities

Location of the existing utilities indicated is approximate. Physically verify the location and elevation of the existing utilities indicated prior to starting construction. The Contractor is responsible for protecting utilities from damage during construction.

3.1.2 Drainage and Dewatering

Provide for the collection and disposal of surface and subsurface water encountered during construction.

3.1.2.1 Drainage

Provide for the collection and disposal of surface and subsurface water encountered during construction. Construct storm drainage features (ponds/basins) at the earliest stages of site development, and throughout construction grade the construction area to provide positive surface water runoff away from the construction activity and provide temporary ditches, swales, and other drainage features and equipment as required to keep soils from becoming unstable, prevent erosion, or undermining of foundations. Remove unstable material from working platforms for equipment operation and soil support for subsequent construction features and provide new material as specified herein. It is the responsibility of the Contractor to assess the site conditions to employ necessary measures to permit construction to proceed.

3.1.2.2 Dewatering

Control groundwater flowing toward or into excavations to prevent sloughing of excavation slopes and walls, boils, uplift and heave in the excavation and to eliminate interference with orderly progress of construction. French drains, sumps, ditches or trenches are not allowed within 3 feet of the foundation of any structure, except with specific

written approval, and after specific contractual provisions for restoration of the foundation area have been made. Perform control measures by the time the excavation reaches the water level in order to maintain the integrity of the in-situ material. While the excavation is open, maintain the water level continuously, at least 3 feet below the working level. Submit a Dewatering Work Plan outlining procedures for accomplishing dewatering work. Operate dewatering system continuously until construction work below existing water levels is complete. Measure and record performance of dewatering system at same time each day by use of observation wells or piezometers installed in conjunction with the dewatering system.

3.1.3 Shoring and Sheeting

Submit an Excavation and Trenching Plan to stabilize features, prevent undermining or unintended horizontal and vertical movement of adjacent structures, and prevent slippage or movement in banks or slopes adjacent to the excavation. Submit drawings and calculations, certified by a registered professional engineer, describing the methods for shoring and sheeting of excavations. Drawings to include material sizes and types, arrangement of members, and the sequence and method of installation and removal. Calculations are to include data and references used.

3.1.4 Protection of Graded Surfaces

Protect newly backfilled, graded, and topsoiled areas from traffic, erosion, and settlements that may occur. Repair or reestablish damaged grades, elevations, or slopes.

3.2 BORROW

Select borrow material to meet the requirements and conditions of the fill for which it is to be used. Obtain borrow material from from approved private sources. Unless otherwise provided in the contract, the Contractor is responsible for obtaining the right to procure material, pay royalties and other charges involved, and bear the expense of developing the sources, including rights-of-way for hauling from the owners. Unless specifically provided, do not obtain borrow within the limits of the project site without prior written approval.

3.2.1 Environmental Requirements for Off-Site Soil

Test offsite soils brought in for use as backfill for Total Petroleum Hydrocarbons (TPH), Benzene, Toluene, Ethyl Benzene, and Xylene (BTEX) and full Toxicity Characteristic Leaching Procedure (TCLP) including ignitability, corrosivity and reactivity. Backfill may not contain concentrations above appropriate State and EPA criteria, and for hazardous waste characteristics 10 parts per million (ppm) of total petroleum hydrocarbons (TPH) and 10 ppm of the sum of Benzene, Toluene, Ethyl Benzene, and Xylene (BTEX) and pass the TCLP test. Determine TPH concentrations by using EPA Method 8015. Determine BTEX concentrations by using EPA SW-846.3-3 Method 5030/8020/8260B. Perform TCLP in accordance with EPA SW-846.3-3 Method 1311. Perform hazardous waste characteristic tests for ignitability, corrosivity, and reactivity in accordance with accepted standard methods. Perform PCB testing in accordance with accepted standard methods for sampling and analysis of bulk solid samples. Provide borrow site testing for petroleum hydrocarbons and BTEX from a grab sample of material from the area most likely to be contaminated at the borrow site (as indicated by visual or olfactory

evidence), with at least one test from each borrow site. Provide borrow site testing for hazardous waste characteristics (TPH, BTEX and TCLP) from a composite sample of material, collected in accordance with standard soil sampling techniques. Do not bring borrow material to project site until Borrow Plan containing environmental test results has been received and approved by the Contracting Officer.

3.3 SURFACE PREPARATION

3.3.1 Stripping

Strip site where improvements are planned as indicated on the plans. Strip existing surface materials to a depth of 64 inches below the existing ground surface in all areas within the planned limits of disturbance. All stripped aggregate and soil materials not suitable for reuse will be wasted in specified disposal area. Screen all stripped soils and aggregates to remove roots and organic materials prior disposal. Aggregate materials may be reused on site in areas indicated on the plans.

3.3.2 Proof Rolling

Perform proof rolling on exposed subgrade that is unfrozen and free of surface water (wet conditions resulting from rainfall).

After excavating, and rough grading to the planned elevation, proof roll the existing subgrade of all building, pavement and embankment locations with six passes of a 15 ton, pneumatic-tired or smooth drum roller. Operate the roller in a systematic manner to ensure the number of passes over all areas, and at speeds between 2.5 to 3.5 miles per hour. Subgrade materials that exhibit excessive deflection and/or rutting during proof rolling need to be scarified, aerated, and re-compacted to specified density at plus or minus 2 percent of optimum moisture content prior to being considered for remedial action by the Contracting Officer. When proof rolling under buildings, the building subgrade is considered to extend 5 feet beyond the building lines, and make one-half of the passes with the roller in a direction perpendicular to the other passes.

3.3.3 Stockpiling Operations

Place and grade stockpiles of satisfactory as specified. Keep stockpiles in a neat and well drained condition, giving due consideration to drainage at all times. Clear, grub, and seal by rubber-tired equipment, the ground surface at stockpile locations; separately stockpile excavated satisfactory and unsatisfactory materials. Protect stockpiles of satisfactory materials from contamination which may destroy the quality and fitness of the stockpiled material. Do not create stockpiles that could obstruct the flow of any stream, endanger a partly finished structure, impair the efficiency or appearance of any structure, or be detrimental to the completed work in any way. If the Contractor fails to protect the stockpiles, and any material becomes unsatisfactory, remove and replace such material with satisfactory material from approved sources.

3.4 EXCAVATION

Excavate to contours, elevation, and dimensions indicated. Excavate soil disturbed or weakened by Contractor's operations, and soils softened or made unstable for subsequent construction due to exposure to weather. Use material removed from excavations meeting the specified requirements in the construction of fills, embankments, subgrades, shoulders, bedding (as

backfill), and for similar purposes to minimize surplus material and to minimize additional material to brought on site. Do not excavate below indicated depths except to remove unstable material as determined by the Government or Geotechnical Engineer and confirmed by the Contracting Officer. Remove and replace excavations below the grades shown with appropriate materials as directed by the Contracting Officer.

If at any time during excavation, including excavation from borrow areas, the Contractor encounters material that may be classified as rock or as hard/unyielding material, uncover such material, and notify the Contracting Officer. Do not proceed with the excavation of this material until the Contracting Officer has classified the materials as common excavation or rock excavation. Failure on the part of the Contractor to uncover such material, notify the Contracting Officer, and allow sufficient time for classification and delineation of the undisturbed surface of such material will cause the forfeiture of the Contractor's right of claim to any classification or volume of material to be paid for other than that allowed by the Contracting Officer for the areas of work in which such deposits occur.

3.4.1 Trench Excavation Requirements

Excavate the trench as recommended by the manufacturer of the pipe to be installed. Slope trench walls below the top of the pipe, or make vertical, and of such width as recommended by the manufacturer. Provide vertical trench walls where no manufacturer installation instructions are available. Do not exceed the trench width of 24 inches below the top pipe plus pipe outside diameter (O.D.) for pipes of less than 24 inches inside diameter, and do not exceed 36 inches plus pipe outside diameter for pipe sizes larger than 24 inches inside diameter. Where recommended trench widths are exceeded, provide redesign, stronger pipe, or special installation procedures. The Contractor is responsible for the cost of redesign, stronger pipe, or special installation procedures without any additional cost to the Government.

3.4.1.1 Bottom Preparation

Grade the bottoms of trenches accurately to provide uniform bearing and support for the bottom quadrant of each section of the pipe. Excavate bell holes to the necessary size at each joint or coupling to eliminate point bearing. Remove stones of 6 inch or greater in any dimension, or as recommended by the pipe manufacturer, whichever is smaller, to avoid point bearing.

3.4.1.2 Removal of Unyielding Material

Where overdepth is not indicated and unyielding material is encountered in the bottom of the trench, notify the Contracting Officer. Following approval, remove such material inch below the required grade and replaced with suitable materials as provided in paragraph FILLING AND COMPACTION.

3.4.1.3 Removal of Unstable Material

Where unstable material is encountered in the bottom of the trench, remove such material to the depth directed and replace it to the proper grade with suitable material as provided in paragraph FILLING AND COMPACTION. When removal of unstable material is required due to the Contractor's fault or neglect in performing the work, the Contractor is responsible for excavating the resulting material and replacing it without additional cost

to the Government.

3.4.1.4 Excavation for Appurtenances

Provide excavation for manholes, catch-basins, inlets, or similar structures sufficient to leave at least 12 inches clear between the outer structure surfaces and the face of the excavation or support members.

3.4.1.5 Gas Distribution

Excavate trenches to a depth that will provide a minimum 24 inches of cover in other excavation.

3.4.1.6 Water Lines

Excavate trenches to a depth that provides a minimum cover of 5 feet from the existing ground surface or at a minimum to match cover over existing pipes.

3.4.2 Underground Utilities

Perform work adjacent to utilities in accordance with procedures outlined by utility owner. Excavation made with power-driven equipment is not permitted within 2 feet of known utility or subsurface construction. For work immediately adjacent to or for excavations exposing a utility or other buried obstruction, excavate by hand. Start hand excavation on each side of the indicated obstruction and continue until the obstruction is uncovered or until clearance for the new grade is assured. Support uncovered lines or other existing work affected by the contract excavation until approval for backfill is granted by the Contracting Officer. Report damage to utility lines or subsurface construction immediately to the Contracting Officer.

3.5 SUBGRADE PREPARATION

3.5.1 General Requirements

Shape subgrade to line, grade, and cross section as indicated. Remove unsatisfactory and unstable material in surfaces to receive fill or in excavated areas, and replaced with satisfactory materials or structural fill. Do not place material on surfaces that are muddy, frozen, contain frost, or otherwise containing unstable material. Scarify the surface to a depth of 4 inches prior to placing fill. Step or bench sloped surfaces steeper than 1 vertical to 4 horizontal prior to scarifying. Place 4 inches of loose fill and blend with scarified material. When subgrade is part fill and part excavation or natural ground, scarify to a depth of 8 inches.

3.5.2 Subgrade for Structures, Spread Footings, and Concrete Slabs

Do not excavate below depth shown for structures, spread footings, and concrete slabs. If over excavation occurs, compact disturbed material to 95 percent of ASTM D698. After final rolling, the surface of the subgrade for buildings and pavements must not show deviations greater than 0.05 foot when tested with a 12-foot straightedge applied both parallel and at right angles to the centerline of the area.

3.5.3 Subgrade for Pavements

Compact top 12 inches of subgrade for pavements to at least 95 percent of ASTM D1557. After final rolling, the surface of the subgrade for buildings and pavements must not show deviations greater than 0.05 foot when tested with a 12-foot straightedge applied both parallel and at right angles to the centerline of the area.

3.5.4 Subgrade Filter Fabric

Place filter fabric as indicated directly on prepared subgrade free of vegetation, stumps, rocks larger than 2 inch diameter and other debris which may puncture or otherwise damage the fabric. Repair damaged fabric by placing an additional layer of fabric to cover the damaged area a minimum of 3 feet overlap in all directions. Overlap fabric at joints a minimum of 3 feet. Obtain approval of filter fabric installation before placing fill or backfill. Place fill or backfill on fabric in the direction of overlaps and compact as specified herein. Follow manufacturer's recommended installation procedures.

3.6 FILLING AND COMPACTION

Prepare ground surface on which backfill is to be placed and provide compaction requirements for backfill materials in conformance with the applicable portions of paragraphs for SUBGRADE PREPARATION. Do not place material on surfaces that are muddy, frozen, or contain frost. Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, or other approved equipment well suited to the soil being compacted. Moisten material as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used. Fill and backfill to contours, elevations, and dimensions indicated. Compact and test each lift before placing overlaying lift.

3.6.1 Trench Backfill

Backfill trenches to the grade shown. Backfill the trench to 2 feet above the top of pipe prior to performing the required pressure tests. Leave the joints and couplings uncovered during the pressure test.

3.6.1.1 Replacement of Unyielding Material

Replace unyielding material removed from the bottom of the trench with satisfactory material or initial backfill material.

3.6.1.2 Replacement of Unstable Material

Replace unstable material removed from the bottom of the trench or excavation with satisfactory material placed in layers not exceeding 6 inches loose thickness.

3.6.1.3 Bedding and Initial Backfill

Place initial backfill material and compact it with approved tampers to a height of at least one foot above the utility pipe or conduit. Bring up the backfill evenly on both sides of the pipe for the full length of the pipe. Take care to ensure thorough compaction of the fill under the haunches of the pipe. Except where shown or when specified otherwise in the individual piping section, provide bedding for buried piping in accordance with PART 2 paragraph UTILITY BEDDING MATERIAL. Compact

backfill to top of pipe to 95 percent of ASTM D698 maximum dry density. Provide plastic piping with bedding to spring line of pipe.

3.6.1.4 Final Backfill

Do not begin backfill until construction below finish grade has been approved, underground utilities systems have been inspected, tested and approved, forms removed, and the excavation cleaned of trash and debris. Bring backfill to indicated finish grade. Where pipe is coated or wrapped for protection against corrosion, the backfill material up to an elevation 2 feet above sewer lines and one foot above other utility lines need to be free from stones larger than one inch in any dimension. Heavy equipment for spreading and compacting backfill are not to be operated closer to foundation or retaining walls than a distance equal to the height of backfill above the top of footing; compact remaining area in layers not more than 4 inches in compacted thickness with power-driven hand tampers suitable for the material being compacted. Place backfill carefully around pipes or tanks to avoid damage to coatings, wrappings, or tanks. Do not place backfill against foundation walls prior to 7 days after completion of the walls. As far as practicable, bring backfill up evenly on each side of the wall and sloped to drain away from the wall.

Fill the remainder of the trench, except for special materials for buildings and pavements with satisfactory material. Place backfill material and compact as follows:

3.6.1.4.1 Buildings and Pavements

Place backfill up to the required elevation as specified. Do not permit water flooding or jetting methods of compaction. Compact as specified for Structural Fill.

3.6.1.4.2 Turfed or Seeded Areas and Miscellaneous Areas

Deposit backfill in layers of a maximum of 12 inches loose thickness, and compact it to 85 percent maximum dry density for cohesive soils and 90 percent maximum dry density for cohesionless soils. Apply this requirement to all other areas not specifically designated above.

3.6.1.5 Heat Distribution System

Free initial backfill material of stones larger than 1/4 inch in any dimension.

3.6.1.6 Electrical Distribution System

Provide a minimum cover of 24 inches from the finished grade to direct burial cable and conduit or duct line, unless otherwise indicated.

3.6.1.7 Displacement of Features

After other required tests have been performed and the trench backfill compacted to 2 feet above the top of the pipe , inspect the pipe to determine whether unexpected or damaging displacement has occurred. Conduct walk-through inspection of pipe sizes larger than 48 inches. Inspect pipes smaller than 48 inches using remote methods using closed circuit television, sonar, or hybrid that can provide a 360-degree inspection of the pipe. Prepare and submit a pipe inspection report consisting of digital video or photos. If, in the judgment of the

Contracting Officer, the interior of the pipe shows poor alignment or any other defects that would cause improper functioning of the system, replace or repair the defects as directed at no additional cost to the Government.

3.6.1.8 Buried Tape And Detection Wire

3.6.1.8.1 Buried Warning and Identification Tape

Provide buried utility lines with utility identification tape. Bury tape 12 inches below finished grade; under pavements and slabs, bury tape 6 inches below top of subgrade.

3.6.1.8.2 Buried Detection Wire

Bury detection wire directly above non-metallic piping at a distance not to exceed 12 inches above the top of pipe. Extend the wire continuously and unbroken, from manhole to manhole. Terminate the ends of the wire inside the manholes at each end of the pipe, with a minimum of 3 feet of wire, coiled, remaining accessible in each manhole. Furnish insulated wire over its entire length. Install wires at manholes between the top of the corbel and the frame, and extend up through the chimney seal between the frame and the chimney seal. For force mains, terminate the wire in the valve pit at the pump station end of the pipe.

3.6.2 Structural Fill Placement

Place fill and backfill beneath and adjacent to structures in successive horizontal layers of loose material not more than 8 inches in depth, or in loose layers not more than 4 inches in depth when using hand-operated compaction equipment. Do not place over wet or frozen materials. Compact to at least 90 percent of laboratory maximum dry density for cohesive materials or 95 percent of laboratory maximum dry density for cohesionless materials, except as otherwise specified. Perform compaction in such a manner as to prevent wedging action or eccentric loading upon or other damage to the structure. Moisture condition fill and backfill material to a moisture content that will readily facilitate obtaining the specified compaction.

3.6.3 Backfill for Appurtenances

After the manhole, catchbasin, inlet, or similar structure has been constructed and the concrete has been allowed to cure for 7 days, place backfill in such a manner that the structure is not be damaged by the shock of falling earth. Deposit the backfill material, compact it as specified for final backfill, and bring up the backfill evenly on all sides of the structure to prevent eccentric loading and excessive stress.

3.6.4 Porous Fill Placement

Provide under floor and area-way slabs on a compacted subgrade. Place in a single lift and compact with a minimum of two passes of a hand-operated plate-type vibratory compactor.

3.6.5 Flowable Fill

Place fill in a manner to completely fill voids in the location indicated. Do not place when atmospheric temperatures are expected to be below 33 degrees F at any time during the 3 day period following placement.

3.6.6 Compaction

3.6.6.1 General Site

Compact underneath areas designated for vegetation and areas outside the 5 foot line of the paved area or structure to 90 percent of ASTM D698 .

3.6.6.2 Adjacent Areas

Compact areas within 5 feet of structures to 95 percent of ASTM D698 .

3.7 FINISHING/FINISH OPERATIONS

During construction, keep excavations shaped and drained. Maintain ditches and drains along subgrade to drain effectively at all times. Do not disturb the finished subgrade by traffic or other operation. Protect and maintain the finished subgrade in a satisfactory condition until subbase, base, or pavement is placed. Do not permit the storage or stockpiling of materials on finished subgrade. Do not lay subbase, base course, or pavement until the subgrade has been checked and approved, and in no case place subbase, base, surfacing, pavement on a muddy, spongy, frozen or otherwise unstable subgrade.

Finish the surface of excavations, embankments, and subgrades to a smooth and compact surface in accordance with the lines, grades, and cross sections or elevations shown. Provide the degree of finish for graded areas within 0.1 foot of the grades and elevations indicated except as indicated for subgrades specified in paragraph SUBGRADE PREPARATION. Finish gutters and ditches in a manner that will result in effective drainage. Finish the surface of areas to be turfed to a smoothness suitable for the application of turfing materials. Repair graded, topsoiled, or backfilled areas prior to acceptance of the work, and re-established grades to the required elevations and slopes.

3.7.1 Capillary Water Barrier

Place a capillary water barrier under concrete floor and area-way slabs grade directly on the subgrade and compact with a minimum of two passes of a hand-operated plate-type vibratory compactor.

3.7.2 Grading Around Structures

Construct areas within 5 feet outside of each building and structure line true-to-grade, shape to drain, and maintain free of trash and debris until final inspection has been completed and the work has been accepted.

3.7.3 Grading

Finish grades as indicated within one-tenth of one foot. Grade areas to drain water away from structures. Maintain areas free of trash and debris. For existing grades that will remain but which were disturbed by Contractor's operations, grade as directed.

3.7.4 Topsoil and Seed

On areas to receive topsoil, prepare the compacted subgrade soil to a 2 inches depth for bonding of topsoil with subsoil. Spread topsoil evenly to a thickness of 4 inches and grade to the elevations and slopes shown. Do not spread topsoil when frozen or excessively wet or dry. Keep topsoil

separate from other excavated materials, brush, litter, objectionable weeds, roots, stones larger than 2 inches in diameter, and other materials that would interfere with planting and maintenance operations.

3.8 DISPOSITION OF SURPLUS MATERIAL

Remove from Government property all surplus or other soil material not required or not suitable for filling or backfilling, along with brush, refuse, stumps, roots, and timber. Properly disposed of in accordance with all applicable laws and regulations. Prepare plan for Disposition of Surplus Materials to include permissions document to dispose of nonsalable products.

3.9 TESTING

Perform testing as indicated in Table 1. Submit Material Test Reports within 7 days of tests being completed.

Material Type	Test Method	Test Frequency
Structural Fill, Fill/Backfill, Utility Bedding Material	Density - ASTM D1556/D1556M	One test per 2000 square feet, or fraction thereof, of each lift of fill or backfill areas compacted by other than hand-operated machines. Double testing frequency for areas compacted by hand-operated machines.
Structural Fill, Fill/Backfill, Utility Bedding Material	Moisture Content - ASTM D2216	Two tests per day for each type of fill and backfill. Sample taken immediately prior to compaction after moisture conditioning.

Material Type	Test Method	Test Frequency
Structural Fill, Fill/Backfill, Utility Bedding Material	Moisture Density Relationship - ASTM D1557	One representative test per 500 cubic yards of fill and backfill, or when any change in material occurs which may affect the optimum moisture content or laboratory maximum dry density. Sample to be taken from stockpile or location of placement.
Structural Fill, Fill/Backfill, Utility Bedding Material	Relative Density - ASTM D4253 and ASTM D4254	One test per 2000 square feet, or fraction thereof, of each lift of fill or backfill areas compacted by other than hand-operated machines. Double testing frequency for areas compacted by hand-operated machines.

Material Type	Test Method	Test Frequency
Structural Fill, Fill/Backfill, Utility Bedding Material	Gradation - ASTM C136/C136M	One representative test per 500 cubic yards of fill and backfill, or when any change in material occurs which may affect the optimum moisture content or laboratory maximum dry density. Sample to be taken from stockpile or location of placement.
Structural Fill, Fill/Backfill, Utility Bedding Material	Atterberg Limits - ASTM D4318	One representative test per 500 cubic yards of fill and backfill, or when any change in material occurs which may affect the optimum moisture content or laboratory maximum dry density. Sample to be taken from stockpile or location of placement.

-- End of Section --

SECTION 32 11 20

BASE COURSE FOR RIGID PAVING
05/22

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C29/C29M	(2023) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C117	(2023) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C131/C131M	(2020) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136/C136M	(2025) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM D75/D75M	(2019) Standard Practice for Sampling Aggregates
ASTM D1556/D1556M	(2015; E 2016) Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
ASTM D1557	(2012; E 2015) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D3665	(2012; R 2017) Standard Practice for Random Sampling of Construction Materials
ASTM D4318	(2017; E 2018) Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D4718/D4718M	(2015) Standard Practice for Correction of Unit Weight and Water Content for Soils Containing Oversize Particles
ASTM D6938	(2017a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

ASTM D7928	(2017) Standard Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis
ASTM E11	(2024) Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves

1.2 DEGREE OF COMPACTION

Degree of compaction required, except as noted in the second sentence, is expressed as a percentage of the maximum laboratory dry density obtained by the test procedure presented in ASTM D1557.. Since ASTM D1557 applies only to soils that have 30 percent or less by weight of their particles retained on the 3/4 inch sieve, express the degree of compaction for material having more than 30 percent by weight of their particles retained on the 3/4 inch sieve as a percentage of the laboratory maximum dry density in accordance with ASTM D1557 Method C and corrected with ASTM D4718/D4718M.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Plant, Equipment, and Tools; G

SD-06 Test Reports

Initial Tests; G

In-Place Tests; G

1.4 QUALITY ASSURANCE

Perform sampling and testing using a laboratory approved in accordance with Section 01 45 00 QUALITY CONTROL. Do not start work requiring testing until the testing laboratory has been inspected and approved. All contractor quality control testing laboratories performing acceptance testing require USACE validation by the Material Testing Center (MTC) for both parent laboratory and on-site laboratory. Validation on all laboratories is required to remain current throughout the duration of the paving project. Contact the MTC manager listed at https://mtc.erdc.dren.mil/requestvalidation.aspx# for costs and scheduling. Test the materials to establish compliance with the specified requirements and perform testing at the specified frequency. Furnish copies of test results within 24 hours of completion of the tests.

1.4.1 Sampling

Take samples for laboratory testing in conformance with ASTM D75/D75M.

1.4.2 Tests

1.4.2.1 Gradation

Perform gradation in conformance with ASTM C117 and ASTM C136/C136M using sieves conforming to ASTM E11. Perform particle-size analysis of the soils in conformance with ASTM D7928.

1.4.2.2 Liquid Limit and Plasticity Index

Determine liquid limit and plasticity index in accordance with ASTM D4318.

1.4.2.3 Moisture-Density Determinations

Determine the laboratory maximum dry density and optimum moisture in accordance with paragraph DEGREE OF COMPACTION.

1.4.2.4 Field Density Tests

Measure field density in accordance with ASTM D1556/D1556M, or ASTM D6938. For the method presented in ASTM D1556/D1556M, use the base plate, as shown in the drawing. For the method presented in ASTM D6938, check the calibration curves and adjust them, if necessary, using only the sand cone method as described in Annex A2, of the ASTM publication. Use ASTM D6938 to determine the moisture content of the soil. Check the calibration curves furnished with the moisture gauges along with density calibration checks as described in ASTM D6938. Make the calibration checks of both the density and moisture gauges using the prepared containers of material method, as described in Annex A2, in ASTM D6938, on each different type of material to be tested at the beginning of a job and at intervals as directed. Submit calibration curves and related test results prior to using the device or equipment being calibrated.

1.4.2.5 Wear Test

Perform wear tests on rigid pavement base course material in conformance with ASTM C131/C131M.

1.4.2.6 Weight of Slag

Determine weight per cubic foot of slag in accordance with ASTM C29/C29M.

1.5 ENVIRONMENTAL REQUIREMENTS

Perform construction when the atmospheric temperature is above 35 degrees F. When the temperature falls below 35 degrees F, protect all completed areas by approved methods against detrimental effects of freezing. Correct completed areas damaged by freezing, rainfall, or other weather conditions to meet specified requirements.

1.6 ACCEPTANCE

1.6.1 Tolerances

Acceptance of rigid pavement base course is based on compliance with the tolerances presented in Table 1. Remove and replace any course identified by the failing tests.

TABLE 1	
Measurement	Tolerance
Grade	Plus 0, Minus 1/2 inch
Smoothness	Plus/Minus 1/2 inch
Total Thickness	Plus/Minus 1/2 inch
Average Job Thickness	Plus/Minus 1/4 inch
Compaction	
Rigid Pavement Base Course	Minimum 95 percent

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Rigid Pavement Base Course

Provide aggregates consisting of crushed stone or slag, gravel, shell, sand, or other sound, durable, approved materials processed and blended or naturally combined. Provide aggregates which are durable and sound, free from lumps and balls of clay, organic matter, objectionable coatings, and other foreign material. Limit the percentage of loss to a maximum of 50 percent after 500 revolutions when tested in accordance with ASTM C131/C131M. Provide aggregates with at least 75 percent by weight retained on each sieve having one freshly fractured face with the area at least equal to 75 percent of the smallest midsectional area of the piece. Provide aggregate that is reasonably uniform in density and quality. Provide slag that is an air-cooled, blast-furnace product having a dry weight of not less than 70 pcf. Provide aggregates having a maximum size of 2 inches, a minimum of 70 percent passing the 3/4 inch sieve, and within the limits specified as follows:

TABLE 3	
Maximum Allowable Percentage by Weight Passing Square-Mesh Sieve	
Sieve Designation	Rigid Pavement Base Course
No. 10	85
No. 200	15

Limit particles having diameters less than 0.02 mm to a maximum of 3 percent by weight of the total sample tested as determined in accordance with ASTM D7928. Limit the portion of any blended component and of the completed course passing the No. 40 sieve to be either nonplastic or have a liquid limit not greater than 25 and a plasticity index not greater than 6. Provide any additional stability required to maintain a working platform for construction equipment. If a test section can demonstrate that a material has adequate stability to support construction equipment,

the fractured face requirement can be deleted, subject to approval by the Government.

2.2 TESTS, INSPECTIONS, AND VERIFICATIONS

2.2.1 Initial Tests

Perform one of each of the following Initial Tests on the proposed material prior to commencing construction to demonstrate that the proposed material meets all specified requirements prior to installation. Complete this testing for each source if materials from more than one source are proposed.

a. Gradation.

b. Liquid limit and plasticity index.

c. Moisture-density relationship.

Submit certified copies of test results for approval not less than 30 days before material is required for the work.

2.2.2 Approval of Material

Tentative approval of material will be based on initial test results.

2.3 EQUIPMENT, TOOLS, AND MACHINES

All plant, equipment, and tools used in the performance of the work are subject to approval by the Government before the work is started. Maintain all plant, equipment, and tools in satisfactory working condition at all times. Submit a list of proposed equipment, including descriptive data. Use equipment capable of minimizing segregation, producing the required compaction, meeting grade controls, thickness control, and smoothness requirements as set forth herein.

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

Provide adequate drainage during the entire period of construction to prevent water from collecting or standing on the working area.

3.2 OPERATION OF AGGREGATE SOURCES

Condition aggregate sources on private lands in accordance with local laws and authorities.

3.3 STOCKPILING MATERIAL

Clear and level storage sites prior to stockpiling of material. Stockpile all materials, including approved material available from excavation and grading, in the manner and at the locations designated. Stockpile aggregates on the cleared and leveled areas designated to prevent segregation. Stockpile materials obtained from different sources separately.

3.4 PREPARATION OF UNDERLYING COURSE OR SUBGRADE

Clean the underlying course or subgrade of all foreign substances prior to constructing the rigid pavement base course. Do not construct rigid pavement base course on underlying course or subgrade that is frozen. Construct the surface of the underlying course or subgrade to meet specified compaction and surface tolerances. Correct ruts or soft yielding spots in the underlying courses, areas having inadequate compaction, and deviations of the surface from the specified requirements set forth herein by loosening and removing soft or unsatisfactory material and adding approved material, reshaping to line and grade, and recompacting to specified density requirements.

3.5 GRADE CONTROL

Provide a finished and completed rigid pavement base course conforming to the lines, grades, and cross sections shown. Place line and grade stakes as necessary for control.

3.6 MIXING AND PLACING MATERIALS

Mix and place the materials to obtain uniformity of the material at the water content specified. Make such adjustments in mixing or placing procedures or in equipment as directed to obtain the true grades, to minimize segregation and degradation, to reduce or accelerate loss or increase of water, and to provide a satisfactory course.

3.7 LAYER THICKNESS

Compact the completed course to the thickness indicated. Limit individual compacted lifts to a maximum thickness of 6 inches and a minimum thickness of 3 inches. Compact the course(s) to a total thickness that is within the tolerances of paragraph ACCEPTANCE. Where the measured thickness is more than 1/2 inch deficient, correct such areas by scarifying, adding new material of proper gradation, reblading, and recompacting as directed. Where the measured thickness is more than 1/2 inch thicker than indicated, the course will be considered as conforming to the specified thickness requirements. However, the requirements for the overlying course thickness and plan grade are still applicable. The average job thickness will be the average of all thickness measurements taken for the job and within the tolerances of paragraph ACCEPTANCE.

3.8 COMPACTION

Compact each lift of the material, as specified, with approved compaction equipment. For cohesive soils, maintain water content during the compaction procedure to within plus or minus 2 percent of optimum water content determined from laboratory tests as specified in this Section and for cohesionless soils, maintain a water content to facilitate compaction without bulking. Begin rolling at the outside edge of the surface and proceed to the center, overlapping on successive trips at least one-half the width of the roller. Slightly vary the length of alternate trips of the roller. Adjust speed of the roller as needed so that displacement of the aggregate does not occur. Compact mixture with hand-operated power tampers in all places not accessible to the rollers. Continue compaction of the rigid pavement base until each lift is compacted through the full depth to meet the compaction requirements of Table 1. Make such adjustments in compacting or finishing procedures to obtain true grades, to minimize segregation and degradation, to reduce or increase water

content, and to ensure a compliant rigid pavement base course. Remove any materials that are found to be non-compliant and replace with compliant material or rework, as directed, to meet the requirements of this specification.

3.9 PROOF ROLLING

In addition to the compaction specified, proof roll subbase course in areas designated on the drawings by application of four coverages of a heavy pneumatic-tired roller having four or more tires abreast, each tire loaded to a minimum of 30,000 pounds and inflated to a minimum of 125 psi. A coverage is defined as the application of one tire print over the designated area. In the areas designated, apply proof rolling to the top lift of the completed subbase course. Maintain water content of the top lift of the subbase course as specified in paragraph COMPACTION from start of compaction to completion of proof rolling. Remove any subbase course materials that produce permanent deformation exceeding 1/2 inch and replace with satisfactory materials. Then recompact and proof roll to meet specifications.

3.10 FINISHING

Finish the surface of the top lift of rigid pavement base course after final compaction and proof rolling by cutting any overbuild to grade and rolling with a steel-wheeled roller. Do not add thin lifts of material to the top lift of rigid pavement base course to meet grade. If the elevation of the top lift of rigid pavement base course exceeds the tolerances of paragraph ACCEPTANCE, scarify the top lift to a depth of at least 3 inches and blend new material in and compact to bring to grade. Make adjustments to rolling and finishing procedures to minimize segregation and degradation, obtain grades, maintain moisture content, and insure an acceptable rigid pavement base course. If the surface becomes rough, corrugated, uneven in texture, or traffic marked prior to completion, scarify the non-compliant portion and rework and recompact it or replace as directed.

3.11 SMOOTHNESS TEST

Construct the top lift so that the surface shows no deviations exceeding the tolerances of paragraph ACCEPTANCE when tested with a 12 foot straightedge. Test the entire area in both a longitudinal and a transverse direction on parallel lines. Perform the transverse lines 15 feet or less apart, as directed. Perform the longitudinal lines at the centerline of each placement lane and at the 1/8th point in from each side of the lane. Hold the straightedge in contact with the surface and move ahead one-half the length of the straightedge for each successive measurement. Determine the amount of surface irregularity by placing the freestanding (unleveled) straightedge on the surface and measuring the maximum gap between the straightedge and the surface. Determine measurements along the entire length of the straight edge. Correct deviations exceeding the tolerances of Table 1 by removing material and replacing with new material, or by reworking existing material and compacting it to meet these specifications.

3.12 FIELD QUALITY CONTROL

3.12.1 In-Place Tests

Perform one of each of the following In-Place Tests on samples taken from

the placed and compacted rigid pavement base course. Determine sample locations using random sampling in accordance with ASTM D3665. Take samples and test at the rates indicated.

a. Perform density tests on every lift of material placed and at a frequency of one set of tests for every 500 square yards, or portion thereof, of completed area.

b. Perform gradation on every lift of material placed and at a frequency of one gradation for every 1,000 square yards, or portion thereof, of material placed.

c. Perform liquid limit and plasticity index tests at the same frequency as the gradation.

d. Measure the thickness of each course at intervals providing at least one measurement for each 500 square yards or part thereof. Measure the thickness using test holes, at least 3 inches in diameter through the course.

3.12.2 Approval of Material

Final approval of the materials will be based on tests for gradation, liquid limit, and plasticity index performed on samples taken from the completed and fully compacted course(s).

3.13 TRAFFIC

Completed portions of the rigid pavement base course can be opened to limited traffic, provided there is no marring or distorting of the surface by the traffic. Do not allow heavy equipment on the completed rigid pavement base course except when necessary for construction. When it is necessary for heavy equipment to travel on the completed rigid pavement base course, protect the area against marring or damage to the completed work. Repair damage to meet these specifications.

3.14 MAINTENANCE

Maintain the completed course in a satisfactory condition until the full pavement section is completed and accepted. Immediately repair any defects and repeat repairs as often as necessary to keep the area intact. Retest any course that was not paved over prior to the onset of winter to verify that it still complies with the requirements of this specification. Rework or replace any area that is damaged as necessary to comply with this specification.

3.15 DISPOSAL OF UNSATISFACTORY MATERIALS

Dispose of any unsuitable materials that have been removed outside the limits of Government-controlled land as directed. No additional payments will be made for materials that have to be replaced.

-- End of Section --

SECTION 32 13 13.06

PORTLAND CEMENT CONCRETE PAVEMENT FOR ROADS AND SITE FACILITIES
05/20

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN CONCRETE INSTITUTE (ACI)

ACI 211.1	(1991; R 2009) Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete
ACI 305R	(2020) Guide to Hot Weather Concreting
ACI 306R	(2016) Guide to Cold Weather Concreting

ASTM INTERNATIONAL (ASTM)

ASTM A184/A184M	(2024) Standard Specification for Welded Deformed Steel Bar Mats for Concrete Reinforcement
ASTM A615/A615M	(2024) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A775/A775M	(2022) Standard Specification for Epoxy-Coated Steel Reinforcing Bars
ASTM A966/A966M	(2024) Standard Practice for Magnetic Particle Examination of Steel Forgings Using Alternating Current
ASTM C31/C31M	(2024c) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C33/C33M	(2024a) Standard Specification for Concrete Aggregates
ASTM C42/C42M	(2020) Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C78/C78M	(2022) Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
ASTM C88	(2018) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate

ASTM C94/C94M	(2024c) Standard Specification for Ready-Mixed Concrete
ASTM C143/C143M	(2020) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C150/C150M	(2024) Standard Specification for Portland Cement
ASTM C171	(2020) Standard Specification for Sheet Materials for Curing Concrete
ASTM C172/C172M	(2017) Standard Practice for Sampling Freshly Mixed Concrete
ASTM C231/C231M	(2024) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C260/C260M	(2024) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C309	(2019) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C494/C494M	(2024) Standard Specification for Chemical Admixtures for Concrete
ASTM C595/C595M	(2024) Standard Specification for Blended Hydraulic Cements
ASTM C618	(2025a) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C881/C881M	(2020a) Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C989/C989M	(2025) Standard Specification for Slag Cement for Use in Concrete and Mortars
ASTM C1017/C1017M	(2013; E 2015) Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
ASTM C1077	(2024) Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
ASTM C1240	(2020) Standard Specification for Silica Fume Used in Cementitious Mixtures
ASTM C1260	(2023) Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)

ASTM C1542/C1542M	(2019) Standard Test Method for Measuring Length of Concrete Cores
ASTM C1567	(2023) Standard Test Method for Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
ASTM C1602/C1602M	(2022) Standard Specification for Mixing Water Used in Production of Hydraulic Cement Concrete
ASTM D1751	(2018) Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D2995	(2023) Determining Application Rate of Bituminous Distributors
ASTM E1274	(2018); R 2024 Standard Test Method for Measuring Pavement Roughness Using a Profilograph

NATIONAL READY MIXED CONCRETE ASSOCIATION (NRMCA)

NRMCA QC 3	(2015) Quality Control Manual: Section 3, Plant Certifications Checklist: Certification of Ready Mixed Concrete Production Facilities

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Curing Materials

Reinforcement

Epoxy Resin

Dowel Bars

Expansion Joint Filler

SD-05 Design Data

Mix Design Report; G

SD-06 Test Reports

Concrete Slump Tests

Concrete Uniformity

Flexural Strength

Air Content

SD-07 Certificates

Batch Tickets

NRMCA Certificate Of Conformance

SD-08 Manufacturer's Instructions

Diamond Grinding Plan

1.3 QUALITY CONTROL

1.3.1 NRMCA Certificate of Conformance

Provide a batching and mixing plant consisting of a stationary-type central mix plant, including permanent installations and portable or relocatable plants installed on stable foundations. Provide a plant designed and operated to produce concrete within the specified tolerances, with a minimum capacity of 250 cubic yards per hour. Submit NRMCA Certificate of Conformance that conforms to the requirements of NRMCA QC 3 including provisions addressing:

1. Material Storage and Handling

2. Batching Equipment

3. Central Mixer

4. Ticketing System

5. Delivery System

1.3.2 Qualifications

1.3.2.1 Laboratory Accreditation

Perform sampling and testing using an approved commercial testing laboratory or on-site facilities that are accredited in accordance with ASTM C1077. Do not start work requiring testing until the facilities have been inspected and approved. The Government will inspect all laboratories requiring validation for equipment and test procedures prior to the start of any concreting operations for conformance to ASTM C1077. Schedule and provide payment for laboratory inspections. Additional payment or a time extension due to failure to acquire the required laboratory validation is not allowed. Maintain this certification for the duration of the project.

1.3.2.2 Field Technicians

Provide field technicians meeting one of the following criteria:

a. Have at least one National Ready Mixed Concrete Association (NRMCA) certified concrete craftsman and at least one American Concrete

Institute (ACI) Flatwork Finisher Certified craftsman on site, overseeing each placement crew during all concrete placement.

b. Have no less than three NRMCA certified concrete installers and at least two American Concrete Institute (ACI) Flatwork Finisher Certified installers on site working as members of each placement crew during all concrete placement.

1.3.3 Batch Tickets

Submit batch tickets for each load of ready-mixed concrete in accordance with ASTM C94/C94M.

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver concrete paving in accordance with ASTM C94/C94M.

1.5 ACCEPTANCE

1.5.1 Tolerances

Acceptance of Portland cement concrete pavement is based on compliance with the tolerances presented in Table 1. Remove and replace concrete pavement represented by the failing tests or submit repair plan for approval.

Table 1

Measurement	Tolerance
PLASTIC CONCRETE	
Slump	plus 0, minus 1.5 inches
Air Content	plus/minus 1.5 percent
Flexural Strength	No individual specimen less than 100 psi below specified strength.
HARDENED CONCRETE	
Grade	plus/minus 0.05 feet from plan
Smoothness	No abrupt change exceeding 1/8 inch
Straightedge	Not more than 1/8 in for roads. Not more than 1/4 in for open storage areas.
Profilograph	Not more than 9 inches/mile
Thickness	minus 3/4 inch for pavement equal to/greater than 8 inches thick minus 1/2 inch for pavement less than 8 inches thick.

Table 1	
Edge Slump	85 percent less than 1/4 inch and 100 percent less than 3/8 inch.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Cementitious Materials

2.1.1.1 Portland Cement

Conforming to ASTM C150/C150M, Type I or II III, for high early concrete .

2.1.1.2 Blended Cement

Provide blended cement conforming to ASTM C595/C595M, Type IP or IS, including the optional requirement for mortar expansion. Provide pozzolan added to the Type IP blend consisting of ASTM C618 Class F or Class N and that is interground with the cement clinker. Include in written statement from the manufacturer that the amount of pozzolan in the finished cement does not vary more than plus or minus 5 mass percent of the finished cement from lot to lot or within a lot. The percentage and type of mineral admixture used in the blend are not allowed to change from that submitted for the aggregate evaluation and mixture proportioning. The requirements of paragraph Supplementary Cementitious Materials (SCM) Content do not apply to the SCM content of blended cement.

2.1.1.3 Fly Ash and Pozzolan

Conforming to ASTM C618, Type F, or N, with a loss on ignition not exceeding 3 percent. Include test results in accordance with ASTM C618.

2.1.1.4 Ultra Fine Fly Ash and Ultra Fine Pozzolan

Ultra Fine Fly Ash (UFFA) and Ultra Fine Pozzolan (UFP) conforming to ASTM C618, Class F or N, and the following additional requirements:

a. The strength activity index at 28 days of age at least 95 percent of the control specimens.

b. The average particle size not exceeding 6 microns.

c. Loss on ignition not exceeding 3 percent.

2.1.1.5 Silica Fume

Provide silica fume that conforms to ASTM C1240, including the optional limits on reactivity with cement alkalis. Provide silica fume as a dry, densified material or as a slurry. Provide the services of a manufacturer's technical representative, experienced in mixing, proportioning, placement procedures, and curing of concrete containing silica fume, at no expense to the Government. This representative is required to be present on the project prior to and during at least the first 4 days of concrete production and placement using silica fume.

2.1.1.6 Slag

Conforming to ASTM C989/C989M, Slag Cement (formerly Ground Granulated Blast Furnace Slag) Grade 100 or 120. Include test results in accordance with ASTM C989/C989M.

2.1.1.7 Supplementary Cementitious Materials (SCM) Content

Include one of the SCMs listed in Table 2 within the range specified therein, whether or not the aggregates are found to be reactive in accordance with the paragraph Alkali Reactivity Test. Use of one of the SCMs listed below is optional, unless the SCM is required to mitigate ASR. The use of SCMs is encouraged in accordance with Section 01 33 29 SUSTAINABILITY REQUIREMENTS AND REPORTING.

TABLE 2
SUPPLEMENTARY CEMENTITIOUS MATERIALS CONTENT

Supplementary Cementitious Material	Minimum Content (percent)	Maximum Content (percent)
Class N Pozzolan and Class F Fly Ash		
SiO2 + Al2O3 + Fe2O3 greater than 70 percent	25	35
SiO2 + A12O3 + Fe2O3 greater than 80 percent	20	35
SiO2 + A12O3 + Fe2O3 greater than 90 percent	15	35
UFFA and UFP	7	16
GGBF Slag	40	50
Silica Fume	7	10

2.1.2 Water

Water conforming to ASTM C1602/C1602M.

2.1.3 Aggregate

2.1.3.1 Durability

Evaluate and test all fine and coarse aggregates to be used in all concrete for durability in accordance with ASTM C88. Provide fine and coarse aggregates with a maximum of 18 percent loss when subjected to 5 cycles using Magnesium Sulfate or a maximum of 12 percent loss when subjected to 5 cycles of Sodium Sulfate.

2.1.3.2 Alkali Reactivity Test

Evaluate and test fine and coarse aggregates to be used in all concrete for alkali-aggregate reactivity. Test all size groups and sources proposed for use.

a. Evaluate the fine and coarse aggregates separately, using ASTM C1260. Reject individual aggregates with test results that indicate an

expansion of greater than 0.08 percent after 28 days of immersion in 1N NaOH solution, or perform additional testing as follows: utilize the proposed low alkali portland cement, blended cement, or SCM in combination with each individual aggregate. Test in accordance with ASTM C1567. Determine the quantity that meets all the requirements of these specifications and that lowers the expansion equal to or less than 0.08 percent after 28 days of immersion in a 1N NaOH solution. Base the mixture proportioning on the highest percentage of SCM required to mitigate ASR-reactivity.

b. If any of the above options does not lower the expansion to less than 0.08 percent after 28 days of immersion in a 1N NaOH solution, reject the aggregate(s) and submit new aggregate sources for retesting. Submit the results of testing for evaluation and acceptance.

2.1.3.3 Fine Aggregates

Conforming to the quality and gradation of ASTM C33/C33M.

2.1.3.4 Coarse Aggregates

Conforming to the quality and gradation of ASTM C33/C33M.

2.1.4 Chemical Admixtures

2.1.4.1 Water Reducing Admixtures

Provide admixture conforming to ASTM C494/C494M: Type A, water reducing; Type B, retarding; Type C, accelerating; Type D, water-reducing and retarding; and Type E, water-reducing and accelerating admixture. Do not use calcium chloride admixtures. ASTM C494/C494M Type S specific performance admixtures and ASTM C1017/C1017M flowable admixtures are not allowed.

2.1.4.2 Air Entraining Admixture

Conforming to ASTM C260/C260M: Air-entraining.

2.1.4.3 High Range Water Reducing Admixture

Provide a high-range water-reducing admixture that meets the requirements of ASTM C494/C494M, Type F or G, that is free from chlorides, alkalis, and is of the synthesized, sulfonated complex polymer type. Add the HRWRA to the concrete as a single component at the batch plant. Add the admixture to the concrete mixture only when its use is approved or directed, and only when it has been used in mixture proportioning studies to arrive at approved mixture proportions. Submit certified copies of the independent laboratory test results required for compliance with ASTM C494/C494M.

2.1.5 Reinforcement

2.1.5.1 Dowel Bars

Dowel bars conforming to ASTM A615/A615M, Grade 40 for plain billet-steel bars of the size and length indicated. Remove all burrs and projections from the bars. Epoxy coat in accordance with ASTM A775/A775M.

2.1.5.2 Tie Bars

Billet or axle steel deformed bars conforming to ASTM A615/A615M or ASTM A966/A966M Grade 40. Epoxy coat in accordance with ASTM A775/A775M.

2.1.5.3 Reinforcement

Deformed steel bar mats conforming to ASTM A184/A184M. Bar reinforcement conforming to ASTM A615/A615M, Grade 40. Epoxy coat in accordance with ASTM A775/A775M.

2.1.6 Curing Materials

Provide curing materials consisting of:

2.1.6.1 White-Burlap-Polyethylene Sheet

Conforming to ASTM C171, 0.004 inch thick white opaque polyethylene bonded to 10 oz/linear yard (40 inch) wide burlap.

2.1.6.2 Liquid Membrane-Forming Compound

Conforming to ASTM C309, white pigmented, Type 2, Class B, free of paraffin or petroleum.

2.1.6.3 Liquid Chemical Sealer-Hardener Compound

Compound consisting of magnesium fluosilicate which when mixed with water seals and hardens the surface of the concrete. Do not use on exterior slabs exposed to freezing conditions.

2.1.7 Joint Fillers and Sealants

Match new joints with existing alignment.

2.1.8 Biodegradable Form Release Agent

Provide form release agent that is colorless and biodegradable. Provide product that does not bond with, stain, or adversely affect concrete surfaces and does not impair subsequent treatments of concrete surfaces. Provide form release agent with a minimum of 87 percent biobased material and does not contain diesel fuel, petroleum-based lubricating oils, waxes, or kerosene.

2.1.9 Epoxy Resin

Provide epoxy-resin materials that consist of two-component materials conforming to the requirements of ASTM C881/C881M, Class as appropriate for each application temperature to be encountered, except that in addition, the materials meet the following requirements:

a. Type IV, Grade 3, for use for embedding dowels and anchor bolts.

b. Type III, Grade as approved, for use as patching materials for complete filling of spalls and other voids and for use in preparing epoxy resin mortar.

c. Type IV, Grade 1, for use for injecting cracks.

d. Type V, Grade as approved, for bonding freshly mixed portland cement concrete or mortar or freshly mixed epoxy resin concrete or mortar to hardened concrete.

2.1.10 Joint Materials

2.1.10.1 Expansion Joint Materials

Provide preformed expansion joint filler material conforming to ASTM D1751. Provide expansion joint filler that is 3/4 inch thick, unless otherwise indicated, and provided in a single full depth piece.

2.1.10.2 Slip Joint Material

Provide slip joint material that is 1/4 inch thick expansion joint filler, unless otherwise indicated, conforming to paragraph EXPANSION JOINT MATERIAL.

2.2 MIX DESIGN

Proportion concrete mix in accordance with ACI 211.1 except as modified herein.

2.2.1 Specified Concrete Properties

2.2.1.1 Flexural Strength

Provide concrete with a minimum flexural strength of 650 psi at 28 days of age.

2.2.1.2 Air Entrainment

Provide an entrained air content of 6.0 percent.

2.2.1.3 Slump

For fixed form and hand placement, provide a maximum slump of 3 inches.

2.2.1.4 Water/Cementitious Materials Ratio

Maximum allowable water-cementitious material ratio is 0.40. The water-cementitious material ratio is based on absolute volume equivalency, where the ratio is determined using the weight of cement for a cement only mix, or using the total volume of cement plus pozzolan converted to an equivalent weight of cement by the absolute volume equivalency method described in ACI 211.1.

2.2.2 Mix Design Report

Perform trial design batches, mixture proportioning studies, testing, and include test results demonstrating that the proposed mixture proportions produce concrete of the qualities indicated. An existing mix design may be submitted if developed within the previous 12 months. Submit test results in a mix design report to include:

a. Coarse and fine aggregate gradations and plots.

b. Coarse and fine aggregate quality test results, include deleterious materials and ASR testing.

c. Mill certificates for cement and supplemental cementitious materials.

d. Certified test results for all proposed admixtures.

e. Specified flexural strength, slump, and air content.

f. Recommended proportions and volumes for proposed mixture and each of three trial water-cementitious materials ratios.

g. Individual beam breaks.

h. Flexural strength summaries and plots.

i. Historical record of test results, documenting production standard deviation (if available).

j. Narrative discussing methodology on how the mix design was developed.

2.2.3 Mix Verification

Mix verification tests may be performed by the Government. Provide quantities of cementitious materials, aggregates and admixtures as requested.

2.3 EQUIPMENT

2.3.1 Batching and Mixing

Provide a batch plant conforming to ASTM C94/C94M and as specified. Do not weigh water or measure cumulatively with another ingredient. Batch all concrete materials in accordance with ASTM C94/C94M requirements. Verify batching, mixers, mixing time, permitted reduction of mixing time, and concrete uniformity in accordance with the requirements of ASTM C94/C94M, and document in the initial weekly QC Report.

2.3.2 Transporting Equipment

Provide transporting equipment in conformance with ASTM C94/C94M and as specified herein. Transport concrete to the paving site in rear-dump trucks, in truck mixers designed with extra large blading and rear opening specifically for low slump concrete, or in agitators. Do not permit bottom-dump trucks for delivery of concrete.

2.3.3 Delivery Equipment

When concrete transport equipment cannot operate on the paving lane, provide side-delivery transport equipment consisting of self-propelled moving conveyors to deliver concrete from the transport equipment and discharge it in front of the paver. Do not permit front-end loaders, dozers, or similar equipment to distribute the concrete.

2.3.4 Paver-Finisher

Provide a heavy-duty, self-propelled paver-finisher machine designed specifically for paving and finishing high quality pavement and capable of spreading, consolidating, and shaping the plastic concrete to the desired cross section in one pass. Equip the paver-finisher with a full width "knock-down" auger, capable of operating in both directions, which

will evenly spread the fresh concrete in front of the screed or extrusion plate. Gang-mount immersion vibrators at the front of the paver on a frame equipped with suitable controls so that all vibrators can be operated at any desired depth within the slab or completely withdrawn from the concrete. Automatically control the vibrators so they will be immediately stopped as forward motion of the paver ceases. Space the immersion vibrators across the paving lane as necessary to properly consolidate the concrete, but limit the clear distance between vibrators not to exceed 30 inches, and the outside vibrators not to exceed 12 inches from the edge of the lane. Vibrators may be pneumatic, gas driven, or electric, and operated at frequencies within the concrete between 6,000 and 7,000 vibrations per minute, with an amplitude of vibration such that noticeable vibrations occur at 1.5 foot radius when the vibrator is inserted in the concrete to the depth specified. Equip the paver-finisher with a transversely oscillating screed or an extrusion plate to shape, compact, and smooth the surface.

2.3.4.1 Paver-Finisher with Fixed Forms

Equip the paver-finisher with wheels designed to ride the forms, keep it aligned with the forms, and to prevent deformation of the forms.

2.3.4.2 Other Types of Finishing Equipment

Heavy duty vibratory truss screeds may be approved for use if successfully demonstrated on the test section to consolidate the slab full depth and without segregation. Clary screeds, rotating tube floats, or laser screeds will not be allowed on the project. Provide hand floats that are not less than 12 feet long and 6 inches wide and stiffened to prevent flexing and warping.

2.3.4.3 Work Bridge

Provide a self-propelled work bridge capable of spanning the paving lane and supporting the workmen without excessive deflection.

2.3.5 Texturing Equipment

Provide texturing equipment as specified below.

2.3.5.1 Fabric Drag

Clean, reasonably new burlap measuring from 3 to 10 feet long, 2 feet wider than the width of the pavement, and securely attached to a separate wheel mounted frame spanning the paving lane or to one of the other similar pieces of equipment. Select dimension of burlap drag so that at least 3 feet of the material is in contact with the pavement.

2.3.5.2 Deep Texturing Equipment

Provide texturing equipment consisting of a stiff bristled broom which will produce true, even grooves. Mount this drag in a wheeled frame spanning the paving lane and constructed to mechanically pull the drag in a straight line across the paving lane perpendicular to the centerline.

2.3.6 Curing Equipment

Provide equipment for applying membrane-forming curing compound mounted on a self-propelled frame that spans the paving lane. Constantly agitate the

curing compound reservoir mechanically (not air) during operation and provide a means for completely draining the reservoir. Provide a spraying system that consists of a mechanically powered pump which maintains constant pressure during operation, an operable pressure gauge, and either a series of spray nozzles evenly spaced across the lane to provide uniformly overlapping coverage or a single spray nozzle which is mounted on a carriage which automatically traverses the lane width at a speed correlated with the forward movement of the overall frame. Protect all spray nozzles with wind screens. Calibrate the spraying system in accordance with ASTM D2995, Method A, for the rate of application required in subpart CURING AND PROTECTION. Provide hand-operated sprayers powered by compressed air supplied by a mechanical air compressor. Immediately replace curing equipment if it fails to apply an even coating of compound at the specified rate.

2.3.7 Sawing Equipment

Provide equipment for sawing joints and for other similar sawing of concrete consisting of standard diamond-type concrete saws mounted on a wheeled chassis which can be easily guided to follow the required alignment. Provide diamond tipped blades. If demonstrated to operate properly, abrasive blades may be used. Provide spares as required to maintain the required sawing rate. Early-entry saws may be used, subject to demonstration and approval. No change to the initial sawcut depth is permitted.

2.3.8 Straightedge

Furnish one 12 foot straightedge constructed of aluminum or magnesium alloy, having blades of box or box-girder cross section with flat bottom, adequately reinforced to insure rigidity and accuracy. Provide handles for operation on the pavement.

PART 3 EXECUTION

3.1 PREPARATION FOR PAVING

3.1.1 Weather Limitations

When windy conditions during paving appear probable, have equipment and material at the paving site to provide windbreaks, shading, fogging, or other action to prevent plastic shrinkage cracking or other damaging drying of the concrete.

3.1.1.1 Inclement Weather

Do not commence placing operations when heavy rain or other damaging weather conditions appear imminent. At all times when placing concrete, maintain on-site sufficient waterproof cover and means to rapidly place it over all unhardened concrete or concrete that might be damaged by rain. Suspend placement of concrete whenever rain, high winds, or other damaging weather commences to damage the surface or texture of the placed unhardened concrete, washes cement out of the concrete, or changes the water content of the surface concrete. Immediately cover and protect all unhardened concrete from the rain or other damaging weather. Completely remove and replace any slab damaged by rain or other weather full depth, by full slab width, to the nearest original joint.

3.1.1.2 Hot Weather

Maintain required concrete temperature in accordance with ACI 305R to prevent evaporation rate from exceeding 0.2 pound of water per square foot of exposed concrete per hour. Cool ingredients before mixing, place concrete during cooler night time hours, or use other suitable means to control concrete temperature and prevent rapid drying of newly placed concrete. Water is not allowed to be added after the initial introduction of mixing water except, when on arrival at the job site, the slump is less than specified and the water-cement ratio is less than that given as a maximum in the approved mixture. Additional water may be added to bring the slump within the specified range provided the approved water-cement ratio is not exceeded. Inject water into the head of the mixer (end opposite the discharge opening) drum under pressure, and turn the drum or blades a minimum of 30 additional revolutions at mixing speed. The addition of water to the batch at any later time is not allowed. After placement, use fog spray, apply monomolecular film, or use other suitable means to reduce the evaporation rate. Start curing when surface of fresh concrete is sufficiently hard to permit curing without damage. Cool underlying material by sprinkling lightly with water before placing concrete. Follow practices found in ACI 305R.

3.1.1.3 Prevention of Plastic Shrinkage Cracking

During weather with low humidity, and particularly with high temperature and appreciable wind, develop and institute measures to prevent plastic shrinkage cracks from developing. If plastic shrinkage cracking occurs, halt further placement of concrete until protective measures are in place to prevent further cracking. Periods of high potential for plastic shrinkage cracking can be anticipated by use of ACI 305R. In addition to the protective measures specified in the previous paragraph, the concrete placement may be further protected by erecting shades and windbreaks and by applying fog sprays of water, the addition of monomolecular films, or wet covering. Apply monomolecular films after finishing is complete, do not use in the finishing process. Immediately commence curing procedures when such water treatment is stopped.

3.1.1.4 Cold Weather

Do not place concrete when ambient temperature is below 40 degrees F or when concrete is likely to be subjected to freezing temperatures within 24 hours. When authorized, when concrete is likely to be subjected to freezing within 24 hours after placing, heat concrete materials so that temperature of concrete when deposited is between 65 and 80 degrees F. Methods of heating materials are subject to approval. Do not heat mixing water above 165 degrees F. Remove lumps of frozen material and ice from aggregates before placing aggregates in mixer. Follow practices found in ACI 306R.

3.1.2 Conditioning of Underlying Material

Verify the underlying material, upon which concrete is to be placed is clean, damp, and free from debris, waste concrete or cement, frost, ice, and standing or running water. Prior to setting forms or placement of concrete, verify the underlying material is well drained and has been satisfactorily graded by string-line controlled, automated, trimming machine and uniformly compacted in accordance with the applicable Section of these specifications. Test the surface of the underlying material to crown, elevation, and density in advance of setting forms. Trim high

areas to proper elevation. Fill and compact low areas to a condition similar to that of surrounding grade, or fill with concrete monolithically with the pavement. Low areas filled with concrete are not to be cored for thickness to avoid biasing the average thickness used for evaluation and payment adjustment. Rework and compact any underlying material disturbed by construction operations to specified density immediately in front of the paver.

3.1.3 Forms

Use steel forms, except that wood forms may be used for curves having a radius of 150 feet or less, and for fillets. Forms may be built up with metal or wood, added only to the base, to provide an increase in depth of not more than 25 percent. Provide forms with the base width not less than eight-tenths of the vertical height of the form, except that for forms 8 inches or less in vertical height, provide forms with a base width not less than the vertical height of the form. Provide wood forms adequate in strength and rigidly braced for curves and fillets. Set forms on firm material cut true to grade so that each form section when placed will be firmly in contact with the underlying layer for its entire base. Do not set forms on blocks or on built-up spots of underlying material. Set and secure forms in place with stakes or by other approved methods for overlay pavements and for other locations where forms are set on existing pavements. Carefully drill holes in existing pavements for form stakes without cracking or spalling the existing pavement. Prior to setting forms for paving operations, demonstrate the proposed form setting procedures at an approved location and do not proceed further until the proposed method is approved. Before placing the concrete, coat the contact surfaces of forms except existing pavement sections where bonding is required, with a non-staining mineral oil, non-staining form coating compound, biodegradable form release agent, or two coats of nitro-cellulose lacquer. When using existing pavement as a form, clean existing concrete and then coat with asphalt emulsion bondbreaker before concrete is placed. Check and correct grade elevations and alignment of the forms immediately before placing concrete.

3.1.4 Reinforcement

3.1.4.1 Dowel Bars

Install dowels with horizontal and vertical alignment plus or minus 1 inch. Except as otherwise specified, maintain location of dowels within a skew alignment of 1/4 inch over 1 foot length. Omit Dowels when the center of the dowel is located within a horizontal distance from an intersecting joint equal to or less than one-fourth of the slab thickness. Maintain dowels in position during concrete placement and curing. Before concrete placement, thoroughly grease the entire length of each dowel secured in a dowel basket or fixed form.

3.1.4.2 Tie Bars

Install bars, accurately aligned horizontally and vertically, and to the tolerances shown on the drawings, at indicated locations.

3.1.4.3 Setting Slab Reinforcement

Position reinforcement on suitable chairs prior to concrete placement. At expansion, contraction and construction joints, place the reinforcement as indicated. Clean reinforcement free of mud, oil, scale or other foreign

materials. Place reinforcement accurately and wire securely. Lap splices 12 inches minimum. Maintain the bar spacing from ends and sides of slabs and joints as indicated.

3.2 MEASURING, MIXING, CONVEYING, AND PLACING CONCRETE

3.2.1 Measuring

Conform to ASTM C94/C94M.

3.2.2 Mixing

Conform to ASTM C94/C94M, except as modified herein. Begin mixing within 30 minutes after cement has been added to aggregates. When the air temperature is greater than 85 degrees F, place concrete within 60 minutes. With approval, a hydration stabilizer admixture meeting the requirements of ASTM C494/C494M Type D, may be used to extend the placement time to 90 minutes. Additional water may be added to bring slump within required limits as specified in ASTM C94/C94M, provided that the specified water-cement ratio is not exceeded.

3.2.3 Conveying

Conform to ASTM C94/C94M.

3.2.4 Placing

Do not exceed a free vertical drop of 5 feet from the point of discharge. Deposit concrete either directly from the transporting equipment or by conveyor on to the pre-wetted subgrade or subbase, unless otherwise specified. Deposit the concrete between the forms to an approximately uniform height. Place concrete continuously at a uniform rate, without damage to the grade and without unscheduled stops except for equipment failure or other emergencies. If an unscheduled stop occurs within 10 feet of a previously placed expansion joint, remove concrete back to joint, repair any damage to grade, install a construction joint and continue placing concrete only after cause of the stop has been corrected.

3.3 PAVING

Construct pavement with paving and finishing equipment utilizing fixed forms.

3.3.1 Paving Plan

Submit for approval a paving plan identifying the following items:

a. A description of the placing and protection methods proposed when concrete is to be placed in or exposed to hot, cold, or rainy weather conditions.

b. A detailed paving sequence plan and proposed paving pattern showing all planned construction joints.

c. Plan and equipment proposed to control alignment of formed or sawn joints within the specified tolerances.

3.3.2 Required Results

Operate the paver-finisher to produce a thoroughly consolidated slab throughout, true to line and grade within specified tolerances. Adjust the paver-finishing operation to produce a surface finish free of irregularities, tears, voids of any kind, and other discontinuities, with only a minimum of paste at the surface. Do not permit multiple passes of the paver-finisher. Produce a finished surface requiring no hand finishing, other than the use of cutting straightedges, except in very infrequent instances. Do not apply water, other than true fog sprays (mist), to the concrete surface during paving and finishing.

3.3.3 Operation

When the paver is operated between or adjacent to previously constructed pavement (fill-in lanes), make provisions to prevent damage to the previously constructed pavement, including keeping the existing pavement surface free of debris, and placing rubber mats beneath the paver tracks. Operate transversely oscillating screeds and extrusion plates to overlap the existing pavement the minimum possible, but in no case more than 8 inches.

3.3.4 Consolidation

Immediately after spreading concrete, consolidate full depth with internal type vibrating equipment along the boundaries of all slabs regardless of slab thickness, and interior of all concrete slabs. For pavements less than 10 inches thick, operate vibrators at mid-depth parallel with or at a slight angle to the base course. For thicker pavements, angle vibrators toward the vertical, with vibrator tip preferably about 2 inches above the base course, and top of vibrator a few inches below pavement surface. Automatically control the vibrators or tamping units in front of the paver so that they stop immediately as forward motion ceases. Limit duration of vibration to that necessary to produce consolidation of concrete. Do not permit excessive vibration. Vibrate concrete in small, odd-shaped slabs or in locations inaccessible to the paver mounted vibration equipment with a hand-operated immersion vibrator operated from a bridge spanning the area. Do not operate vibrators at one location for more than 15 seconds. Do not use vibrators to transport or spread the concrete.

3.3.5 Fixed Form Paving

Spread and strike off concrete with with the paver. Shape the concrete to the specified and indicated cross section in one pass, and finish the surface and edges so that only a very minimum amount of hand finishing is required. Use single spud hand vibrators to consolidate the concrete adjacent to fixed forms as required to achieve a void-free formed edge. Do not allow vibrators to contact reinforcement, forms, or the grade during vibration.

3.4 JOINTS

3.4.1 Contraction Joints

Hold dowels and tie bars in longitudinal and transverse contraction joints within the paving lane securely in place by means of rigid metal basket assemblies. Weld the dowels and tie bars to the assembly or hold firmly by mechanical locking arrangements that will prevent them from becoming distorted during paving operations. Anchor the basket assemblies securely

in the proper location.

3.4.2 Construction Joints - Fixed Form Paving

Install dowels and tie bars by the bonded-in-place method, supported by means of devices fastened to the forms. Do not permit installation by removing and replacing in preformed holes.

3.4.3 Dowels Installed In Hardened Concrete

Install by bonding the dowels into holes drilled into the hardened concrete. Drill holes into the hardened concrete approximately 1/8 inch greater in diameter than the dowels. Bond the dowels in the drilled holes using epoxy resin injected at the back of the hole before installing the dowel and extruded to the collar during insertion of the dowel so as to completely fill the void around the dowel. Application by buttering the dowel is not permitted. Hold the dowels in alignment at the collar of the hole, after insertion and before the epoxy resin hardens, by means of a suitable metal or plastic collar fitted around the dowel. Check the vertical alignment of the dowels by placing the straightedge on the surface of the pavement over the top of the dowel and measuring the vertical distance between the straightedge and the beginning and ending point of the exposed part of the dowel.

3.5 FINISHING CONCRETE

Start finishing operations immediately after placement of concrete. Use finishing machine, except hand finishing may be used in emergencies and for concrete slabs in inaccessible locations or of such shapes or sizes that machine finishing is impracticable. Immediately halt any operations which produce more than 1/8 inch of mortar-rich surface (defined as deficient in plus U.S. No. 4 sieve size aggregate) and modify the equipment, mixture, or procedures. Finish pavement surface on both sides of a joint to the same grade. Finish formed joints from a securely supported transverse bridge. Provide hand finishing equipment for use at all times.

3.5.1 Machine Finishing

Strike off and screed concrete to the required slope and cross-section by a power-driven transverse finishing machine. A transverse rotating tube or pipe is not permitted. Maintain elevation of concrete such that, when consolidated and finished, pavement surface will be adequately consolidated and at the required grade. Equip finishing machine with a screed which is readily and accurately adjustable for changes in pavement slope and compensation for wear and other causes. Do not permit excessive operation over an area, which will result in an excess of mortar and water being brought to the surface.

3.5.1.1 Equipment Operation

Maintain the travel of machine on the forms without lifting, wobbling, or other variation of the machine which tend to affect the precision of concrete finish. Keep the tops of the forms clean by a device attached to the machine. Maintain a uniform ridge of concrete ahead of the front screed for its entire length.

3.5.1.2 Joint Finish

Before concrete is hardened, correct edge slump of pavement, exclusive of edge rounding, in excess of 0.25 inches. Finish concrete surface on each side of construction joints to the same plane, and correct deviations before newly placed concrete has hardened.

3.5.1.3 Hand Finishing

Strike-off and screed surface of concrete to elevations slightly above finish grade so that when concrete is consolidated and finished, the pavement surface is at the indicated elevation. Vibrate entire surface until required compaction and reduction of surface voids is secured with a strike-off template. After initial finishing, further smooth and consolidate concrete by means of hand-operated longitudinal floats.

3.5.2 Texturing

Before the surface sheen has disappeared and before the concrete hardens, provide a texture to the surface of the pavement as described herein. After curing is complete, thoroughly broom all textured surfaces to remove all debris. Finish the concrete in areas of recesses for tie-down anchors, lighting fixtures, and other outlets in the pavement to provide a surface of the same texture as the surrounding area.

3.5.2.1 Burlap Drag Finish

Before concrete becomes non-plastic, finish the surface of the slab by dragging a strip of clean, wet burlap on the surface. Drag the surface so as to produce a finished surface with a fine granular or sandy texture without leaving disfiguring marks. Keep the burlap clean and saturated during use.

3.5.2.2 Brooming

Finish the surface of the slab by brooming the surface with a new wire broom at least 18 inches wide. Gently pull the broom over the surface of the pavement from edge to edge just before the concrete becomes non-plastic. Slightly overlap adjacent strokes of the broom. Broom perpendicular to centerline of pavement so that corrugations produced will be uniform in character and width, and not more than 1/16 inch in depth. Maintain broomed surface free from porous spots, irregularities, depressions, and small pockets or rough spots such as may be caused by accidentally disturbing particles of coarse aggregate embedded near the surface.

3.5.3 Edging

At the time the concrete has attained a degree of hardness suitable for edging, carefully finish slab edges, including edges at formed joints, with an edge having a maximum radius of 1/8 inch. Clean by removing loose fragments and soupy mortar from corners or edges of slabs which have crumbled and areas which lack sufficient mortar for proper finishing. Refill voids solidly with a mixture of suitable proportions and consistency and refinish. Remove unnecessary tool marks and edges. Smooth remaining edges true to line.

3.6 CURING AND PROTECTION

Protect concrete adequately from injurious action by sun, rain, flowing water, frost, mechanical injury, tire marks and oil stains, and do not allow it to dry out from the time it is placed until the expiration of the minimum curing periods specified herein. Do not use membrane-forming compound on surfaces where its appearance would be objectionable, on surfaces to be painted, where coverings are to be bonded to concrete, or on concrete to which other concrete is to be bonded.

3.6.1 Moist Curing

Maintain concrete to be moist-cured continuously wet for the entire curing period, or until curing compound is applied, commencing immediately after finishing. If forms are removed before the end of the curing period, provide curing on unformed surfaces, using suitable materials. Cure surfaces by ponding, by continuous sprinkling, by continuously saturated burlap or cotton mats, or by continuously saturated plastic coated burlap. Provide burlap and mats that are clean and free from any contamination and completely saturated before being placed on the concrete. Lap sheets to provide full coverage. Provide an approved work system to ensure that moist curing is continuous 24 hours per day and that the entire surface is wet.

3.6.2 White-Burlap-Polyethylene Sheet

Wet entire exposed surface thoroughly with a fine spray of water, saturate burlap but do not have excessive water dripping off the burlap and then cover concrete with White-Burlap-Polyethylene Sheet, burlap side down. Lay sheets directly on concrete surface and overlap 12 inches. Make sheeting not less than 18 inches wider than concrete surface to be cured, and weight down on the edges and over the transverse laps to form closed joints. Repair or replace sheets when damaged during curing. Check daily to assure burlap has not lost all moisture. If moisture evaporates, resaturate burlap and re-place on pavement (limit re-saturation and re-placing to less than 10 minutes per sheet). Leave sheeting on concrete surface to be cured for at least 7 days.

3.6.3 Liquid Membrane-Forming Compound Curing

Apply compound immediately after surface loses its water sheen and has a dull appearance and before joints are sawed. Agitate curing compound thoroughly by mechanical means during use and apply uniformly in a two-coat continuous operation by suitable power-spraying equipment. Apply a total coverage for the two coats at least one gallon of undiluted compound per 200 square feet to produce a uniform, continuous, coherent film that will not check, crack, or peel and free from pinholes or other imperfections. The application of curing compound by hand-operated, mechanical powered pressure sprayers is permitted only on odd widths or shapes of slabs and on concrete surfaces exposed by the removal of forms. When the application is made by hand-operated sprayers, apply a second coat in a direction approximately at right angles to the direction of the first coat. Apply an additional coat of compound immediately to areas where film is defective. Respray concrete surfaces that are subject to heavy rainfall within 3 hours after curing compound has been applied in the same manner.

3.6.4 Protection of Treated Surfaces

After the initial saw cut is complete and the slurry has been removed, respray the area with curing compound or restore the white burlap polyethylene sheet to maintain a continuous curing environment in the area of the sawn joints. Keep concrete surfaces to which liquid membrane-forming compounds have been applied free from vehicular traffic and other sources of abrasion for not less than 72 hours. Foot traffic is allowed after 24 hours for inspection purposes. Maintain continuity of coating for entire curing period and repair damage to coating immediately.

3.7 FIELD QUALITY CONTROL

3.7.1 Sampling

Collect samples of fresh concrete in accordance with ASTM C172/C172M during each working day as required to perform tests specified herein. Make test specimens in accordance with ASTM C31/C31M.

3.7.2 Consistency Tests

Perform concrete slump tests in accordance with ASTM C143/C143M. Take samples for slump determination from concrete during placement. Perform tests at the beginning of a concrete placement operation and for each batch (minimum) or every 20 cubic yards (maximum) of concrete to ensure that specification requirements are met. In addition, perform tests each time test beams are made.

3.7.3 Flexural Strength Tests

Test for flexural strength in accordance with ASTM C78/C78M. Fabricate and cure four test specimens in accordance with ASTM C31/C31M for each set of tests. Test two specimens at 7 days, and the other two at 28 days. Concrete strength will be considered satisfactory when the minimum of the 28-day test results equals or exceeds the specified 28-day flexural strength, and no individual strength test is less than the tolerance indicated on Table 1. If the ratio of the 7-day strength test to the specified 28-day strength is less than 65 percent, make necessary adjustments for conformance. Fabricate, cure and test a minimum of one set of four beams for each shift of concrete placement. Remove concrete which is determined to be defective, based on the strength acceptance criteria therein, and replace with acceptable concrete.

3.7.4 Air Content Tests

Test air-entrained concrete for air content at the same frequency as specified for slump tests. Determine percentage of air in accordance with ASTM C231/C231M on samples taken during placement of concrete in forms.

3.7.5 Surface Testing

Use the profilograph method for all longitudinal testing, except for paving lanes less than 200 feet in length. Use the straightedge method for transverse testing, for longitudinal testing where the length of each pavement lane is less than 200 feet, and at the ends of the paving limits for the project. Smoothness requirements do not apply over crowns, drainage structures, or similar penetrations. Maintain detailed notes of the testing results and submit a copy to the Government after each day's testing.

3.7.5.1 Straightedge Testing Method

Test the surface of the pavement with the straightedge to identify all surface irregularities exceeding the tolerances specified in Table 1. Test the entire area of the pavement in both a longitudinal and a transverse direction on parallel lines approximately 15 feet apart. Hold the straightedge in contact with the surface and move ahead one-half the length of the straightedge for each successive measurement. Determine the amount of surface irregularity by placing the straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length and measuring the maximum gap between the straightedge and the pavement surface, in the area between these two high points.

3.7.5.2 Profilograph Testing Method

Perform profilograph testing using approved California profilograph and procedures described in ASTM E1274. Utilize electronic recording and automatic computerized reduction of data equipment to indicate "must-grind" bumps and the Profile Index for each 0.1 mile segment of the day's paving. Accommodate grade breaks on parking lots by breaking the profile segment into short sections and repositioning the blanking band on each section. Provide the "blanking band" of 0.2 inch wide and the "bump template" span 1 inch with an offset of 0.4 inch. Count the profilograph testing of the last 30 feet of a paving lane in the longitudinal direction from each day's paving operation on the following day's continuation lane. Compute the profile index for each pass of the profilograph (3 per lane) in each 0.1 mile segment. The profile index for each segment is the average of the profile indices for each pass in each segment. Scale and proportion profilographs of unequal lengths to an equivalent 0.1 mile as outlined in the ASTM E1274. Submit a copy of the reduced tapes to the Government at the end of each day's testing.

3.7.5.3 "Bumps" (Must Grind Areas)

Reduce any bumps ("must grind" areas) shown on the profilograph trace which exceed 0.4 inch in height by diamond grinding in accordance with subparagraph Diamond Grinding until they do not exceed 0.3 inch when retested. Taper such diamond grinding in all directions to provide smooth transitions to areas not requiring diamond grinding.

3.7.5.4 Diamond Grinding

Those performing diamond grinding are required to have a minimum of three years experience in diamond grinding of rigid concrete pavements. In areas not meeting the specified limits for surface smoothness and plan grade, reduce high areas to attain the required smoothness and grade, except as depth is limited below. Reduce high areas by diamond grinding the hardened concrete with an approved equipment after the concrete is at a minimum age of 14 days. Perform diamond grinding by sawing with an industrial diamond abrasive which is impregnated in the saw blades. Assemble the saw blades in a cutting head mounted on a machine designed specifically for diamond grinding that produces the required texture and smoothness level without damage to the concrete pavement or joint faces. Provide diamond grinding equipment with saw blades that are 1/8-inch wide, a minimum of 60 blades per 12 inches of cutting head width, and capable of cutting a path a minimum of 3 ft wide. Diamond grinding equipment that causes ravels, aggregate fractures, spalls or disturbance to the joints is not permitted. The maximum area corrected by diamond grinding the

surface of the hardened concrete is 10 percent of the total area of a day's production. The maximum depth of diamond grinding is 1/4 inch. Provide diamond grinding machine equipped to flush and vacuum the pavement surface. Dispose of all debris from diamond grinding operations off Government property. Prior to diamond grinding, submit a Diamond Grinding Plan for review and approval. At a minimum, include the daily reports for the deficient areas, the location and extent of deficiencies, corrective actions, and equipment. Remove and replace all pavement areas requiring plan grade or surface smoothness corrections in excess of the limits specified in Table 1. All areas in which diamond grinding has been performed are subject to the thickness tolerances specified in Table 1.

3.7.6 Plan Grade Testing and Conformance

Within 5 days after each day's paving, test the finished surface of the pavement area by running lines of levels at intervals corresponding with every longitudinal and transverse joint to determine the elevation at each joint intersection. Record the results of this survey and submit a copy to the Government at the completion of the survey.

3.7.7 Edge Slump

Test the pavement surface to determine edge slump immediately after the concrete has hardened sufficiently to permit walking thereon. Perform testing with a minimum 12 foot straightedge to reveal irregularities exceeding the edge slump tolerance specified in Table 1. Determine the vertical edge slump at each free edge of each slipformed paving lane constructed. Place the straightedge transverse to the direction of paving and the end of the straightedge located at the edge of the paving lane. Record measurements at 5 to 10 foot spacings, as directed, commencing at the header where paving was started. Initially record measurements at 5 foot intervals in each lane. When no deficiencies are present after 5 measurements, the interval may be increased. The maximum interval is 10 feet. When any deficiencies exist, return the interval to 5 feet. In addition to the transverse edge slump determination above, at the same time, record the longitudinal surface smoothness of the joint on a continuous line 1 inch back from the joint line using the minimum 12 foot straightedge advanced one-half its length for each reading. Perform other tests of the exposed joint face to ensure that a uniform, true vertical joint face is attained. Properly reference all recorded measurements in accordance with paving lane identification and stationing, and submit a report within 24 hours after measurement is made. Identify areas requiring replacement within the report.

3.7.8 Test for Pavement Thickness

Take full depth cores of 4 inch diameter of concrete pavement every 500 square feet in accordance with ASTM C42/C42M. Measure thickness in accordance with ASTM C1542/C1542M. Record and submit testing, inspection, and evaluation of each core for surface paste, uniformity of aggregate distribution, segregation, voids, cracks, and depth of reinforcement or dowel (if present). Moisten the core with water to visibly expose the aggregate and take a minimum of three photographs of the sides of the core, rotating the core approximately 120 degrees between photographs. Include a ruler for scale in the photographs. Submit plan view of location for each core.

3.7.9 Reinforcement

Inspect reinforcement prior to installation to verify it is free of loose flaky rust, loose scale, oil, mud, or other objectionable material.

3.7.10 Dowels

Inspect dowel placement prior to placing concrete to verify that dowels are of the size indicated, and are spaced, aligned and painted and oiled as specified. Do not permit dowels to exceed the tolerances shown in paragraph: DOWEL BARS.

-- End of Section --

SECTION 32 15 00

AGGREGATE SURFACING
05/17

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO T 180	(2025) Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop
AASHTO T 224	(2010) Standard Method of Test for Correction for Coarse Particles in the Soil Compaction Test

ASTM INTERNATIONAL (ASTM)

ASTM C117	(2023) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C131/C131M	(2020) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136/C136M	(2025) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM D75/D75M	(2019) Standard Practice for Sampling Aggregates
ASTM D1556/D1556M	(2015; E 2016) Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
ASTM D1557	(2012; E 2015) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D2167	(2015) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D4318	(2017; E 2018) Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

ASTM D6938	(2017a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM E11	(2024) Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves

1.2 DEGREE OF COMPACTION

Degree of compaction required, except as noted in the second sentence, is expressed as a percentage of the maximum laboratory dry density obtained by the test procedure presented in ASTM D1557 abbreviated as a percent of laboratory maximum dry density. Since ASTM D1557 applies only to soils that have 30 percent or less by weight of their particles retained on the 3/4 inch sieve, the degree of compaction for material having more than 30 percent by weight of their particles retained on the 3/4 inch sieve will be expressed as a percentage of the laboratory maximum dry density in accordance with AASHTO T 180 Method D and corrected with AASHTO T 224.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Plant, Equipment, and Tools; G

SD-06 Test Reports

Initial Tests; G

In-Place Tests; G

1.4 EQUIPMENT, TOOLS, AND MACHINES

All plant, equipment, and tools used in the performance of the work will be subject to approval by the Contracting Officer before the work is started. Maintain all plant, equipment, and tools in satisfactory working condition at all times. Submit a list of proposed equipment, including descriptive data. Provide adequate equipment having the capability of minimizing segregation, producing the required compaction, meeting grade controls, thickness control, and smoothness requirements as set forth herein.

1.5 QUALITY ASSURANCE

Sampling and testing are the responsibility of the Contractor. Perform sampling and testing using a laboratory approved in accordance with Section 01 45 00 QUALITY CONTROL. Work requiring testing will not be permitted until the testing laboratory has been inspected and approved. Test the materials to establish compliance with the specified requirements and perform testing at the specified frequency. The Contracting Officer may specify the time and location of the tests. Furnish copies of test results to the Contracting Officer within 24 hours of completion of the tests.

1.5.1 Sampling

Take samples for laboratory testing in conformance with ASTM D75/D75M. When deemed necessary, the sampling will be observed by the Contracting Officer.

1.5.2 Testing

1.5.2.1 Sieve Analysis

Perform sieve analysis in conformance with ASTM C117 and ASTM C136/C136M using sieves conforming to ASTM E11.

1.5.2.2 Liquid Limit and Plasticity Index

Determine liquid limit and plasticity index in accordance with ASTM D4318.

1.5.2.3 Moisture-Density Determinations

Determine the laboratory maximum dry density and optimum moisture content in accordance with paragraph DEGREE OF COMPACTION.

1.5.2.4 Field Density Tests

Measure field density in accordance with ASTM D1556/D1556M, ASTM D2167 or ASTM D6938. For the method presented in ASTM D1556/D1556M use the base plate as shown in the drawing. For the method presented in ASTM D6938 check the calibration curves and adjust them, if necessary, using only the sand cone method as described in paragraph Calibration, of the ASTM publication. Tests performed in accordance with ASTM D6938 result in a wet unit weight of soil and ASTM D6938 will be used to determine the moisture content of the soil. Also check the calibration curves furnished with the moisture gauges along with density calibration checks as described in ASTM D6938. Make the calibration checks of both the density and moisture gauges using the prepared containers of material method, as described in paragraph Calibration of ASTM D6938, on each different type of material being tested at the beginning of a job and at intervals as directed. Submit calibration curves and related test results prior to using the device or equipment being calibrated.

1.5.2.5 Wear Test

Perform wear tests on aggregate surface course material in conformance with ASTM C131/C131M.

1.6 ENVIRONMENTAL REQUIREMENTS

Perform construction when the atmospheric temperature is above 35 degrees F. It is the responsibility of the Contractor to protect, by approved method or methods, all areas of surfacing that have not been accepted by the Contracting Officer. Bring surfaces damaged by freeze, rainfall, or other weather conditions to a satisfactory condition.

PART 2 PRODUCTS

2.1 AGGREGATES

Provide aggregates consisting of clean, sound, durable particles of natural gravel, crushed gravel, crushed stone, sand, slag, soil, or other

approved materials processed and blended or naturally combined. Provide aggregates free from lumps and balls of clay, organic matter, objectionable coatings, and other foreign materials. The Contractor is responsible for obtaining materials that meet the specification and can be used to meet the grade and smoothness requirements specified herein after all compaction and proof rolling operations have been completed.

2.1.1 Coarse Aggregates

The material retained on the No. 4 sieve is known as coarse aggregate. Use only coarse aggregates that are reasonably uniform in density and quality. Use only coarse aggregate having a percentage of wear not exceeding 50 percent after 500 revolutions as determined by ASTM C131/C131M. The amount of flat and/or elongated particles must not exceed 20 percent. A flat particle is one having a ratio of width to thickness greater than three; an elongated particle is one having a ratio of length to width greater than three. When the coarse aggregate is supplied from more than one source, aggregate from each source must meet the requirements set forth herein.

2.1.2 Fine Aggregates

The material passing the No. 4 sieve is known as fine aggregate. Fine aggregate consists of screenings, sand, soil, or other finely divided mineral matter that is processed or naturally combined with the coarse aggregate.

2.1.3 Gradation Requirements

Gradation requirements specified in TABLE I apply to the completed aggregate surface. It is the responsibility of the Contractor to obtain materials that will meet the gradation requirements after mixing, placing, compacting, and other operations. TABLE I shows permissible gradings for granular material used in aggregate surface roads and airfields. Use sieves conforming to ASTM E11.

TABLE I. GRADATION FOR AGGREGATE SURFACE COURSES
Percentage by Weight Passing Square-Mesh Sieve

Sieve Designation	No. 1
3 inch	100
2-1/2 inch	80-100
2 inch	60-85
1 1/2	50-70
1 inch	25-50
1/2	05-20
3/8	0-10

TABLE I. GRADATION FOR AGGREGATE SURFACE COURSES Percentage by Weight Passing Square-Mesh Sieve	
Sieve Designation	No. 1
No. 4	0-3

2.2 LIQUID LIMIT AND PLASTICITY INDEX

The portion of the completed aggregate surface course passing the No. 40 sieve must have a maximum liquid limit of 35 and a plasticity index of 4 to 9.

2.3 TESTS, INSPECTIONS, AND VERIFICATIONS

2.3.1 Initial Tests

Perform one of each of the following tests, on the proposed material prior to commencing construction, to demonstrate that the proposed material meets all specified requirements when furnished. Complete this testing for each source if materials from more than one source are proposed.

a. Sieve Analysis.

b. Liquid limit and plasticity index.

c. Moisture-density relationship.

d. Wear.

Submit certified copies of test results for approval not less than 30 days before material is required for the work.

2.3.2 Approval of Material

Tentative approval of material will be based on initial test results.

PART 3 EXECUTION

3.1 OPERATION OF AGGREGATE SOURCES

Finalize aggregate sources on private lands in agreement with local laws or authorities.

3.2 STOCKPILING MATERIAL

Prior to stockpiling the material, clear and level the storage sites. Stockpile all materials, including approved material available from excavation and grading, in the manner and at the locations designated. Stockpile aggregates in such a manner that will prevent segregation. Stockpile aggregates and binders obtained from different sources separately.

3.3 PREPARATION OF UNDERLYING SUBGRADE

Clean the subgrade and shoulders of all foreign substances. Do not construct the surface course on subgrade that is frozen material. Correct

ruts or soft yielding spots in the subgrade, areas having inadequate compaction and deviations of the surface from the requirements set forth herein by loosening and removing soft or unsatisfactory material and by adding approved material, reshaping to line and grade and recompacting to density requirements specified in Section 32 11 20 BASE COURSE FOR RIGID AND SUBBASE FOR FLEXIBLE PAVING. Do not allow traffic or other operations to disturb the completed subgrade and maintain in a satisfactory condition until the surface course is placed.

3.4 GRADE CONTROL

During construction, maintain the lines and grades including crown and cross slope indicated for the aggregate surface course by means of line and grade stakes placed by the Contractor in accordance with the SPECIAL CONTRACT REQUIREMENTS.

3.5 MIXING AND PLACING MATERIALS

Mix and place the materials to obtain uniformity of the material and a uniform optimum water content for compaction. Make adjustments in mixing, placing procedures, or in equipment to obtain the true grades, to minimize segregation and degradation, to obtain the desired water content, and to ensure a satisfactory surface course.

3.6 LAYER THICKNESS

Place the aggregate material on the subgrade in layers of uniform thickness. Compact the completed aggregate surface course to the thickness indicated. No individual layer may be thicker than 6 inches nor be thinner than 3 inches in compacted thickness. Compact the aggregate surface course to a total thickness that is within 1/2 inch of the thickness indicated. Where the measured thickness is more than 1/2 inch deficient, correct such areas by scarifying, adding new material of proper gradation, reblading, and recompacting as directed. Where the measured thickness is more than 1/2 inch thicker than indicated, the course will be considered as conforming to the specified thickness requirements. The average job thickness will be the average of all thickness measurements taken for the job and must be within 1/4 inch of the thickness indicated. Measure the total thickness of the aggregate surface course at intervals of one measurement for each 500 square yards of surface course. Measure total thickness using 3 inch diameter test holes penetrating the aggregate surface course.

3.7 COMPACTION

Degree of compaction is a percentage of the maximum density obtained by the test procedure presented in ASTM D1557 abbreviated herein as percent laboratory maximum density. Compact each layer of the aggregate surface course with approved compaction equipment, as required in the following paragraphs. Maintain the water content during the compaction procedure at optimum or at the percentage specified by the Contracting Officer. Compact the mixture with mechanical tampers in locations not accessible to rollers. Continue compaction until each layer through the full depth is compacted to at least 100 percent of laboratory maximum density. Remove any materials that are found to be unsatisfactory and replace them with satisfactory material or rework them to produce a satisfactory material.

3.8 PROOF ROLLING

In addition to the compaction specified above, proof roll the designated areas by application of 30 coverages of a heavy rubber-tired roller having four tires abreast with each tire loaded to 30,000 pounds and tires inflated to150 psi. In the areas designated, proof roll the top lift of layer on which surface course is laid and to each layer of the surface course. Maintain the water content of the lift of the layer on which the surface course is placed and each layer of the aggregate surface course at optimum or at the percentage directed from the start of compaction to the completion of a proof rolling. Remove and replace materials in the aggregate surface course or underlying materials indicated to be unacceptable by the proof rolling with acceptable materials as directed.

3.9 EDGES OF AGGREGATE SURFACE COURSE

Place approved material along the edges of the aggregate surface course in such quantity as to compact to the thickness of the course being constructed. Simultaneously roll and compact at least 1 foot of shoulder width with the rolling and compacting of each layer of the surface course when the course is being constructed in two or more layers.

3.10 SMOOTHNESS TEST

Construct each layer so that the surface shows no deviations in excess of 3/8 inch when tested with a 10 foot straightedge applied both parallel with and at right angles to the centerline of the area to be paved. Correct deviations exceeding this amount by removing material, replacing with new material, or reworking existing material and compacting, as directed.

3.11 FIELD QUALITY CONTROL

3.11.1 In-Place Tests

Perform each of the following tests on samples taken from the placed and compacted aggregate surface course. Take samples and test at the rates indicated.

a. Perform density tests on every lift of material placed and at a frequency of one set of tests for every 250 square yards, or portion thereof, of completed area.

b. Perform sieve analysis on every lift of material placed and at a frequency of one sieve analysis for every 500 square yards, or portion thereof, of material placed.

c. Perform liquid limit and plasticity index tests at the same frequency as the sieve analysis.

d. Measure the thickness of the aggregate surface course at intervals providing at least one measurement for each 500 square yards of base course or part thereof. Measure the thickness using test holes, at least 3 inch in diameter through the aggregate surface course.

3.11.2 Approval of Material

Final approval of the materials will be based on tests for gradation, liquid limit, and plasticity index performed on samples taken from the

completed and full coompacted aggregate surface course.

3.12 MAINTENANCE

Maintain the aggregate surface course in a condition that will meet all specification requirements until accepted.

-- End of Section --

SECTION 32 16 19

CONCRETE CURBS, GUTTERS AND SIDEWALKS
05/18

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 182	(2005; R 2021) Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats

ASTM INTERNATIONAL (ASTM)

ASTM A615/A615M	(2024) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A1064/A1064M	(2024) Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
ASTM C31/C31M	(2024c) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C143/C143M	(2020) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C171	(2020) Standard Specification for Sheet Materials for Curing Concrete
ASTM C172/C172M	(2017) Standard Practice for Sampling Freshly Mixed Concrete
ASTM C173/C173M	(2024a) Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C231/C231M	(2024) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C309	(2019) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C920	(2018; R 2024) Standard Specification for Elastomeric Joint Sealants

ASTM D1751	(2018) Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D1752	(2018) Standard Specification for Preformed Sponge Rubber, Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction
ASTM D5893/D5893M	(2016) Standard Specification for Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements

INTERNATIONAL CODE COUNCIL (ICC)

ICC A117.1	(2017) Standard And Commentary Accessible and Usable Buildings and Facilities

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Concrete

Biodegradable Form Release Agent

SD-06 Test Reports

Field Quality Control

1.3 EQUIPMENT, TOOLS, AND MACHINES

1.3.1 General Requirements

Plant, equipment, machines, and tools used in the work will be subject to approval and must be maintained in a satisfactory working condition at all times. Use equipment capable of producing the required product, meeting grade controls, thickness control and smoothness requirements as specified. Discontinue using equipment that produces unsatisfactory results. Allow the Contracting Officer access at all times to the plant and equipment to ensure proper operation and compliance with specifications.

1.3.2 Slip Form Equipment

Slip form paver or curb forming machines, will be approved based on trial use on the job and must be self-propelled, automatically controlled, crawler mounted, and capable of spreading, consolidating, and shaping the plastic concrete to the desired cross section in one pass.

1.4 ENVIRONMENTAL REQUIREMENTS

1.4.1 Placing During Cold Weather

Do not place concrete when the air temperature reaches 40 degrees F and is falling, or is already below that point. Placement may begin when the air temperature reaches 35 degrees F and is rising, or is already above 40 degrees F. Make provisions to protect the concrete from freezing during the specified curing period. If necessary to place concrete when the temperature of the air, aggregates, or water is below 35 degrees F, placement and protection must be approved in writing. Approval will be contingent upon full conformance with the following provisions. Prepare and protect the underlying material so that it is entirely free of frost when the concrete is deposited. Heat mixing water and aggregates as necessary to result in the temperature of the in-place concrete being between 50 and 85 degrees F. Methods and equipment for heating must be approved. Use only aggregates that are free of ice, snow, and frozen lumps before entering the mixer. Provide covering or other means as needed to maintain the concrete at a temperature of at least 50 degrees F for not less than 72 hours after placing, and at a temperature above freezing for the remainder of the curing period.

1.4.2 Placing During Warm Weather

The temperature of the concrete as placed must not exceed 85 degrees F except where an approved retarder is used. Cool the mixing water and aggregates as necessary to maintain a satisfactory placing temperature. The placing temperature must not exceed 95 degrees F at any time.

PART 2 PRODUCTS

2.1 CONCRETE

Provide concrete conforming to the applicable requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE except as otherwise specified. Concrete must have a minimum compressive strength of 3500 psi at 28 days. Size of aggregate must not exceed 1-1/2 inches. Submit copies of certified delivery tickets for all concrete used in the construction.

2.1.1 Air Content

Use concrete mixtures that have an air content by volume of concrete of 5 to 7 percent, based on measurements made immediately after discharge from the mixer.

2.1.2 Slump

Use concrete with a slump of 3 inches plus or minus 1 inch for hand placed concrete or 1 inch plus or minus 1/2 inch for slipformed concrete as determined in accordance with ASTM C143/C143M.

2.1.3 Reinforcement Steel

Use reinforcement bars conforming to ASTM A615/A615M. Use wire mesh reinforcement conforming to ASTM A1064/A1064M.

2.2 CONCRETE CURING MATERIALS

2.2.1 Impervious Sheet Materials

Use impervious sheet materials conforming to ASTM C171, type optional, except that polyethylene film, if used, must be white opaque.

2.2.2 Burlap

Use burlap conforming to AASHTO M 182.

2.2.3 White Pigmented Membrane-Forming Curing Compound

Use white pigmented membrane-forming curing compound conforming to ASTM C309, Type 2.

2.3 CONCRETE PROTECTION MATERIALS

Use concrete protection materials consisting of a linseed oil mixture of equal parts, by volume, of linseed oil and either mineral spirits, naphtha, or turpentine. At the option of the Contractor, commercially prepared linseed oil mixtures, formulated specifically for application to concrete to provide protection against the action of deicing chemicals may be used, except that emulsified mixtures are not acceptable.

2.4 JOINT FILLER STRIPS

2.4.1 Contraction Joint Filler for Curb and Gutter

Use hard-pressed fiberboard contraction joint filler for curb and gutter.

2.4.2 Expansion Joint Filler, Premolded

Onless otherwise indicated, use 1/2 inch thick premolded expansion joint filler conforming to ASTM D1751 or ASTM D1752.

2.5 JOINT SEALANTS

Use cold-applied joint sealant conforming to ASTM C920 or ASTM D5893/D5893M.

2.6 FORM WORK

Design and construct form work to ensure that the finished concrete will conform accurately to the indicated dimensions, lines, and elevations, and within the tolerances specified. Use wood or steel forms that are straight and of sufficient strength to resist springing during depositing and consolidating concrete.

2.6.1 Wood Forms

Use forms that are surfaced plank, 2 inches nominal thickness, straight and free from warp, twist, loose knots, splits or other defects. Use forms with a nominal length of 10 feet. Radius bends may be formed with 3/4 inch boards, laminated to the required thickness.

2.6.2 Steel Forms

Use channel-formed sections with a flat top surface and welded braces at each end and at not less than two intermediate points. Use forms with

interlocking and self-aligning ends. Provide flexible forms for radius forming, corner forms, form spreaders, and fillers as needed. Use forms with a nominal length of 10 feet and that have a minimum of 3 welded stake pockets per form. Use stake pins consisting of solid steel rods with chamfered heads and pointed tips designed for use with steel forms.

2.6.3 Sidewalk Forms

Use sidewalk forms that are of a height equal to the full depth of the finished sidewalk.

2.6.4 Curb and Gutter Forms

Use curb and gutter outside forms that have a height equal to the full depth of the curb or gutter. Use rigid forms for curb returns, except that benders or thin plank forms may be used for curb or curb returns with a radius of 10 feet or more, where grade changes occur in the return, or where the central angle is such that a rigid form with a central angle of 90 degrees cannot be used. Back forms for curb returns may be made of 1-1/2 inch benders, for the full height of the curb, cleated together. In lieu of inside forms for curbs, a curb "mule" may be used for forming and finishing this surface, provided the results are approved.

2.6.5 Biodegradable Form Release Agent

Use form release agent that is colorless and biodegradableand that is composed of at least 87 percent biobased material. Provide product that does not bond with, stain, or adversely affect concrete surfaces and does not impair subsequent treatments of concrete surfaces. Provide form release agent that does not contain diesel fuel, petroleum-based lubricating oils, waxes, or kerosene.

2.7 Detectable Warning System

Detectable Warning Systems shown on the Contract plans are to meet requirements of ICC A117.1 - Section 705.

PART 3 EXECUTION

3.1 SUBGRADE PREPARATION

Construct subgrade to the specified grade and cross section prior to concrete placement.

3.1.1 Sidewalk Subgrade

Place and compact the subgrade in accordance with Section 32 11 20 BASE COURSE FOR RIGID AND SUBBASE FOR FLEXIBLE PAVING. Test the subgrade for grade and cross section with a template extending the full width of the sidewalk and supported between side forms.

3.1.2 Curb and Gutter Subgrade

Place and compact the subgrade in accordance with Section 32 11 20 BASE COURSE FOR RIGID AND SUBBASE FOR FLEXIBLE PAVING. Test the subgrade for grade and cross section by means of a template extending the full width of the curb and gutter. Use subgrade materials equal in bearing quality to the subgrade under the adjacent pavement.

3.1.3 Maintenance of Subgrade

Maintain subgrade in a smooth, compacted condition in conformity with the required section and established grade until the concrete is placed. The subgrade must be in a moist condition when concrete is placed. Prepare and protect subgrade so that it is free from frost when the concrete is deposited.

3.2 FORM SETTING

Set forms to the indicated alignment, grade and dimensions. Hold forms rigidly in place by a minimum of 3 stakes per form placed at intervals not to exceed 4 feet. Use additional stakes and braces at corners, deep sections, and radius bends, as required. Use clamps, spreaders, and braces where required to ensure rigidity in the forms. Remove forms in a manner that will not injure the concrete. Do not use bars or heavy tools against the concrete when removing the forms. Promptly and satisfactorily repair concrete found to be defective after form removal. Clean forms and coat with form oil or biodegradable form release agent each time before concrete is placed. Wood forms may, instead, be thoroughly wetted with water before concrete is placed, except that with probable freezing temperatures, oiling is mandatory.

3.2.1 Sidewalks

Set forms for sidewalks with the upper edge true to line and grade with an allowable tolerance of 1/8 inch in any 10 foot long section. After forms are set, grade and alignment must be checked with a 10 foot straightedge. Sidewalks must have a transverse slope of 1/4 inch per foot Unless otherwise indicated, construct sidewalks that are located adjacent to curbs with the low side adjacent to the curb. Do not remove side forms less than 12 hours after finishing has been completed.

3.2.2 Curbs and Gutters

Remove forms used along the front of the curb not less than 2 hours nor more than 6 hours after the concrete has been placed. Do not remove forms used along the back of curb until the face and top of the curb have been finished, as specified for concrete finishing. Do not remove gutter forms while the concrete is sufficiently plastic to slump in any direction.

3.3 SIDEWALK CONCRETE PLACEMENT AND FINISHING

3.3.1 Formed Sidewalks

Place concrete in the forms in one layer. When consolidated and finished, the sidewalks must be of the thickness indicated. Use a strike-off guided by side forms after concrete has been placed in the forms to bring the surface to proper section to be compacted. Consolidate concrete by tamping and spading or with an approved vibrator. Finish the surface to grade with a strike off.

3.3.2 Concrete Finishing

After straightedging, when most of the water sheen has disappeared, and just before the concrete hardens, finish the surface with a wood or magnesium float or darby to a smooth and uniformly fine granular or sandy texture free of waves, irregularities, or tool marks. Produce a scored surface by brooming with a fiber-bristle brush in a direction transverse

to that of the traffic, followed by edging.

3.3.3 Edge and Joint Finishing

Finish all slab edges, including those at formed joints, with an edger having a radius of 1/8 inch. Edge transverse joints before brooming. Eliminate the flat surface left by the surface face of the edger with brooming. Clean and solidly fill corners and edges which have crumbled and areas which lack sufficient mortar for proper finishing with a properly proportioned mortar mixture and then finish.

3.3.4 Surface and Thickness Tolerances

Finished surfaces must not vary more than 5/16 inch from the testing edge of a 10-foot straightedge. Permissible deficiency in section thickness will be up to 1/4 inch.

3.4 CURB AND GUTTER CONCRETE PLACEMENT AND FINISHING

3.4.1 Formed Curb and Gutter

Place concrete to the required section in a single lift. Consolidate concrete using approved mechanical vibrators. Curve shaped gutters must be finished with a standard curb "mule".

3.4.2 Curb and Gutter Finishing

Approved slipformed curb and gutter machines may be used in lieu of hand placement.

3.4.3 Concrete Finishing

Float and finish exposed surfaces with a smooth wood float until true to grade and section and uniform in texture. Brush floated surfaces with a fine-hair brush using longitudinal strokes. Round the edges of the gutter and top of the curb with an edging tool to a radius of 1/2 inch. Immediately after removing the front curb form, rub the face of the curb with a wood or concrete rubbing block and water until blemishes, form marks, and tool marks have been removed. Brush the front curb surface, while still wet, in the same manner as the curb top.

3.4.4 Joint Finishing

Finish curb edges at formed joints as indicated.

3.4.5 Surface and Thickness Tolerances

Finished surfaces must not vary more than 1/4 inch from the testing edge of a 10-foot straightedge. Permissible deficiency in section thickness will be up to 1/4 inch.

3.5 SIDEWALK JOINTS

Construct sidewalk joints to divide the surface into rectangular areas. Space transverse contraction joints at a distance equal to the sidewalk width or 5 feet on centers, whichever is less, and continuous across the slab. Construct longitudinal contraction joints along the centerline of all sidewalks 10 feet or more in width. Construct transverse expansion joints at sidewalk returns and opposite expansion joints in adjoining

curbs. Where the sidewalk is not in contact with the curb, install transverse expansion joints as indicated. Form expansion joints around structures and features which project through or into the sidewalk pavement, using joint filler of the type, thickness, and width indicated. Expansion joints are not required between sidewalks and curb that abut the sidewalk longitudinally.

3.5.1 Sidewalk Contraction Joints

Form contraction joints in the fresh concrete by cutting a groove in the top portion of the slab to a depth of at least one-fourth of the sidewalk slab thickness. Unless otherwise approved or indicated, either use a jointer to cut the groove or saw a groove in the hardened concrete with a power-driven saw. Construct sawed joints by sawing a groove in the concrete with a 1/8 inch blade. Provide an ample supply of saw blades on the jobsite before concrete placement is started. Provide at least one standby sawing unit in good working order at the jobsite at all times during the sawing operations.

3.5.2 Sidewalk Expansion Joints

Form expansion joints using 1/2 inch joint filler strips. Joint filler in expansion joints surrounding structures and features within the sidewalk may consist of preformed filler material conforming to ASTM D1752 or building paper. Hold joint filler in place with steel pins or other devices to prevent warping of the filler during floating and finishing. Immediately after finishing operations are completed, round joint edges using an edging tool having a radius of 1/8 inch. Remove any concrete over the joint filler. At the end of the curing period, clean the top of expansion joints and fill with cold-applied joint sealant. Use joint sealant that is gray or stone in color. Thoroughly clean the joint opening before the sealing material is placed. Do not spill sealing material on exposed surfaces of the concrete. Apply joint sealing material only when the concrete at the joint is surface dry and atmospheric and concrete temperatures are above 50 degrees F. Immediately remove any excess material on exposed surfaces of the concrete and clean the concrete surfaces.

3.5.3 Reinforcement Steel Placement

Accurately and securely fasten reinforcement steel in place with suitable supports and ties before the concrete is placed.

3.6 CURB AND GUTTER JOINTS

Construct curb and gutter joints at right angles to the line of curb and gutter.

3.6.1 Contraction Joints

Construct contraction joints directly opposite contraction joints in abutting portland cement concrete pavements and spaced so that monolithic sections between curb returns will not be less than 5 feet nor greater than 15 feet in length.

a. Construct contraction joints (except for slip forming) by means of 1/8 inch thick separators and of a section conforming to the cross section of the curb and gutter. Remove separators as soon as practicable after concrete has set sufficiently to preserve the width and shape of

the joint and prior to finishing.

b. When slip forming is used, cut the contraction joints in the top portion of the gutter/curb hardened concrete in a continuous cut across the curb and gutter, using a power-driven saw. Cut the contraction joint to a depth of at least one-fourth of the gutter/curb depth using a 1/8 inch saw blade.

3.6.2 Expansion Joints

Form expansion joints by means of preformed expansion joint filler material cut and shaped to the cross section of curb and gutter. Construct expansion joints in curb and gutter directly opposite expansion joints of abutting portland cement concrete pavement using the same type and thickness of joints as joints in the pavement. Where curb and gutter do not abut portland cement concrete pavement, provide expansion joints at least 1/2 inch in width at intervals not less than 30 feet nor greater than 120 feet. Seal expansion joints immediately following curing of the concrete or as soon thereafter as weather conditions permit. Seal expansion joints and the top 1 inch depth of curb and gutter contraction-joints with joint sealant. Thoroughly clean the joint opening before the sealing material is placed. Do not spill sealing material on exposed surfaces of the concrete. Concrete at the joint must be surface dry and atmospheric and concrete temperatures must be above 50 degrees F at the time of application of joint sealing material. Immediately remove excess material on exposed surfaces of the concrete and clean concrete surfaces.

3.7 CURING AND PROTECTION

3.7.1 General Requirements

Protect concrete against loss of moisture and rapid temperature changes for at least 7 days from the beginning of the curing operation. Protect unhardened concrete from rain and flowing water. All equipment needed for adequate curing and protection of the concrete must be on hand and ready for use before actual concrete placement begins. Protect concrete as necessary to prevent cracking of the pavement due to temperature changes during the curing period.

3.7.1.1 Mat Method

Cover the entire exposed surface with two or more layers of burlap. Overlap mats at least 6 inches. Thoroughly wet the mat with water prior to placing on concrete surface and keep the mat continuously in a saturated condition and in intimate contact with concrete for not less than 7 days.

3.7.1.2 Impervious Sheeting Method

Wet the entire exposed surface with a fine spray of water and then cover with impervious sheeting material. Lay sheets directly on the concrete surface with the light-colored side up and overlapped 12 inches when a continuous sheet is not used. Use sheeting that is not less than 18-inches wider than the concrete surface to be cured. Secure sheeting using heavy wood planks or a bank of moist earth placed along edges and laps in the sheets. Satisfactorily repair or replace sheets that are torn or otherwise damaged during curing. Sheeting must remain on the concrete surface to be cured for not less than 7 days.

3.7.1.3 Membrane Curing Method

Apply a uniform coating of white-pigmented membrane-curing compound to the entire exposed surface of the concrete as soon after finishing as the free water has disappeared from the finished surface. Coat formed surfaces immediately after the forms are removed and in no case longer than 1 hour after the removal of forms. Do not allow concrete surface to dry before application of the membrane. If drying has occurred, moisten the surface of the concrete with a fine spray of water and apply the curing compound as soon as the free water disappears. Apply curing compound in two coats by hand-operated pressure sprayers at a coverage of approximately 200 square feet/gallon for the total of both coats. Apply the second coat in a direction approximately at right angles to the direction of application of the first coat. The compound must form a uniform, continuous, coherent film that will not check, crack, or peel and must be free from pinholes or other imperfections. If pinholes, abrasion, or other discontinuities exist, apply an additional coat to the affected areas within 30 minutes. Respray concrete surfaces that are subjected to heavy rainfall within 3 hours after the curing compound has been applied by the method and at the coverage specified above. Respray areas where the curing compound is damaged by subsequent construction operations within the curing period. Take precautions necessary to ensure that the concrete is properly cured at sawed joints, and that no curing compound enters the joints. Tightly seal the top of the joint opening and the joint groove at exposed edges before the concrete in the region of the joint is resprayed with curing compound. Use a method used for sealing the joint groove that prevents loss of moisture from the joint during the entire specified curing period. Provide approved standby facilities for curing concrete pavement at a location accessible to the jobsite for use in the event of mechanical failure of the spraying equipment or other conditions that might prevent correct application of the membrane-curing compound at the proper time. Adequately protect concrete surfaces to which membrane-curing compounds have been applied during the entire curing period from pedestrian and vehicular traffic, except as required for joint-sawing operations and surface tests, and from other possible damage to the continuity of the membrane.

3.7.2 Backfilling

After curing, remove debris and backfill, grade, and compact the area adjoining the concrete to conform to the surrounding area in accordance with lines and grades indicated.

3.7.3 Protection

Protect completed concrete from damage until accepted. Repair damaged concrete and clean concrete discolored during construction. Remove and reconstruct concrete that is damaged for the entire length between regularly scheduled joints. Refinishing the damaged portion will not be acceptable. Dispose of removed material as directed.

3.7.4 Protective Coating

Apply a protective coating of linseed oil mixture to the exposed-to-view concrete surface after the curing period, if concrete will be exposed to de-icing chemicals within 6 weeks after placement. Moist cure concrete to receive a protective coating.

3.7.4.1 Application

Complete curing and backfilling operation prior to applying two coats of protective coating. Concrete must be surface dry and clean before each application. Spray apply at a rate of not more than 50 square yards/gallon for first application and not more than 70 square yards/gallon for second application, except that the number of applications and coverage for each application for commercially prepared mixture must be in accordance with the manufacturer's instructions. Protect coated surfaces from vehicular and pedestrian traffic until dry.

3.7.4.2 Precautions

Do not heat protective coating by direct application of flame or electrical heaters and protect the coating from exposure to open flame, sparks, and fire adjacent to open containers or applicators. Do not apply material at ambient or material temperatures lower than 50 degrees F.

3.8 FIELD QUALITY CONTROL

Submit copies of all test reports within 24 hours of completion of the test.

3.8.1 General Requirements

Perform the inspection and tests described and meet the specified requirements for inspection details and frequency of testing. Based upon the results of these inspections and tests, take the action and submit reports as required below, and additional tests to ensure that the requirements of these specifications are met.

3.8.2 Concrete Testing

3.8.2.1 Strength Testing

Take concrete samples in accordance with ASTM C172/C172M not less than once a day nor less than once for every 250 cubic yards of concrete placed. Mold cylinders in accordance with ASTM C31/C31M for strength testing by an approved laboratory. Each strength test result must be the average of 2 test cylinders from the same concrete sample tested at 28 days, unless otherwise specified or approved. Concrete specified on the basis of compressive strength will be considered satisfactory if the averages of all sets of three consecutive strength test results equal or exceed the specified strength, and no individual strength test result falls below the specified strength by more than 500 psi.

3.8.2.2 Air Content

Determine air content in accordance with ASTM C173/C173M or ASTM C231/C231M. Use ASTM C231/C231M with concretes and mortars made with relatively dense natural aggregates. Make two tests for air content on randomly selected batches of each class of concrete placed during each shift. Make additional tests when excessive variation in concrete workability is reported by the placing foreman or the Government inspector. Notify the placing foreman if results are out of tolerance. The placing foreman must take appropriate action to have the air content corrected at the plant. Additional tests for air content will be performed on each truckload of material until such time as the air content is within the tolerance specified.

3.8.2.3 Slump Test

Perform two slump tests on randomly selected batches of each class of concrete for every 250 cubic yards, or fraction thereof, of concrete placed during each shift. Perform additional tests when excessive variation in the workability of the concrete is noted or when excessive crumbling or slumping is noted along the edges of slip-formed concrete.

3.8.3 Thickness Evaluation

Determine the anticipated thickness of the concrete prior to placement by passing a template through the formed section or by measuring the depth of opening of the extrusion template of the curb forming machine. If a slip form paver is used for sidewalk placement, construct the subgrade true to grade prior to concrete placement. The thickness will be determined by measuring each edge of the completed slab.

3.8.4 Surface Evaluation

Provide finished surfaces for each category of the completed work that are uniform in color and free of blemishes and form or tool marks.

3.9 SURFACE DEFICIENCIES AND CORRECTIONS

3.9.1 Thickness Deficiency

When measurements indicate that the completed concrete section is deficient in thickness by more than 1/4 inch the deficient section will be removed, between regularly scheduled joints, and replaced.

3.9.2 High Areas

In areas not meeting surface smoothness and plan grade requirements, reduce high areas either by rubbing the freshly finished concrete with carborundum brick and water when the concrete is less than 36 hours old or by grinding the hardened concrete with an approved surface grinding machine after the concrete is 36 hours old or more. The area corrected by grinding the surface of the hardened concrete must not exceed 5 percent of the area of any integral slab, and the depth of grinding must not exceed 1/4 inch. Remove and replace pavement areas requiring grade or surface smoothness corrections in excess of the limits specified.

3.9.3 Appearance

Exposed surfaces of the finished work will be inspected by the Contracting Officer and deficiencies in appearance will be identified. Remove and replace areas which exhibit excessive cracking, discoloration, form marks, or tool marks or which are otherwise inconsistent with the overall appearances of the work.

3.10 DETECTABLE WARNING SYSTEM

Install Detectable Warning Systems required by Contract plans in accordance with ICC A117.1, Section 705, and by manufacturers' installation instructions.

-- End of Section --

SECTION 32 31 13

CHAIN LINK FENCES AND GATES
11/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A392	(2011; R 2022a) Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric
ASTM A780/A780M	(2020) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM A824	(2001; R 2022) Standard Specification for Metallic-Coated Steel Marcelled Tension Wire for Use With Chain Link Fence
ASTM C94/C94M	(2024c) Standard Specification for Ready-Mixed Concrete
ASTM F567	(2023) Standard Practice for Installation of Chain Link Fence
ASTM F626	(2014; R 2023) Standard Specification for Fence Fittings
ASTM F883	(2013; R 2022) Standard Performance Specification for Padlocks

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS RR-F-191/1	(Rev F) Fencing, Wire and Post, Metal (Chain-Link Fence Fabric)
FS RR-F-191/2	(Rev E) Fencing, Wire and Post, Metal (Chain-Link Fence Gates)
FS RR-F-191/3	(2023; Rev F) Fencing, Wire and Post, Metal (Chain-Link Fence Posts, Top Rails and Braces)
FS RR-F-191/4	(Rev F) Fencing, Wire and Post, Metal (Chain-Link Fence Accessories)

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance

with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Fence Assembly; G

Gate Hardware and Accessories; G

SD-03 Product Data

Fence Assembly; G

Gate Assembly; G

Gate Hardware and Accessories; G

Zinc Coating; G

Fabric; G

Stretcher Bars; G

Concrete; G

SD-04 Samples

Fabric; G

Posts; G

Braces; G

Line Posts; G

Sleeves; G

Top Rail; G

Bottom Rail; G

Tension Wire; G

Stretcher Bars; G

Gate Posts; G

Gate Hardware and Accessories; G

Padlocks; G

Wire Ties; G

SD-07 Certificates

Certificates of Compliance

1.3 QUALITY CONTROL

1.3.1 Certificates of Compliance

Submit certificates of compliance in accordance with the applicable reference standards and descriptions of this section for the following:

a. Zinc coating

b. Fabric

c. Stretcher bars

d. Gate hardware and accessories

e. Concrete

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver materials to site in an undamaged condition. Store materials off the ground to provide protection against oxidation caused by ground contact.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Submit reports of listing chain-link fencing and accessories regarding weight in ounces for zinc coating.

Submit manufacturer's catalog data for complete fence assembly, gate assembly, gate hardware and accessories.

2.2 FENCES

2.2.1 Fabric

FS RR-F-191/1; Type I, zinc-coated steel, 9 gauge conforming to ASTM A392, with 2.0 ounces per square foot of coated surface. Provide selvage twisted and barbed at both selvages. Height of fabric, as indicated.

Provide fabric consisting of wires woven into a 2 inch diamond mesh. Provide one-piece fabric widths for fence heights up to 12 feet.

2.2.1.1 Top and Bottom Selvages

Provide knuckled selvages at top and bottom for fabric with 2 inch mesh and up to 60 inches high, and if over 60 inches high, provide twisted and barbed on both selvages.

Knuckle top and bottom selvages for 1-3/4 inch and 1 inch mesh fabric.

2.2.2 Posts

2.2.2.1 Metal

2.2.2.1.1 Line Posts

Provide line posts complying with FS RR-F-191/3. Provide Class 1, steel

pipe, Grade A or B, Regular Strength.

2.2.2.1.2 End, Corner and Pull Posts

Provide end, corner, and pull posts in minimum sizes listed in FS RR-F-191/3 for each class and grade. Provide Class 1, steel pipe, Grade Regular Strength.

2.2.2.1.3 Steel Pipe, Class 1, Grade B Test Requirements

Steel pipe, Class 1, Grade B meeting the following performance criteria when subjected to salt spray testing in accordance with ASTM B117:

a. Exterior: 1,000 hours with maximum 5 percent red rust.

b. Interior: 650 hours with maximum 5 percent red rust.

2.2.2.2 Post Tops

Provide aluminum tops and designed as a weathertight closure cap. Post top to have finish and coating matching rails and posts. Provide one cap for each post, unless equal protection is provided by a combination post-cap and wire supporting arm. Provide caps with an opening to permit through passage of the top rail.

2.2.3 Braces and Rails

Class 1, steel pipe, Grade A or B, Regular Strength.

2.2.3.1 Top Rail

Provide top rail conforming to minimum sizes specified in FS RR-F-191/3 for each class and grade unless members are to be oversized. Provide expansion couplings 6 inches long at each joint in top rails.

2.2.3.2 Bottom Rail

Provide bottom rail conforming to minimum sizes specified in FS RR-F-191/3 for each class and grade unless members are to be oversized.

2.2.3.3 Post-Brace Assembly

Provide bracing conforming to minimum sizes specified in FS RR-F-191/3 for each class and grade, and 3/8 inch adjustable truss rods and turnbuckles.

2.2.4 Wire Ties

Provide 9-gauge wire for tying fabric to line posts,spaced 12 inches on center. For tying fabric to rails and braces, space wire ties 24 inches on center. For tying fabric to tension wire, space 0.105-inch hog rings 24 inches on center. Manufacturer's standard procedure will be accepted if of equal strength and durability.

FS RR-F-191/4. Provide wire ties constructed of the same material and coating as the fencing fabric.

2.2.5 Sleeves

Provide sleeves for setting into concrete construction of the same

material as post sections, sized 1 inch greater than the diameter or dimension of the post. Weld flat plates to each sleeve base to provide anchorage and prevent intrusion of concrete.

2.2.6 Stretcher Bars

Provide bars that have one-piece lengths equal to the full height of the fabric with a minimum cross section of 3/16 by 3/4 inch, in accordance with ASTM F626.

2.2.7 Stretcher Bar Bands

Provide bar bands for securing stretcher bars to posts that are steel, wrought iron, or malleable iron spaced not over 15 inches on center. Bands may also be used in conjunction with special fittings for securing rails to posts. Provide bands with projecting edges chamfered or eased.

2.2.8 Tension Wire

Provide metallic coated steel marcelled tension wire,(No. 7-gauge) complying with ASTM A824. Provide zinc-coated steel wire with zinc coating that weighs not less than 1.2 ounces per square foot.

2.2.9 Miscellaneous Hardware

Provide miscellaneous hot-dip galvanized hardware as required.

2.3 GATES

FS RR-F-191/2; Type II, double swing. Shape and size of gate frame, as indicated. Framing and bracing members, round of steel alloy. Steel member finish, zinc-coated. Provide gate frames and braces of minimum sizes listed in FS RR-F-191/3 for each Class and Grade, except that steel pipe frames are a minimum of 1.90 inches o.d., 0.120 inches minimum wall thickness and aluminum pipe frames and intermediate braces are 1.869 inches o.d. minimum, 0.940 lb/ft of length. Provide truss rods or intermediate braces for gate leaves less than 8 feet wide.

2.3.1 Gate Posts

Provide gate posts for supporting each gate leaf in minimum sizes listed in FS RR-F-191/3 for each material class and grade. Gate post material class, grade and finish to match other fence posts.

2.3.2 Gate Fabric

Gate fabric, is as specified for fencing fabric. Attach gate fabric to gate frame in accordance with manufacturer's standards, except that welding is not permitted.

2.3.3 Gate Frame

Provide gate frame assembly that is welded or assembled with special malleable or pressed-steel fittings and rivets to provide rigid connections. Install fabric with stretcher bars at vertical edges; stretcher bars may also be used at top and bottom edges. Attach stretcher bars and fabric to gate frames on all sides at intervals not exceeding 15 inches. Attach hardware with rivets or by other means which provides equal security against breakage or removal.

2.3.4 Padlocks

Provide padlocks conforming to ASTM F883, with chain.

2.3.5 Gate Hardware and Accessories

Provide gate hardware and accessories that conforms to ASTM A392 and ASTM F626, and as specified. Coating for steel latches, stops, hinges, keepers, and accessories, is galvanized

a. Provide forged steel hinges to suit gate size, non-lift-off type, offset to permit 180-degree opening. Provide hinge with stainless steel pin.

b. Provide latch that permits accessibility and operation from either side of the gate regardless of the latching arrangement, and with a padlock eye provided as an integral part of the latch. Provide fork or plunger bar type gate latches.

c. Provide stops and holders of malleable iron for vehicular gates. Provide stops that automatically engage the gate and hold it in the open position until manually released.

d. Provide accessories constructed of aluminum alloy in conformance with ASTM F626.

2.4 MATERIALS

2.4.1 Zinc Coating

Provide zinc-coated ferrous metal components and accessories that are factory coated after fabrication, except as otherwise specified.

For galvanizing field repairs, provide material that is cold-applied zinc-rich coating conforming to ASTM A780/A780M.

2.4.2 Concrete

Provide concrete conforming to ASTM C94/C94M, and obtaining a minimum 28-day compressive strength of 3,000 psi.

2.4.3 Grout

Provide grout of proportions one part portland cement to three parts clean, well-graded sand and a minimum amount of water to produce a workable mix.

PART 3 EXECUTION

Provide complete installation conforming to ASTM F567.

3.1 PREPARATION

Ensure final grading and established elevations are complete prior to commencing fence installation.

3.2 INSTALLATION

3.2.1 Fence Installation

Install fence on prepared surfaces to line and grade indicated. Install fence in accordance with fence manufacturer's written installation instructions except as modified herein.

3.2.1.1 Post Spacing

Provide line posts spaced equidistantly apart, not exceeding 10 feet on center. Provide gate posts spaced as necessary for size of gate openings. Do not exceed 500 feet on straight runs between braced posts. Provide corner or pull posts, with bracing in both directions, for changes in direction of 15 degrees or more, or for abrupt changes in grade.

3.2.1.2 Top and Bottom Tension Wire

Install top and bottom tension wires before installing chain-link fabric, and pull wires taut. Place top and bottom tension wires within 8 inches of respective fabric line.

3.2.2 Excavation

Provide excavations for post footings which are in virgin or compacted soil, of minimum sizes as indicated. Space footings for line posts 10 feet on center maximum and at closer intervals when indicated, with bottoms of the holes approximately 3 inches below the bottoms of the posts. Set bottom of each post not less than 36 inches below finished grade when in firm, undisturbed soil. Set posts deeper, as required, in soft and problem soils and for heavy, lateral loads. Remove excavated soil from Government property.

When solid rock is encountered near the surface, drill into the rock at least 12 inches for line posts and at least 18 inches for end, pull, corner, and gate posts. Drill holes at least 1 inch greater in diameter than the largest dimension of the placed post. If solid rock is below the soil overburden, drill to the full depth required except that penetration into rock need not exceed the minimum depths specified above.

3.2.3 Setting Posts

Remove loose and foreign materials from holes and moisten the soil prior to placing concrete. Provide tops of footings that are trowel finished and sloped or domed to shed water away from posts. Set hold-open devices, sleeves, and other accessories in concrete.

Keep exposed concrete moist for at least 7 calendar days after placement or cured with a membrane curing material, as approved. Maintain vertical alignment of posts in concrete construction until concrete has set.

3.2.3.1 Earth and Bedrock

Provide concrete bases of dimensions indicated on the manufactures installation drawings. Compact concrete to eliminate voids, and finish to a dome shape.

3.2.3.2 Bracing

Brace gate, corner, end, and pull posts to nearest post with a horizontal brace used as a compression member, placed at least 12 inches below top of fence.

3.2.3.3 Tolerances

Provide posts that are straight and plumb within a vertical tolerance of 1/4 inch after the fabric has been stretched. Provide fencing and gates that are true to line with no more than 1/2 inch deviation from the established centerline between line posts. Repair defects as directed.

3.2.4 Concrete Strength

Provide concrete that has attained at least 75 percent of its minimum 28-day compressive strength, but in no case sooner than 7 calendar days after placement, before rails, tension wire, or fabric are installed. Do not stretch fabric and wires or hang gates until the concrete has attained its full design strength.

Sample and test concrete in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.2.5 Top Rails

Provide top rails that run continuously through post caps or extension arms, bending to radius for curved runs. Provide expansion couplings as recommended by the fencing manufacturer.

3.2.6 Brace Assembly

Provide bracing assemblies at end and gate posts and at both sides of corner and pull posts, with the horizontal brace located at midheight of the fabric.

Install brace assemblies so posts are plumb when the diagonal rod is under proper tension. Provide two complete brace assemblies at corner and pull posts where required for stiffness and as indicated.

3.2.7 Tension Wire Installation

Install tension wire by weaving them through the fabric and tying them to each post with not less than 7-gauge galvanized wire or by securing the wire to the fabric with 10-gauge ties or clips spaced 24 inches on center.

3.2.8 Fabric Installation

Provide fabric in single lengths between stretch bars with bottom barbs placed approximately 1-1/2 inches above the ground line. Pull fabric taut and tied to posts, rails, and tension wire with wire ties and bands.

Install fabric on the security side of fence, unless otherwise directed. Ensure fabric remains under tension after the pulling force is released.

3.2.9 Stretcher Bar Installation

Thread stretcher bars through or clamped to fabric 4 inches on center and secured to posts with metal bands spaced 15 inches on center.

3.2.10 Gate Installation

Install gates plumb, level, and secure, with full opening without interference. Install ground set items in concrete for anchorage as recommended by the fence manufacturer. Adjust hardware for smooth operation and lubricated where necessary.

3.2.11 Tie Wires

Provide tie wires that are U-shaped to the pipe diameters to which attached. Twist ends of tie wires not less than two full turns and bent so as not to present a hazard.

3.2.12 Fasteners

Install nuts for tension bands and hardware on the side of the fence opposite the fabric side. Peen ends of bolts to prevent removal of nuts.

3.2.13 Zinc-Coating Repair

Clean and repair galvanized surfaces damaged by welding or abrasion, and cut ends of fabric, or other cut sections with specified galvanizing repair material applied in strict conformance with the manufacturer's printed instructions.

3.2.14 Accessories Installation

3.2.14.1 Post Caps

Design post caps to accommodate top rail. Install post caps as recommended by the manufacturer.

3.2.14.2 Padlocks

Provide padlocks for gate openings and provide chains that are securely attached to gate or gate posts. Provide padlocks keyed alike, and provide two keys for each padlock.

3.3 CLOSEOUT ACTIVITIES

Remove waste fencing materials and other debris from the work site.

-- End of Section --

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SECTION 33 71 02

UNDERGROUND ELECTRICAL DISTRIBUTION
08/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO HB-17	(2002; Errata 2003; Errata 2005, 17th Edition) Standard Specifications for Highway Bridges

AMERICAN CONCRETE INSTITUTE (ACI)

ACI 318M	(2019; Errata 2022) Building Code Requirements for Structural Concrete & Commentary
ACI MNL-66	(2020) ACI Detailing Manual

ASTM INTERNATIONAL (ASTM)

ASTM B1	(2013) Standard Specification for Hard-Drawn Copper Wire
ASTM B3	(2013; R 2024) Standard Specification for Soft or Annealed Copper Wire
ASTM B8	(2023) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM B800	(2005; R 2021) Standard Specification for 8000 Series Aluminum Alloy Wire for Electrical Purposes-Annealed and Intermediate Tempers
ASTM B801	(2018; R 2023) Standard Specification for Concentric-Lay-Stranded Conductors of 8000 Series Aluminum Alloy for Subsequent Covering or Insulation
ASTM C309	(2019) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C478	(2018) Standard Specification for Circular Precast Reinforced Concrete Manhole Sections

ASTM C857	(2016) Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures
ASTM C990	(2009; R 2019) Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE 400.2	(2024) Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF)
IEEE C2	(2023) National Electrical Safety Code
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C119.1	(2023) Electric Connectors - Sealed Insulated Underground Connector Systems Rated 600 Volts
NEMA RN 1	(2018) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA TC 2	(2020) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 3	(2021) Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing
NEMA TC 9	(2020) Standard for Fittings for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installation

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2026; TIA 26-1; ERTA 26-1; TIA 26-2; TIA 26-3; TIA 26-4; TIA 26-5; TIA 26-6; TIA 26-7; ERTA 26-2; ERTA 26-3) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-758	(2012b) Customer-Owned Outside Plant Telecommunications Infrastructure Standard

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS Bull 1751F-644	(2002) Underground Plant Construction

UL SOLUTIONS (UL)

UL 6	(2022) UL Standard for Safety Electrical Rigid Metal Conduit-Steel
UL 83	(2017; Reprint Oct 2025) UL Standard for Safety Thermoplastic-Insulated Wires and Cables
UL 94	(2023; Reprint Jan 2024) UL Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment
UL 486A-486B	(2018; Reprint Jul 2023) UL Standard for Safety Wire Connectors
UL 510	(2020; Dec 2022) UL Standard for Safety Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 514A	(2024) UL Standard for Safety Metallic Outlet Boxes
UL 514B	(2012; Reprint Mar 2024) UL Standard for Safety Conduit, Tubing and Cable Fittings
UL 651	(2011; Reprint May 2022) UL Standard for Safety Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings
UL 854	(2020; Reprint Jul 2024) Standard for Service-Entrance Cables

1.2 RELATED REQUIREMENTS

Section 26 08 00 APPARATUS INSPECTION AND TESTING applies to this section, with the additions and modifications specified herein.

1.3 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE Stds Dictionary.

b. In the text of this section, the words conduit and duct are used interchangeably and have the same meaning.

c. In the text of this section, "medium voltage cable splices," and "medium voltage cable joints" are used interchangeably and have the same meaning.

d. Underground structures subject to aircraft loading are indicated on the drawings.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Precast Underground Structures; G

SD-03 Product Data

Precast Concrete Structures; G

Sealing Material

Pulling-In Irons

Handhole Frames and Covers; G

SD-06 Test Reports

Field Acceptance Checks and Tests; G

Arc-proofing Test for cable fireproofing tape; G

Cable Installation Plan and Procedure; G

SD-07 Certificates

Cable splicer/terminator; G

Cable Installer Qualifications; G

1.5 QUALITY ASSURANCE

1.5.1 Precast Underground Structures

Submittal required for each type used. Provide calculations and drawings for precast manholes and handholes bearing the seal of a registered professional engineer including:

a. Material description (i.e., f'c and Fy)

b. Manufacturer's printed assembly and installation instructions

c. Design calculations

d. Reinforcing shop drawings in accordance with ACI MNL-66

e. Plans and elevations showing opening and pulling-in iron locations and details

1.5.2 Certificate of Competency for Cable Splicer/Terminator

The cable splicer/terminator must have a certification from the National Cable Splicing Certification Board (NCSCB) in the field of splicing and terminating shielded medium voltage (5 kV to 35 kV) power cable using pre-manufactured kits (pre-molded, heat-shrink, cold shrink). Submit "Proof of Certification" for approval, for the individuals that will be performing cable splicer and termination work, 30 days before splices or terminations are to be made.

1.5.3 Cable Installer Qualifications

Provide at least one onsite person in a supervisory position with a documentable level of competency and experience to supervise all cable pulling operations. Provide a resume showing the cable installers' experience in the last three years, including a list of references complete with points of contact, addresses and telephone numbers. Cable installer must demonstrate experience with a minimum of three medium voltage cable installations. The Contracting Officer reserves the right to require additional proof of competency or to reject the individual and call for an alternate qualified cable installer.

1.5.4 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship must be in accordance with the mandatory and advisory provisions of IEEE C2 and NFPA 70 unless more stringent requirements are specified or indicated.

1.5.5 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products must have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period must include applications of equipment and materials under similar circumstances and of similar size. The product must have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.5.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.5.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site are not acceptable, unless specified otherwise.

PART 2 PRODUCTS

2.1 CONDUIT, DUCTS, AND FITTINGS

2.1.1 Rigid Metal Conduit

UL 6.

2.1.1.1 Rigid Metallic Conduit, PVC Coated

NEMA RN 1, Type A40, except that hardness must be nominal 85 Shore A durometer, dielectric strength must be minimum 400 volts per mil at 60 Hz, and tensile strength must be minimum 3500 psi.

2.1.2 Plastic Conduit for Direct Burial and Riser Applications

UL 651 and NEMA TC 2, EPC-40.

2.1.3 Plastic Duct for Concrete Encasement

Provide Type EPC-40 per UL 651 and NEMA TC 2.

2.1.4 Duct Sealant

UL 94, Class HBF. Provide high-expansion urethane foam duct sealant that expands and hardens to form a closed, chemically and water resistant, rigid structure. Sealant must be compatible with common cable and wire jackets and capable of adhering to metals, plastics and concrete. Sealant must be capable of curing in temperature ranges of 35 degrees F to 95 degrees F. Cured sealant must withstand temperature ranges of -20 degrees F to 200 degrees F without loss of function.

2.1.5 Fittings

2.1.5.1 Metal Fittings

UL 514B.

2.1.5.2 PVC Conduit Fittings

UL 514B, UL 651, NEMA TC 3.

2.1.5.3 PVC Duct Fittings

NEMA TC 9.

2.1.5.4 Outlet Boxes for Steel Conduit

Outlet boxes for use with rigid or flexible steel conduit must be cast-metal cadmium or zinc-coated if of ferrous metal with gasketed closures and must conform to UL 514A.

2.2 LOW VOLTAGE INSULATED CONDUCTORS AND CABLES

Insulated conductors must be rated 600 volts and conform to the requirements of NFPA 70, including listing requirements. Wires and cables manufactured more than 24 months prior to date of delivery to the site are not acceptable. Service entrance conductors must conform to UL 854, type USE.

2.2.1 Conductor Types

Cable and duct sizes indicated are for copper conductors and THHN/THWN unless otherwise noted. Conductors No. 10 AWG and smaller must be solid. Conductors No. 8 AWG and larger must be stranded. All conductors must be copper.

2.2.2 Conductor Material

Unless specified or indicated otherwise or required by NFPA 70, wires in conduit, other than service entrance, must be 600-volt, Type THWN/THHN conforming to UL 83. Copper conductors must be annealed copper complying with ASTM B3 and ASTM B8. Aluminum conductors must be Type AA-8000 aluminum conductors complying with ASTM B800 and ASTM B801, and must be of an aluminum alloy listed or labeled by UL as "component aluminum-wire stock (conductor material). Type 1350 is not acceptable. Intermixing of copper and aluminum conductors in the same raceway is not permitted.

2.2.3 In Duct

Cables must be single-conductor cable.

2.2.4 Cable Marking

Insulated conductors must have the date of manufacture and other identification imprinted on the outer surface of each cable at regular intervals throughout the cable length.

Identify each cable by means of a fiber, laminated plastic, or non-ferrous metal tags in each manhole, handhole, junction box, and each terminal. Each tag must contain the following information; cable type, conductor size, circuit number, circuit voltage, cable destination and phase identification.

Color code conductors. Provide conductor identification within each enclosure where a tap, splice, or termination is made. Conductor identification must be by color-coded insulated conductors, plastic-coated self-sticking printed markers, colored nylon cable ties and plates, heat shrink type sleeves,or colored electrical tape. Properly identify control circuit terminations. Color must be green for grounding conductors and white for neutrals; except where neutrals of more than one system are installed in same raceway or box, other neutrals may be white with a different colored (not green) stripe for each. Color of ungrounded conductors in different voltage systems are as follows:

a. 208/120 volt, three-phase

    (1) Phase A - black

    (2) Phase B - red

(3) Phase C - blue

b. 480/277 volt, three-phase

(1) Phase A - brown

(2) Phase B - orange

(3) Phase C - yellow

c. 120/240 volt, single phase: Black and red

2.3 LOW VOLTAGE WIRE CONNECTORS AND TERMINALS

Provide a uniform compression over the entire conductor contact surface. Use solderless terminal lugs on stranded conductors.

a. For use with copper conductors: UL 486A-486B.

2.4 LOW VOLTAGE SPLICES

Provide splices in conductors with a compression connector on the conductor and by insulating and waterproofing using one of the following methods which are suitable for continuous submersion in water and comply with ANSI C119.1.

2.4.1 Heat Shrinkable Splice

Provide heat shrinkable splice insulation by means of a thermoplastic adhesive sealant material applied in accordance with the manufacturer's written instructions.

2.4.2 Cold Shrink Rubber Splice

Provide a cold-shrink rubber splice which consists of EPDM rubber tube which has been factory stretched onto a spiraled core which is removed during splice installation. The installation must not require heat or flame, or any additional materials such as covering or adhesive. It must be designed for use with inline compression type connectors, or indoor, outdoor, direct-burial or submerged locations.

2.5 TELECOMMUNICATIONS CABLING

Provide telecommunications cabling in accordance with Section 33 82 00 TELECOMMUNICATIONS OUTSIDE PLANT (OSP).

2.6 TAPE

2.6.1 Insulating Tape

UL 510, plastic insulating tape, capable of performing in a continuous temperature environment of 80 degrees C.

2.6.2 Buried Warning and Identification Tape

Provide detectable tape in accordance with Section 31 00 00 EARTHWORK.

2.6.3 Fireproofing Tape

Provide tape composed of a flexible, conformable, unsupported intumescent elastomer. Tape must be not less than .030 inch thick, noncorrosive to cable sheath, self-extinguishing, noncombustible, adhesive-free, and must not deteriorate when subjected to oil, water, gases, salt water, sewage, and fungus.

2.7 PULL ROPE

Plastic or flat pull line (bull line) having a minimum tensile strength of 200 pounds.

2.8 GROUNDING AND BONDING

2.8.1 Driven Ground Rods

Provide copper-clad steel ground rods conforming to UL 467 not less than 3/4 inch in diameter by 10 feet in length. Sectional type rods may be used for rods 20 feet or longer.

2.8.2 Grounding Conductors

Stranded-bare copper conductors must conform to ASTM B8, Class B, soft-drawn unless otherwise indicated. Solid-bare copper conductors must conform to ASTM B1 for sizes No. 8 and smaller. Insulated conductors must be of the same material as phase conductors and green color-coded, except that conductors must be rated no more than 600 volts. Aluminum is not acceptable.

2.9 CAST-IN-PLACE CONCRETE

Provide concrete in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE. In addition, provide concrete for encasement of underground ducts with 3000 psi minimum 28-day compressive strength. Concrete associated with electrical work for other than encasement of underground ducts must be 4000 psi minimum 28-day compressive strength unless specified otherwise.

2.10 UNDERGROUND STRUCTURES

Provide precast concrete underground structures or standard type cast-in-place manhole types as indicated, conforming to ASTM C857 and ASTM C478. Top, walls, and bottom must consist of reinforced concrete. Walls and bottom must be of monolithic concrete construction. Locate duct entrances and windows near the corners of structures to facilitate cable racking. Covers must fit the frames without undue play. Form steel and iron to shape and size with sharp lines and angles. Castings must be free from warp and blow holes that may impair strength or appearance. Exposed metal must have a smooth finish and sharp lines and arises. Provide necessary lugs, rabbets, and brackets. Set pulling-in irons and other built-in items in place before depositing concrete. Install a pulling-in iron in the wall opposite each duct line entrance. Cable racks, including rack arms and insulators, must be adequate to accommodate the cable.

2.10.1 Cast-In-Place Concrete Structures

Concrete must conform to Section 03 30 00 CAST-IN-PLACE CONCRETE.

2.10.2 Precast Concrete Structures, Risers and Tops

Precast concrete underground structures may be provided in lieu of cast-in-place subject to the requirements specified below. Precast units must be the product of a manufacturer regularly engaged in the manufacture of precast concrete products, including precast manholes.

2.10.2.1 General

Precast concrete structures must have the same accessories and facilities as required for cast-in-place structures. Likewise, precast structures must have plan area and clear heights not less than those of cast-in-place structures. Concrete materials and methods of construction must be the same as for cast-in-place concrete construction, as modified herein. Slope in floor may be omitted provided precast sections are poured in reinforced steel forms. Concrete for precast work must have a 28-day compressive strength of not less than 4000 psi. Structures may be precast to the design and details indicated for cast-in-place construction, precast monolithically and placed as a unit, or structures may be assembled sections, designed and produced by the manufacturer in accordance with the requirements specified. Structures must be identified with the manufacturer's name embedded in or otherwise permanently attached to an interior wall face.

2.10.2.2 Design for Precast Structures

ACI 318M. In the absence of detailed on-site soil information, design for the following soil parameters/site conditions:

a. Angle of Internal Friction (phi) = 30 degrees

b. Unit Weight of Soil (Dry) = 110 pcf, (Saturated) = 130 pcf

c. Coefficient of Lateral Earth Pressure (Ka) = 0.33

d. Ground Water Level = 3 feet below ground elevation

e. Vertical design loads must include full dead, superimposed dead, and live loads including a 30 percent magnification factor for impact. Live loads must consider all types and magnitudes of vehicular (automotive, industrial, or aircraft) traffic to be encountered. The minimum design vertical load must be for H20 highway loading per AASHTO HB-17.

f. Horizontal design loads must include full geostatic and hydrostatic pressures for the soil parameters, water table, and depth of installation to be encountered. Also, horizontal loads imposed by adjacent structure foundations, and horizontal load components of vertical design loads, including impact, must be considered, along with a pulling-in iron design load of 6000 pounds.

g. Each structural component must be designed for the load combination and positioning resulting in the maximum shear and moment for that particular component.

2.10.2.3 Construction

Provide a uniform thickness for structure top, bottom, and wall not less

than 6 inches. Thin-walled knock-out panels for designed or future duct bank entrances are not permitted. Provide quantity, size, and location of duct bank entrance windows as directed, and cast completely open by the precaster. Size of windows must exceed the nominal duct bank envelope dimensions by at least 12 inches vertically and horizontally to preclude in-field window modifications made necessary by duct bank misalignment. However, the sides of precast windows must be a minimum of 6 inches from the inside surface of adjacent walls, floors, or ceilings. Form the perimeter of precast window openings to have a keyed or inward flared surface to provide a positive interlock with the mating duct bank envelope. Provide welded wire fabric reinforcing through window openings for in-field cutting and flaring into duct bank envelopes. Provide additional reinforcing steel comprised of at least two No. 4 bars around window openings. Provide drain sumps a minimum of 12 inches in diameter and 4 inches deep for precast structures.

2.10.2.4 Joints

Provide tongue-and-groove joints on mating edges of precast components. Shiplap joints are not allowed. Design joints to firmly interlock adjoining components and to provide waterproof junctions and adequate shear transfer. Seal joints watertight using preformed plastic strip conforming to ASTM C990. Install sealing material in strict accordance with the sealant manufacturer's printed instructions. Provide waterproofing at conduit/duct entrances into structures, and where access frame meets the top slab, provide continuous grout seal.

2.10.3 Handhole Frames and Covers

Frames and covers of steel must be welded by qualified welders in accordance with standard commercial practice. Provide rolled-steel floor plate covers having an approved antislip surface. Hinges must be of stainless steel with bronze hinge pin, 5 by 5 inches by approximately 3/16 inch thick, without screw holes, and must be for full surface application by fillet welding. Hinges must have nonremovable pins and five knuckles. The surfaces of plates under hinges must be true after the removal of raised antislip surface, by grinding or other approved method.

2.11 CABLE TAGS IN HANDHOLES

Provide polyethylene tags for each power cable located in handholes. Do not provide handwritten letters. The first position on the power cable tag denotes the voltage. The second through sixth positions on the tag identifies the circuit. The next to last position denotes the phase of the circuit and include the Greek "phi" symbol. The last position denotes the cable size. As an example, a tag could have the following designation: "11.5 NAS 1-8(Phase A)500," denoting that the tagged cable is on the 11.5kV system circuit number NAS 1-8, underground, Phase A, sized at 500 kcmil.

2.11.1 Polyethylene Cable Tags

Provide tags of polyethylene having an average tensile strength of 3250 pounds per square inch; and that are 0.08 inch thick (minimum), non-corrosive non-conductive; resistive to acids, alkalis, organic solvents, and salt water; and distortion resistant to 170 degrees F. Provide 0.05 inch (minimum) thick black polyethylene tag holder. Provide a one-piece nylon, self-locking tie at each end of the cable tag, having a minimum loop tensile strength of 175 pounds and black block letters,

numbers, and symbols one inch high on a yellow background. Letters, numbers, and symbols must not fall off or change positions regardless of the cable tags' orientation.

2.12 SOURCE QUALITY CONTROL

2.12.1 Arc-Proofing Test for Cable Fireproofing Tape

Manufacturer must test one sample assembly consisting of a straight lead tube 12 inches long with a 2 1/2 inch outside diameter, and a 1/8 inch thick wall, and covered with one-half lap layer of arc and fireproofing tape per manufacturer's instructions. The arc and fireproofing tape must withstand extreme temperature of a high-current fault arc 13,000 degrees K for 70 cycles as determined by using an argon directed plasma jet capable of constantly producing and maintaining an arc temperature of 13,000 degrees K. Temperature (13,000 degrees K) of the ignited arc between the cathode and anode must be obtained from a dc power source of 305 (plus or minus 5) amperes and 20 (plus or minus 1) volts. Direct the arc toward the sample assembly accurately positioned 5 (plus or minus 1) millimeters downstream in the plasma from the anode orifice by fixed flow rate of argon gas (0.18 g per second). Test each sample assembly at three unrelated points. Start time for tests must be taken from recorded peak current when the specimen is exposed to the full test temperature. Surface heat on the specimen prior to that time must be minimal. The end point is established when the plasma or conductive arc penetrates the protective tape and strikes the lead tube. Submittals for arc-proofing tape must indicate that the test has been performed and passed by the manufacturer.

PART 3 EXECUTION

3.1 INSTALLATION

Install equipment and devices in accordance with the manufacturer's published instructions and with the requirements and recommendations of NFPA 70 and CALPUC G.O.128 as applicable. In addition to these requirements, install telecommunications in accordance with TIA-758 and RUS Bull 1751F-644.

3.2 CABLE INSPECTION

Inspect each cable reel for correct storage positions, signs of physical damage, and broken end seals prior to installation. If end seal is broken, remove moisture from cable prior to installation in accordance with the cable manufacturer's recommendations.

3.3 CABLE INSTALLATION PLAN AND PROCEDURE

Obtain from the manufacturer an installation manual or set of instructions which addresses such aspects as cable construction, insulation type, cable diameter, bending radius, cable temperature limits for installation, lubricants, coefficient of friction, conduit cleaning, storage procedures, moisture seals, testing for and purging moisture, maximum allowable pulling tension, and maximum allowable sidewall bearing pressure.

3.4 UNDERGROUND FEEDERS SUPPLYING BUILDINGS

Terminate underground feeders supplying building at a point 5 feet outside the building and projections thereof, except that conductors must be

continuous to the terminating point indicated. Coordinate connections of the feeders to the service entrance equipment with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide PVC, Type EPC-40 conduit from the supply equipment to a point 5 feet outside the building and projections thereof. Protect ends of underground conduit with plastic plugs until connections are made.

Encase the underground portion of the conduit in a concrete envelope and bury as specified for underground duct with concrete encasement.

3.5 UNDERGROUND STRUCTURE CONSTRUCTION

Provide standard type cast-in-place construction as specified herein and as indicated, or precast construction as specified herein. Horizontal concrete surfaces of floors must have a smooth trowel finish. Cure concrete by applying two coats of white pigmented membrane forming-curing compound in strict accordance with the manufacturer's printed instructions, except that precast concrete may be steam cured. Curing compound must conform to ASTM C309. Locate duct entrances and windows in the center of end walls (shorter) and near the corners of sidewalls (longer) to facilitate cable racking and splicing. Covers for underground structures must fit the frames without undue play. Form steel and iron to shape and size with sharp lines and angles. Castings must be free from warp and blow holes that may impair strength or appearance. Exposed metal must have a smooth finish and sharp lines and arises. Provide necessary lugs, rabbets, and brackets. Set pulling-in irons and other built-in items in place before depositing concrete.

3.5.1 Precast Concrete Construction

Set commercial precast structures on 6 inches of level, 90 percent compacted granular fill, 3/4 inch to 1 inch size, extending 12 inches beyond the structure on each side. Compact granular fill by a minimum of four passes with a plate type vibrator. Installation must additionally conform to the manufacturer's instructions.

3.5.2 Pulling-In Irons

Provide steel bars bent as indicated, and cast in the walls and floors. Alternatively, pipe sleeves may be precast into the walls and floors where required to accept U-bolts or other types of pulling-in devices possessing the strengths and clearances stated herein. The final installation of pulling-in devices must be made permanent. Cover and seal exterior projections of thru-wall type pulling-in devices with an appropriate protective coating. In the floor, locate the irons a minimum of 6 inches from the edge of the sump, and in the walls, locate the irons within 6 inches of the projected center of the duct bank pattern or precast window in the opposite wall. However, the pulling-in iron must not be located within 6 inches of an adjacent interior surface, or duct or precast window located within the same wall as the iron. If a pulling-in iron cannot be located directly opposite the corresponding duct bank or precast window due to this clearance limitation, locate the iron directly above or below the projected center of the duct bank pattern or precast window the minimum distance required to preserve the 6 inch clearance previously stated. In the case of directly opposing precast windows, pulling-in irons consisting of a 3 foot length of No. 5 reinforcing bar, formed into a hairpin, may be cast-in-place within the precast windows simultaneously with the end of the corresponding duct bank envelope. Irons installed in this manner must be positioned directly in line with, or when not

possible, directly above or below the projected center of the duct bank pattern entering the opposite wall, while maintaining a minimum clear distance of 3 inches from any edge of the cast-in-place duct bank envelope or any individual duct. Pulling-in irons must have a clear projection into the structure of approximately 4 inches and must be designed to withstand a minimum pulling-in load of 6000 pounds. Hot-dip galvanize irons after fabrication.

3.5.3 Field Painting

Clean cast-iron frames and covers not buried in concrete or masonry of mortar, rust, grease, dirt and other deleterious materials, and coat with bituminous paint.

3.6 UNDERGROUND CONDUIT AND DUCT SYSTEMS

3.6.1 Requirements

Run conduit in straight lines except where a change of direction is necessary. Provide numbers and sizes of ducts as indicated. Provide a 4/0 AWG bare copper grounding conductor above medium-voltage distribution duct banks. Ducts must have a continuous slope downward toward underground structures and away from buildings, laid with a minimum slope of 3 inches per 100 feet. Depending on the contour of the finished grade, the high-point may be at a terminal, a handhole, or between handholes. Terminate all PVC conduit end points in utility holes, switching cabinets, transform handholes and buildings with end bells. The bell end of the conduits that enter handholes must be flush with the wall.

Perform changes in ductbank direction as follows:

a. Short-radius manufactured 90-degree duct bends may be used only for pole or equipment risers, unless specifically indicated as acceptable.

b. The minimum manufactured bend radius must be 18 inches for ducts of less than 3 inch diameter, and 36 inches for ducts 3 inches or greater in diameter.

c. As an exception to the bend radius required above, provide field manufactured longsweep bends having a minimum radius of 25 feet for a change of direction of more than 5 degrees, either horizontally or vertically, using a combination of curved and straight sections. Maximum manufactured curved sections allowed for use in field manufactured longsweep bend: 30 degrees.

3.6.2 Treatment

Keep ducts clean of concrete, dirt, or foreign substances during construction. Make field cuts requiring tapers with proper tools and match factory tapers. Use a coupling recommended by the duct manufacturer whenever an existing duct is connected to a duct of different material or shape. Store ducts to avoid warping and deterioration with ends sufficiently plugged to prevent entry of any water or solid substances. Thoroughly clean ducts before being laid. Store plastic ducts on a flat surface and protected from the direct rays of the sun.

3.6.3 Conduit Cleaning

As each conduit run is completed, for conduit sizes 3 inches and larger,

draw a flexible testing mandrel approximately 12 inches long with a diameter less than the inside diameter of the conduit through the conduit. After which, draw a stiff bristle brush through until conduit is clear of particles of earth, sand and gravel; then immediately install conduit plugs. For conduit sizes less than 3 inches, draw a stiff bristle brush through until conduit is clear of particles of earth, sand and gravel; then immediately install conduit plugs.

3.6.4 Jacking and Drilling Under Roads and Structures

Conduits to be installed under existing paved areas which are not to be disturbed, and under roads and railroad tracks, must be zinc-coated, rigid steel, jacked into place. Where ducts are jacked under existing pavement, install rigid steel conduit because of its strength. To protect the corrosion-resistant conduit coating, predrilling or installing conduit inside a larger iron pipe sleeve (jack-and-sleeve) is required. For crossings of existing railroads and airfield pavements greater than 50 feet in length, the predrilling method or the jack-and-sleeve method will be used. Separators or spacing blocks must be made of steel, concrete, plastic, or a combination of these materials placed not farther apart than 4 feet on centers.

3.6.5 Galvanized Conduit Concrete Penetrations

Galvanized conduits which penetrate concrete (slabs, pavement, and walls) in wet locations must be PVC coated and extend from at least 2 inches within the concrete to the first coupling or fitting outside the concrete (minimum of 6 inches from penetration).

3.6.6 Multiple Conduits

Separate multiple conduits by a minimum distance of 3 inches, except that light and power conduits must be separated from control, signal, and telephone conduits by a minimum distance of 12 inches. Stagger the joints of the conduits by rows (horizontally) and layers (vertically) to strengthen the conduit assembly. Provide plastic duct spacers that interlock vertically and horizontally. Spacer assembly must consist of base spacers, intermediate spacers, ties, and locking device on top to provide a completely enclosed and locked-in conduit assembly. Install spacers per manufacturer's instructions, but provide a minimum of two spacer assemblies per 10 feet of conduit assembly.

3.6.7 Conduit Plugs and Pull Rope

Provide new conduit indicated as being unused or empty with plugs on each end. Plugs must contain a weephole or screen to allow water drainage. Provide a plastic pull rope having 3 feet of slack at each end of unused or empty conduits.

3.6.8 Conduit and Duct Without Concrete Encasement

Depths to top of the conduit must be not less than 24 inches below finished grade. Provide not less than 3 inches clearance from the conduit to each side of the trench. Grade bottom of trench smooth; where rock, soft spots, or sharp-edged materials are encountered, excavate the bottom for an additional 3 inches, fill and tamp level with original bottom with sand or earth free from particles, that would be retained on a 1/4 inch sieve. The first 6 inch layer of backfill cover must be sand compacted as previously specified. The rest of the excavation must be backfilled and

compacted in 3 to 6 inch layers. Provide color, type and depth of warning tape as specified in Section 31 00 00 EARTHWORK.

3.6.8.1 Encasement Under Roads and Structures

Under roads, paved areas, and railroad tracks, install conduits in concrete encasement of rectangular cross-section providing a minimum of 3 inch concrete cover around ducts. Extend concrete encasement at least 5 feet beyond the edges of paved areas and roads, and 12 feet beyond the rails on each side of railroad tracks. Depths to top of the concrete envelope must be not less than 24 inches below finished grade.

3.6.9 Duct Encased in Concrete

Construct underground duct lines of individual conduits encased in concrete. Depths to top of the concrete envelope must be not less than 18 inches below finished grade, except under roads and pavement, concrete envelope must be not less than 24 inches below finished grade. Do not mix different kinds of conduit in any one duct bank. Concrete encasement surrounding the bank must be rectangular in cross-section and provide at least 3 inches of concrete cover for ducts. Separate conduits by a minimum concrete thickness of 3 inches. Before pouring concrete, anchor duct bank assemblies, prevent floating during concrete pouring by driving reinforcing rods adjacent to duct spacer assemblies and attaching the rods to the spacer assembly.

3.6.9.1 Connections to Existing Underground Structures

For duct bank connections to existing structures, break the structure wall out to the dimensions required and preserve steel in the structure wall. Cut steel and extend into the duct bank envelope. Chip the perimeter surface of the duct bank opening to form a key or flared surface, providing a positive connection with the duct bank envelope.

3.6.9.2 Connections to Existing Concrete Pads

For duct bank connections to concrete pads, break an opening in the pad out to the dimensions required and preserve steel in pad. Cut the steel and extend into the duct bank envelope. Chip out the opening in the pad to form a key for the duct bank envelope.

3.6.9.3 Connections to Existing Ducts

Where connections to existing duct banks are indicated, excavate the banks to the maximum depth necessary. Cut off the banks and remove loose concrete from the conduits before new concrete-encased ducts are installed. Provide a reinforced concrete collar, poured monolithically with the new duct bank, to take the shear at the joint of the duct banks. Remove existing cables which constitute interference with the work. Abandon in place those no longer used ducts and cables which do not interfere with the work.

3.6.9.4 Partially Completed Duct Banks

During construction wherever a construction joint is necessary in a duct bank, prevent debris such as mud, and, and dirt from entering ducts by providing suitable conduit plugs. Fit concrete envelope of a partially completed duct bank with reinforcing steel extending a minimum of 2 feet back into the envelope and a minimum of 2 feet beyond the end of the

envelope. Provide one No. 4 bar in each corner, 3 inches from the edge of the envelope. Secure corner bars with two No. 3 ties, spaced approximately one foot apart. Restrain reinforcing assembly from moving during concrete pouring.

3.6.9.5 Removal of Ducts

Where duct lines are removed from existing underground structures, close the openings to waterproof the structure. Chip out the wall opening to provide a key for the new section of wall.

3.6.10 Duct Sealing

Seal all electrical penetrations for radon mitigation, maintaining integrity of the vapor barrier, and to prevent infiltration of air, insects, and vermin.

3.7 CABLE PULLING

Test existing duct lines with a mandrel and thoroughly swab out to remove foreign material before pulling cables. Pull cables down grade with the feed-in point at the or buildings of the highest elevation. Use flexible cable feeds to convey cables through opening and into duct runs. Do not exceed the specified cable bending radii when installing cable under any conditions, including turnups into switches, transformers, switchgear, switchboards, and other enclosures. Cable with tape shield must have a bending radius not less than 12 times the overall diameter of the completed cable. If basket-grip type cable-pulling devices are used to pull cable in place, cut off the section of cable under the grip before splicing and terminating.

3.7.1 Cable Lubricants

Use lubricants that are specifically recommended by the cable manufacturer for assisting in pulling jacketed cables.

3.8 CABLES IN UNDERGROUND STRUCTURES

Do not install cables utilizing the shortest path between penetrations, but route along those walls providing the longest route and the maximum spare cable lengths. Form cables to closely parallel walls, not to interfere with duct entrances, and support on brackets and cable insulators. Support cable splices in underground structures by racks on each side of the splice. Locate splices to prevent cyclic bending in the spliced sheath. Install cables at middle and bottom of cable racks, leaving top space open for future cables, except as otherwise indicated for existing installations. Provide one spare three-insulator rack arm for each cable rack in each underground structure.

3.8.1 Cable Tag Installation

Install cable tags in each handhole as specified, including each splice. Tag wire and cable provided by this contract. Install cable tags over the fireproofing, if any, and locate the tags so that they are clearly visible without disturbing any cabling or wiring in the handholes.

3.9 CONDUCTORS INSTALLED IN PARALLEL

Group conductors such that each conduit of a parallel run contains one

Phase A conductor, one Phase B conductor, one Phase C conductor, and one neutral conductor.

3.10 MEDIUM VOLTAGE CABLE TERMINATIONS

Make terminations in accordance with the written instruction of the termination kit manufacturer.

3.11 CABLE END CAPS

Cable ends must be sealed at all times with coated heat shrinkable end caps. Cables ends must be sealed when the cable is delivered to the job site, while the cable is stored and during installation of the cable. The caps must remain in place until the cable is spliced or terminated. Sealing compounds and tape are not acceptable substitutes for heat shrinkable end caps. Cable which is not sealed in the specified manner at all times will be rejected.

3.12 FIREPROOFING OF CABLES IN UNDERGROUND STRUCTURES

Fireproof (arc proof) wire and cables which will carry current at 2200 volts or more in underground structures.

3.12.1 Fireproofing Tape

Tightly wrap strips of fireproofing tape around each cable spirally in half-lapped wrapping. Install tape in accordance with manufacturer's instructions.

3.12.2 Tape-Wrap

Tape-wrap metallic-sheathed or metallic armored cables without a nonmetallic protective covering over the sheath or armor prior to application of fireproofing. Wrap must be in the form of two tightly applied half-lapped layers of a pressure-sensitive 10 mil thick plastic tape, and must extend not less than one inch into the duct. Even out irregularities of the cable, such as at splices, with insulation putty before applying tape.

3.13 GROUNDING SYSTEMS

NFPA 70 and IEEE C2, except provide grounding systems with a resistance to solid earth ground not exceeding 10 ohms.

3.13.1 Grounding Electrodes

Provide cone pointed driven ground rods driven full depth plus 6 inches, installed to provide an earth ground of the appropriate value for the particular equipment being grounded.
If the specified ground resistance is not met, provide an additional ground rod in accordance with the requirements of NFPA 70 (placed not less than 6 feet from the first rod). Should the resultant (combined) resistance exceed the specified resistance, measured not less than 48 hours after rainfall, notify the Contracting Officer immediately.

3.13.2 Grounding Connections

Make grounding connections which are buried or otherwise normally inaccessible, by exothermic weld or compression connector.

a. Make exothermic welds strictly in accordance with the weld manufacturer's written recommendations. Welds which are "puffed up" or which show convex surfaces indicating improper cleaning are not acceptable. Mechanical connectors are not required at exothermic welds.

b. Make compression connections using a hydraulic compression tool to provide the correct circumferential pressure. Tools and dies must be as recommended by the manufacturer. An embossing die code or other standard method must provide visible indication that a connector has been adequately compressed on the ground wire.

3.13.3 Grounding Conductors

Provide bare grounding conductors, except where installed in conduit with associated phase conductors. Ground cable sheaths, cable shields, conduit, and equipment with No. 6 AWG. Ground other noncurrent-carrying metal parts and equipment frames of metal-enclosed equipment. Ground metallic frames and covers of handholes and pull boxes with a braided, copper ground strap with equivalent ampacity of No. 6 AWG.

3.13.4 Ground Cable Crossing Expansion Joints

Protect ground cables crossing expansion joints or similar separations in structures and pavements by use of approved devices or methods of installation which provide the necessary slack in the cable across the joint to permit movement. Use stranded or other approved flexible copper cable across such separations.

3.14 EXCAVATING, BACKFILLING, AND COMPACTING

Provide in accordance with NFPA 70 and Section 31 00 00 EARTHWORK.

3.14.1 Reconditioning of Surfaces

3.14.1.1 Unpaved Surfaces

Restore to their original elevation and condition unpaved surfaces disturbed during installation of duct or direct burial cable. Preserve sod and topsoil removed during excavation and reinstall after backfilling is completed. Replace sod that is damaged by sod of quality equal to that removed. When the surface is disturbed in a newly seeded area, re-seed the restored surface with the same quantity and formula of seed as that used in the original seeding, and provide topsoiling, fertilizing, liming, seeding, sodding, sprigging, or mulching.

3.14.1.2 Paving Repairs

Where trenches, pits, or other excavations are made in existing roadways and other areas of pavement where surface treatment of any kind exists, restore such surface treatment or pavement the same thickness and in the same kind as previously existed, except as otherwise specified, and to match and tie into the adjacent and surrounding existing surfaces.

3.15 CAST-IN-PLACE CONCRETE

Provide concrete in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.15.1 Concrete Slabs (Pads) for Equipment

Unless otherwise indicated, the slab must be at least 8 inches thick, reinforced with a 6 by 6 - W2.9 by W2.9 mesh, placed uniformly 4 inches from the top of the slab. Place slab on a 6 inch thick, well-compacted gravel base. Top of concrete slab must be approximately 4 inches above finished grade with gradual slope for drainage. Edges above grade must have 1/2 inch chamfer. Slab must be of adequate size to project at least 8 inches beyond the equipment.

Stub up conduits, with bushings, 2 inches into cable wells in the concrete pad. Coordinate dimensions of cable wells with transformer cable training areas.

3.15.2 Sealing

When the installation is complete, seal all conduit and other entries into the equipment enclosure with an approved sealing compound. Seals must be of sufficient strength and durability to protect all energized live parts of the equipment from rodents, insects, or other foreign matter.

3.16 FIELD QUALITY CONTROL

3.16.1 Performance of Field Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations, and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.16.1.1 Medium Voltage Cables

Perform tests after installation of cable, splices, and terminators and before terminating to equipment or splicing to existing circuits.

a. Visual and Mechanical Inspection

(1) Inspect exposed cable sections for physical damage.

(2) Verify that cable is supplied and connected in accordance with contract plans and specifications.

(3) Inspect for proper shield grounding, cable support, and cable termination.

(4) Verify that cable bends are not less than ICEA or manufacturer's minimum allowable bending radius.

(5) Inspect for proper fireproofing.

(6) Visually inspect jacket and insulation condition.

(7) Inspect for proper phase identification and arrangement.

b. Electrical Tests

(1) Perform a shield continuity test on each power cable by ohmmeter method. Record ohmic value, resistance values in excess of 10 ohms per 1000 feet of cable must be investigated and justified.

(2) Perform acceptance test on new cables before the new cables are connected to existing cables and placed into service, including terminations and joints. Perform maintenance test on complete cable system after the new cables are connected to existing cables and placed into service, including existing cable, terminations, and joints. Tests must be very low frequency (VLF) alternating voltage withstand tests in accordance with IEEE 400.2. VLF test frequency must be 0.05 Hz minimum for a duration of 60 minutes using a sinusoidal waveform. Test voltages must be as follows:

CABLE RATING AC TEST VOLTAGE for ACCEPTANCE TESTING	
5 kV	10kV rms(peak)
8 kV	13kV rms(peak)
15 kV	20kV rms(peak)
25 kV	31kV rms(peak)
35 kV	44kV rms(peak)

CABLE RATING AC TEST VOLTAGE for MAINTENANCE TESTING	
5 kV	7kV rms(peak)
8 kV	10kV rms(peak)
15 kV	16kV rms(peak)
25 kV	23kV rms(peak)
35 kV	33kV rms(peak)

3.16.1.2 Low Voltage Cables, 600-Volt

Perform tests after installation of cable, splices and terminations and before terminating to equipment or splicing to existing circuits.

a. Visual and Mechanical Inspection

(1) Inspect exposed cable sections for physical damage.

(2) Verify that cable is supplied and connected in accordance with contract plans and specifications.

(3) Verify tightness of accessible bolted electrical connections.

(4) Inspect compression-applied connectors for correct cable match and indentation.

(5) Visually inspect jacket and insulation condition.

(6) Inspect for proper phase identification and arrangement.

b. Electrical Tests

(1) Perform insulation resistance tests on wiring No. 6 AWG and larger diameter using instrument which applies voltage of approximately 1000 volts dc for one minute.

(2) Perform continuity tests to insure correct cable connection.

3.16.1.3 Grounding System

a. Visual and mechanical inspection

Inspect ground system for compliance with contract plans and specifications.

b. Electrical tests

Perform ground-impedance measurements utilizing the fall-of-potential method in accordance with IEEE 81. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground resistance tester in accordance with manufacturer's instructions to test each ground or group of grounds. The instrument must be equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test. Provide site diagram indicating location of test probes with associated distances, and provide a plot of resistance vs. distance.

3.16.2 Follow-Up Verification

Upon completion of acceptance checks and tests, show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. As an exception to requirements stated elsewhere in the contract, the Contracting Officer must be given 5 working days advance notice of the dates and times of checking and testing.

-- End of Section --

SECTION 33 82 00

TELECOMMUNICATIONS OUTSIDE PLANT (OSP)
02/26

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM B1	(2013) Standard Specification for Hard-Drawn Copper Wire
ASTM B8	(2023) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C2	(2023) National Electrical Safety Code

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

ICEA S-87-640	(2023) Optical Fiber Outside Plant Communications Cable; 4th Edition
ICEA S-98-688	(2012) Broadband Twisted Pair Telecommunication Cable, Aircore, Polyolefin Insulated, Copper Conductors Technical Requirements
ICEA S-99-689	(2012) Broadband Twisted Pair Telecommunication Cable Filled, Polyolefin Insulated, Copper Conductors Technical Requirements

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2026; TIA 26-1; ERTA 26-1; TIA 26-2; TIA 26-3; TIA 26-4; TIA 26-5; TIA 26-6; TIA 26-7; ERTA 26-2; ERTA 26-3) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

ANSI/TIA-526-7	(2015a; R 2022) Measurement of Optical Power Loss of Installed Single-Mode Fiber

	Cable Plant, Adoption of IEC 61280-4-2 edition 2: Fibre-Optic Communications Subsystem Test Procedures - Part 4-2: Installed Cable Plant - Single-Mode Attenuation and Optical Return Loss Measurement
ANSI/TIA-526-14	(2023d) OFSTP-14A Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant
ANSI/TIA-568.1	(2020e) Commercial Building Telecommunications Infrastructure Standard
ANSI/TIA-568.2	(2024e) Balanced Twisted-Pair Telecommunications Cabling and Components Standards
ANSI/TIA-568.3	(2022e) Optical Fiber Cabling Components Standard
ANSI/TIA-569	(2019e; Add 1 2022) Telecommunications Pathways and Spaces
ANSI/TIA-606	(2021d) Administration Standard for Telecommunications Infrastructure
ANSI/TIA-607	(2019d) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises
TIA-455-78-B	(2020c; R 2024) FOTP-78 Optical Fibres - Part 1-40: Measurement Methods and Test Procedures - Attenuation
TIA-455-107	(1999a) FOTP-107 Determination of Component Reflectance or Link/System Return Loss using a Loss Test Set
TIA-472D000	(2007b) Fiber Optic Communications Cable for Outside Plant Use
TIA-492CAAA	(1998; R 2002) Detail Specification for Class IVa Dispersion-Unshifted Single-Mode Optical Fibers
TIA-590	(1997a) Standard for Physical Location and Protection of Below Ground Fiber Optic Cable Plant
TIA-758	(2012b) Customer-Owned Outside Plant Telecommunications Infrastructure Standard
TIA/EIA-455	(1998b) Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components
TIA/EIA-455-204	(2024b) Standard for Measurement of

	Bandwidth on Multimode Fiber
TIA/EIA-598	(2014D; Add 2 2018) Optical Fiber Cable Color Coding

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS 1755	Telecommunications Standards and Specifications for Materials, Equipment and Construction
RUS Bull 1751F-630	(1996) Design of Aerial Plant
RUS Bull 1751F-643	(2002) Underground Plant Design
RUS Bull 1751F-815	(1979) Electrical Protection of Outside Plant
RUS Bull 1753F-201	(1997) Acceptance Tests of Telecommunications Plant (PC-4)

UL SOLUTIONS (UL)

UL 83	(2017; Reprint Oct 2025) UL Standard for Safety Thermoplastic-Insulated Wires and Cables
UL 510	(2020; Dec 2022) UL Standard for Safety Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape

1.2 RELATED REQUIREMENTS

Section 27 10 00, BUILDING TELECOMMUNICATIONS CABLING SYSTEM, and Section 33 71 02, UNDERGROUND ELECTRICAL DISTRIBUTION apply to this section with additions and modifications specified herein.1.3 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in this specification must be as defined in ANSI/TIA-568.1, ANSI/TIA-568.2, ANSI/TIA-568.3, ANSI/TIA-569, ANSI/TIA-606, and IEEE 100 and herein.

1.3.1 Campus Distributor (CD)

A distributor from which the campus backbone cabling emanates. (International expression for main cross-connect - (MC).)

1.3.2 Entrance Facility (EF) (Telecommunications)

An entrance to the building for both private and public network service cables (including antennae) including the entrance point at the building wall and continuing to the entrance room or space.

1.3.3 Entrance Room (ER) (Telecommunications)

A centralized space for telecommunications equipment that serves the occupants of a building. Equipment housed therein is considered distinct from a telecommunications room because of the nature of its complexity.

1.3.4 Building Distributor (BD)

A distributor in which the building backbone cables terminate and at which connections to the campus backbone cables may be made. (International expression for intermediate cross-connect - (IC).)

1.3.5 Pathway

A physical infrastructure utilized for the placement and routing of telecommunications cable.

1.4 SYSTEM DESCRIPTION

The telecommunications outside plant consists of cable, conduit, manholes, poles, etc. required to provide signal paths from the closest point of presence to the newly renovated facility, including free standing frames or backboards, interconnecting hardware, terminating cables, lightning and surge protection modules at the entrance facility. The work consists of providing, testing and making operational cabling, interconnecting hardware and lightning and surge protection necessary to form a complete outside plant telecommunications system for continuous use. The telecommunications contractor must coordinate with the NMCI contractor concerning layout and configuration of the EF telecommunications and OSP. The telecommunications contractor may be required to coordinate work effort for access to the EF telecommunications and OSP with the NMCI contractor.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Telecommunications Outside Plant; G

Telecommunications Entrance Facility Drawings; G

SD-03 Product Data

Wire and Cable; G

Cable Splices, and Connectors; G

Closures; G

Cross-Connect Terminal Cabinets; G

SD-06 Test Reports

Pre-installation Tests; G

Acceptance Tests; G

Outside Plant Test Plan; G

SD-07 Certificates

Telecommunications Contractor Qualifications; G

Key Personnel Qualifications; G

Minimum Manufacturer's Qualifications; G

SD-08 Manufacturer's Instructions

Cable Tensions; G

Fiber Optic Splices; G

SD-09 Manufacturer's Field Reports

Factory Reel Test Data; G

SD-10 Operation and Maintenance Data

Telecommunications Outside Plant (OSP), Data Package 5; G

SD-11 Closeout Submittals

Record Documentation; G

1.6 QUALITY ASSURANCE

1.6.1 Shop Drawings

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams must identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings must indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. Submittals must include the nameplate data, size, and capacity. Submittals must also include applicable federal, military, industry, and technical society publication references.

1.6.1.1 Telecommunications Outside Plant Shop Drawings

Provide Outside Plant Design in accordance with TIA-758, RUS Bull 1751F-630 for aerial system design, and RUS Bull 1751F-643 for underground system design. Provide T0 shop drawings that show the physical and logical connections from the perspective of an entire campus, such as actual building locations, exterior pathways and campus backbone cabling on plan view drawings, major system nodes, and related connections on the logical system drawings in accordance with ANSI/TIA-606. Drawings must include wiring and schematic diagrams for fiber optic and splices, and pair count, fiber pair count and type, pathway duct and innerduct arrangement, associated construction materials, and any details required to demonstrate that cable system has been coordinated and will properly support the switching and transmission system identified in specification and drawings.

Provide Registered Communications Distribution Designer (RCDD) approved drawings of the telecommunications outside plant. The telecommunications outside plant (OSP) shop drawings must be included in the operation and maintenance manuals.

1.6.1.2 Telecommunications Entrance Facility Drawings

Provide T3 drawings for EF Telecommunications in accordance with ANSI/TIA-606 that include telecommunications entrance facility plan views, pathway layout (cable tray, racks, ladder-racks, an so on), mechanical/electrical layout, and cabinet, rack, backboard and wall elevations. Drawings must show layout of applicable equipment including incoming cable stub or connector blocks, building protector assembly, outgoing cable connector blocks, patch panels and equipment spaces and cabinet/racks. Drawings must include a complete list of equipment and material, equipment rack details, proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearance for maintenance and operation. Provide T3 drawings for EF Telecommunications as specified in the paragraph TELECOMMUNICATIONS SPACE DRAWINGS of Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEMS. The telecommunications entrance facility shop drawings must be included in the operation and maintenance manuals.

1.6.2 Telecommunications Qualifications

Work under this section must be performed by and the equipment must be provided by the approved telecommunications contractor and key personnel. Qualifications must be provided for: the telecommunications system contractor, the telecommunications system installer, the supervisor (if different from the installer), and the cable splicing and terminating personnel. A minimum of 30 days prior to installation, submit documentation of the experience of the telecommunications contractor and of the key personnel.

1.6.2.1 Telecommunications Contractor Qualifications

The telecommunications contractor must be a firm which is regularly and professionally engaged in the business of the applications, installation, and testing of the specified telecommunications systems and equipment. The telecommunications contractor must demonstrate experience in providing successful telecommunications systems that include outside plant and broadband cabling within the past 3 years. Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for the telecommunications contractor. Each of the key personnel must demonstrate experience in providing successful telecommunications systems in accordance with TIA-758 within the past 3 years.

1.6.2.2 Key Personnel Qualifications

Provide key personnel who are regularly and professionally engaged in the business of the application, installation and testing of the specified telecommunications systems and equipment. There may be one key person or more key persons proposed for this solicitation depending upon how many of the key roles each has successfully provided. Each of the key personnel must demonstrate experience in providing successful telecommunications systems within the past 3 years.

a. Cable splicing and terminating personnel assigned to the installation of this system or any of its components must have training in the proper techniques and have a minimum of 3 years experience in splicing and terminating the specified cables. Modular splices must be performed by factory certified personnel or under direct supervision

of factory trained personnel for products used.

b. Supervisors and installers assigned to the installation of this system or any of its components must have factory or factory approved certification from each equipment manufacturer indicating that they are qualified to install and test the provided products.

Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for each of the key personnel. Documentation for each key person must include at least two successful system installations provided that are equivalent in system size and in construction complexity to the telecommunications system proposed for this solicitation. Include specific experience in installing and testing telecommunications outside plant systems, including broadband cabling, and provide the names and locations of at least two project installations successfully completed using optical fiber telecommunications cabling systems. All of the existing telecommunications system installations offered by the key persons as successful experience must have been in successful full-time service for at least 18 months prior to the issuance date for this solicitation. Provide the name and role of the key person, the title, location, and completed installation date of the referenced project, the referenced project owner point of contact information including name, organization, title, and telephone number, and generally, the referenced project description including system size and construction complexity.

a. Indicate that all key persons are currently employed by the telecommunications contractor, or have a commitment to the telecommunications contractor to work on this project. All key persons must be employed by the telecommunications contractor at the date of issuance of this solicitation, or if not, have a commitment to the telecommunications contractor to work on this project by the date that the bid was due to the Contracting Officer.

b. Note that only the key personnel approved by the Contracting Officer in the successful proposal must do work on this solicitation's telecommunications system. Key personnel must function in the same roles in this contract, as they functioned in the offered successful experience. Any substitutions for the telecommunications contractor's key personnel requires approval from The Contracting Officer.

1.6.2.3 Minimum Manufacturer's Qualifications

Cabling, equipment and hardware manufacturers must have a minimum of 3 years experience in the manufacturing, assembly, and factory testing of components which comply with, ANSI/TIA-568.1, ANSI/TIA-568.2 and ANSI/TIA-568.3. In addition, cabling manufacturers must have a minimum of 3 years experience in the manufacturing and factory testing of cabling which comply with ICEA S-87-640, ICEA S-98-688, and ICEA S-99-689.

1.6.3 Outside Plant Test Plan

Prepare and provide a complete and detailed test plan for field tests of the outside plant including a complete list of test equipment for the optical fiber cables, components, and accessories for approval by the Contracting Officer. Include a cut-over plan with procedures and schedules for relocation of facility station numbers without interrupting service to any active location. Submit the plan at least 30 days prior to tests for Contracting Officer approval. Provide outside plant testing and

performance measurement criteria in accordance with ANSI/TIA-568.1 and RUS Bull 1753F-201. Include procedures for certification, validation, and testing that includes fiber optic link performance criteria.

1.6.4 Standard Products

Provide materials and equipment that are standard products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship and must be the manufacturer's latest standard design that has been in satisfactory commercial or industrial use for at least 2 years prior to bid opening. The 2-year period must include applications of equipment and materials under similar circumstances and of similar size. The product must have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Products supplied must be specifically designed and manufactured for use with outside plant telecommunications systems. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.6.4.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is provided.

1.6.4.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site must not be used, unless specified otherwise.

1.6.5 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship must be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.6.5.1 Independent Testing Organization Certificate

In lieu of the label or listing, submit a certificate from an independent testing organization, competent to perform testing, and approved by the Contracting Officer. The certificate must state that the item has been tested in accordance with the specified organization's test methods and that the item complies with the specified organization's reference standard.

1.7 DELIVERY, STORAGE, AND HANDLING

Ship cable on reels with a minimum overage of 10 percent. Radius of the reel drum must not be smaller than the minimum bend radius of the cable. Wind cable on the reel so that unwinding can be done without kinking the cable. Two meters of cable at both ends of the cable must be accessible

for testing. Attach permanent label on each reel showing length, cable identification number, cable size, cable type, and date of manufacture. Provide water resistant label and the indelible writing on the labels. Apply end seals to each end of the cables to prevent moisture from entering the cable. Reels with cable must be suitable for outside storage conditions when temperature ranges from minus 40 degrees C to plus 65 degrees C, with relative humidity from 0 to 100 percent. Equipment, other than cable, delivered and placed in storage must be stored with protection from weather, humidity and temperature variation, dirt and dust, or other contaminants in accordance with manufacturer's requirements.

1.8 MAINTENANCE

1.8.1 Record Documentation

Provide the activity responsible for telecommunications system maintenance and administration a single complete and accurate set of record documentation for the entire telecommunications system with respect to this project.

Provide T5 drawings including documentation on cables and termination hardware in accordance with ANSI/TIA-606. T5 drawings must include schedules to show information for cut-overs and cable plant management, patch panel layouts, cross-connect information and connecting terminal layout as a minimum. T5 drawings must be provided on electronic media using Windows based computer cable management software. Provide the following T5 drawing documentation as a minimum:

a. Cables - A record of installed cable must be provided in accordance with ANSI/TIA-606. The cable records must include the required data fields for each cable and complete end-to-end circuit report for each complete circuit from the assigned outlet to the entry facility in accordance with ANSI/TIA-606. Include manufacture date of cable with submittal.

b. Termination Hardware - Provide a record of installed patch panels, cross-connect points, campus distributor and terminating block arrangements and type in accordance with ANSI/TIA-606. Documentation must include the required data fields as a minimum in accordance with ANSI/TIA-606.

1.9 WARRANTY

The equipment items must be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Products supplied must be specifically designed and manufactured for use with outside plant telecommunications systems.

2.2 TELECOMMUNICATIONS ENTRANCE FACILITY

2.2.1 Fiber Optic Terminations

Provide fiber optic cable terminations as specified in 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

2.3 CLOSURES

2.3.1 Fiber Optic Closures

2.3.1.1 In Vault or Manhole

Provide underground closure suitable to house splice organizer in a protective housing into which can be poured an encapsulating compound. Closure must be of thermoplastic, thermoset, or stainless steel material supplying structural strength necessary to pass the mechanical and electrical requirements in a vault or manhole environment. Encapsulating compound must be reenterable and must not alter the chemical stability of the closure.

2.4 PAD MOUNTED CROSS-CONNECT TERMINAL CABINETS

Provide in accordance with RUS 1755.910 and the following:

a. Constructed of 14 gauge steel.

b. Equipped with a double set of hinged doors with closed-cell foam weatherstripping. Doors must be locked and contain a marker as indicated.

c. Equipped with spool spindle bracket, mounting frames, binding post log, jumpering instruction label, and load coil mounting provisions.

d. Complete with cross connect modules to terminate number of pairs as indicated.

e. Sized as indicated.

2.5 CABLE SPLICES, AND CONNECTORS

2.5.1 Fiber Optic Cable Splices

Provide fiber optic cable splices and splicing materials for fusion methods at locations shown on the construction drawings. The splice insertion loss must be 0.3 dB maximum when measured in accordance with TIA-455-78-B using an Optical Time Domain Reflectometer (OTDR). Splices must be designed for a return loss of 40.0 db max for single mode fiber when tested in accordance with TIA-455-107. Physically protect each fiber optic splice by a splice kit specially designed for the splice.

2.5.2 Fiber Optic Splice Organizer

Provide splice organizer suitable for housing fiber optic splices in a neat and orderly fashion. Splice organizer must allow for a minimum of 3 feet of fiber for each fiber within the cable to be neatly stored without kinks or twists. Splice organizer must accommodate individual strain relief for each splice and allow for future maintenance or modification, without damage to the cable or splices. Provide splice organizer

hardware, such as splice trays, protective glass shelves, and shield bond connectors in a splice organizer kit.

2.6 CONDUIT

Provide conduit as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.7 PLASTIC INSULATING TAPE

UL 510.

2.8 WIRE AND CABLE

2.8.1 Fiber Optic Cable

Provide single-mode, 8/125-um, 0.10 aperture 1310 nm fiber optic cable in accordance with TIA-492CAAA, TIA-472D000, and ICEA S-87-640 including any special requirements made necessary by a specialized design. Provide optical fibers as indicated. Fiber optic cable must be specifically designed for outside use with loose buffer construction. Provide fiber optic color code in accordance with TIA/EIA-598

2.8.1.1 Strength Members

Provide non-central, non-metallic strength members with sufficient tensile strength for installation and residual rated loads to meet the applicable performance requirements in accordance with ICEA S-87-640. The strength member is included to serve as a cable core foundation to reduce strain on the fibers, and must not serve as a pulling strength member.

2.8.1.2 Performance Requirements

Provide fiber optic cable with optical and mechanical performance requirements in accordance with ICEA S-87-640.

2.8.2 Grounding and Bonding Conductors

Provide grounding and bonding conductors in accordance with RUS 1755.200, ANSI/TIA-607, IEEE C2, and NFPA 70. Solid bare copper wire meeting the requirements of ASTM B1 for sizes No. 8 AWG and smaller and stranded bare copper wire meeting the requirements of ASTM B8, for sizes No. 6 AWG and larger. Insulated conductors must have 600-volt, Type TW insulation meeting the requirements of UL 83.

2.9 CABLE TAGS IN MANHOLES, HANDHOLES, AND VAULTS

Provide tags for each telecommunications cable or wire located in manholes, handholes, and vaults. Cable tags must be polyethylene and labeled in accordance with ANSI/TIA-606. Handwritten labeling is unacceptable.

2.9.1 Polyethylene Cable Tags

Provide tags of polyethylene that have an average tensile strength of 3250 pounds per square inch; and that are 0.08 inch thick (minimum), non-corrosive non-conductive; resistive to acids, alkalis, organic solvents, and salt water; and distortion resistant to 170 degrees F. Provide 0.05 inch (minimum) thick black polyethylene tag holder. Provide

a one-piece nylon, self-locking tie at each end of the cable tag. Ties must have a minimum loop tensile strength of 175 pounds. The cable tags must have black block letters, numbers, and symbols one inch high on a yellow background. Letters, numbers, and symbols must not fall off or change positions regardless of the cable tags' orientation.

2.10 BURIED WARNING AND IDENTIFICATION TAPE

Provide fiber optic media marking and protection in accordance with TIA-590. Provide color, type and depth of tape as specified in paragraph BURIED WARNING AND IDENTIFICATION TAPE in Section 31 00 00, EARTHWORK.

2.11 GROUNDING BRAID

Provide grounding braid that provides low electrical impedance connections for dependable shield bonding in accordance with RUS 1755.200. Braid must be made from flat tin-plated copper.

2.12 MANUFACTURER'S NAMEPLATE

Each item of equipment must have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.13 FIELD FABRICATED NAMEPLATES

Provide laminated plastic nameplates in accordance with ASTM D709 for each patch panel, protector assembly, rack, cabinet and other equipment or as indicated on the drawings. Each nameplate inscription must identify the function and, when applicable, the position. Nameplates must be melamine plastic, 0.125 inch thick, white with black center core. Surface must be matte finish. Corners must be square. Accurately align lettering and engrave into the core. Minimum size of nameplates must be one by 2.5 inches. Lettering must be a minimum of 0.25 inch high normal block style.

2.14 TESTS, INSPECTIONS, AND VERIFICATIONS

2.14.1 Factory Reel Test Data

Test 100 percent OTDR test of FO media at the factory in accordance with ANSI/TIA-568.1 and ANSI/TIA-568.3. Use ANSI/TIA-526-7 for single mode fiber and ANSI/TIA-526-14 Method B for multi mode fiber measurements. Calibrate OTDR to show anomalies of 0.2 dB minimum. Submit test reports, including manufacture date for each cable reel and receive approval before delivery of cable to the project site.

PART 3 EXECUTION

3.1 INSTALLATION

Install all system components and appurtenances in accordance with manufacturer's instructions IEEE C2, NFPA 70, and as indicated. Provide all necessary interconnections, services, and adjustments required for a complete and operable telecommunications system.

3.1.1 Contractor Damage

Promptly repair indicated utility lines or systems damaged during site

preparation and construction. Damages to lines or systems not indicated, which are caused by Contractor operations, must be treated as "Changes" under the terms of the Contract Clauses. When Contractor is advised in writing of the location of a nonindicated line or system, such notice must provide that portion of the line or system with "indicated" status in determining liability for damages. In every event, immediately notify the Contracting Officer of damage.

3.1.2 Cable Inspection and Repair

Handle cable and wire provided in the construction of this project with care. Inspect cable reels for cuts, nicks or other damage. Damaged cable must be replaced or repaired to the satisfaction of the Contracting Officer. Reel wraps must remain intact on the reel until the cable is ready for placement.

3.1.3 Underground Duct

Provide underground duct and connections to existing manholes, and new concrete pad as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION with any additional requirements as specified herein.

3.1.4 Reconditioning of Surfaces

Provide reconditioning of surfaces as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.1.5 Penetrations

Caulk and seal cable access penetrations in walls, ceilings and other parts of the building. Seal openings around electrical penetrations through fire resistance-rated wall, partitions, floors, or ceilings in accordance with Section 07 84 00 FIRESTOPPING.

3.1.6 Cable Pulling

Test duct lines with a mandrel and swab out to remove foreign material before the pulling of cables. Avoid damage to cables in setting up pulling apparatus or in placing tools or hardware. Do not step on cables when entering or leaving the manhole. Do not place cables in ducts other than those shown without prior written approval of the Contracting Officer. Roll cable reels in the direction indicated by the arrows painted on the reel flanges. Set up cable reels on the same side of the manhole as the conduit section in which the cable is to be placed. Level the reel and bring into proper alignment with the conduit section so that the cable pays off from the top of the reel in a long smooth bend into the duct without twisting. Under no circumstances must the cable be paid off from the bottom of a reel. Check the equipment set up prior to beginning the cable pulling to avoid an interruption once pulling has started. Use a cable feeder guide of suitable dimensions between cable reel and face of duct to protect cable and guide cable into the duct as it is paid off the reel. As cable is paid off the reel, lubricate and inspect cable for sheath defects. When defects are noticed, stop pulling operations and notify the Contracting Officer to determine required corrective action. Cable pulling must also be stopped when reel binds or does not pay off freely. Rectify cause of binding before resuming pulling operations. Provide cable lubricants recommended by the cable manufacturer. Avoid bends in cables of small radii and twists that might cause damage. Do not bend cable and wire in a radius less than 10 times the outside diameter of

the cable or wire.

3.1.6.1 Cable Tensions

Obtain from the cable manufacturer and provide to the Contracting Officer, the maximum allowable pulling tension. This tension must not be exceeded.

3.1.6.2 Pulling Eyes

Equip cables 1.25 inches in diameter and larger with cable manufacturer's factory installed pulling-in eyes. Provide cables with diameter smaller than 1.25 inches with heat shrinkable type end caps or seals on cable ends when using cable pulling grips. Rings to prevent grip from slipping must not be beaten into the cable sheath. Use a swivel of 3/4 inch links between pulling-in eyes or grips and pulling strand.

3.1.6.3 Installation of Cables in Manholes, Handholes, and Vaults

Do not install cables utilizing the shortest route, but route along those walls providing the longest route and the maximum spare cable lengths. Form cables to closely parallel walls, not to interfere with duct entrances, and support cables on brackets and cable insulators at a maximum of 4 feet. In existing manholes, handholes, and vaults where new ducts are to be terminated, or where new cables are to be installed, modify the existing installation of cables, cable supports, and grounding as required with cables arranged and supported as specified for new cables. Identify each cable with corrosion-resistant embossed metal tags.

3.1.7 Aerial Cable Installation

Pole installation must be as specified in Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION. Where physical obstructions make it necessary to pull distribution wire along the line from a stationary reel, use cable stringing blocks to support wire during placing and tensioning operations. Do not place ladders, cable coils, and other equipment on or against the distribution wire. Wire must be sagged in accordance with the data shown. Protect cable installed outside of building less than 8 feet above finished grade against physical damage.

3.1.7.1 Figure 8 Distribution Wire

Perform spiraling of the wire within 24 hours of the tensioning operation. Perform spiraling operations at alternate poles with the approximate length of the spiral being 15 feet. Do not remove insulation from support members except at bonding and grounding points and at points where ends of support members are terminated in splicing and dead-end devices. Ground support wire at poles to the pole ground.

3.1.7.2 Suspension Strand

Place suspension strand as indicated. Tension in accordance with the data indicated. When tensioning strand, loosen cable suspension clamps enough to allow free movement of the strand. Place suspension strand on the road side of the pole line. In tangent construction, point the lip of the suspension strand clamp toward the pole. At angles in the line, point the suspension strand clamp lip away from the load. In level construction place the suspension strand clamp in such a manner that it will hold the strand below the through-bolt. At points where there is an up-pull on the strand, place clamp so that it will support strand above the

through-bolt. Make suspension strand electrically continuous throughout its entire length, bond to other bare cables suspension strands and connect to pole ground at each pole.

3.1.7.3 Aerial Cable

Keep cable ends sealed at all times using cable end caps. Take cable from reel only as it is placed. During placing operations, do not bend cables in a radius less than 10 times the outside diameter of cable. Place temporary supports sufficiently close together and properly tension the cable where necessary to prevent excessive bending. In those instances where spiraling of cabling is involved, accomplish mounting of enclosures for purposes of loading, splicing, and distribution after the spiraling operation has been completed.

3.1.8 Cable Splicing

3.1.8.1 Fiber Optic Splices

Fiber optic splicing must be in accordance with manufacturer's recommendation and must exhibit an insertion loss not greater than 0.2 dB for fusion splices.

3.1.9 Surge Protection

All cables and conductors, except fiber optic cable, which serve as communication lines through off-premise lines, must have surge protection installed at each end which meet the requirements of RUS Bull 1751F-815.

3.1.10 Grounding

Provide grounding and bonding in accordance with RUS 1755.200, ANSI/TIA-607, IEEE C2, and NFPA 70. Ground exposed noncurrent carrying metallic parts of telephone equipment, cable sheaths, cable splices, and terminals.

3.1.10.1 Telecommunications Master Ground Bar (TMGB)

The TMGB is the hub of the basic telecommunications grounding system providing a common point of connection for ground from outside cable, CD, and equipment. Establish a TMGB for connection point for cable stub shields to connector blocks and CD protector assemblies as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.1.10.2 Incoming Cable Shields

Shields must not be bonded across the splice to the cable stubs. Ground shields of incoming cables in the EF Telecommunications to the TMGB.

3.1.10.3 Campus Distributor Grounding

a. Protection assemblies: Mount CD protector assemblies directly on the telecommunications backboard. Connect assemblies mounted on each vertical frame with No. 6 AWG copper conductor to provide a low resistance path to TMGB.

3.2 LABELING

3.2.1 Labels

Provide labeling for new cabling and termination hardware located within the facility in accordance with ANSI/TIA-606. Handwritten labeling is unacceptable. Stenciled lettering for cable and termination hardware must be provided using thermal ink transfer process.

3.2.2 Cable Tag Installation

Install cable tags for each telecommunications cable or wire located in manholes, handholes, and vaults including each splice. Tag only new wire and cable provided by this contract. The labeling of telecommunications cable tag identifiers must be in accordance with ANSI/TIA-606. Do not provide handwritten letters. Install cable tags so that they are clearly visible without disturbing any cabling or wiring in the manholes, handholes, and vaults.

3.2.3 Termination Hardware

Label patch panels, distribution panels, connector blocks and protection modules using color coded labels with identifiers in accordance with ANSI/TIA-606.

3.3 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.4 FIELD QUALITY CONTROL

Provide the Contracting Officer 10 working days notice prior to each test. Provide labor, equipment, and incidentals required for testing. Correct defective material and workmanship disclosed as the results of the tests. Furnish a signed copy of the test results to the Contracting Officer within 3 working days after the tests for each segment of construction are completed. Perform testing as construction progresses and do not wait until all construction is complete before starting field tests.

3.4.1 Pre-Installation Tests

Perform the following tests on cable at the job site before it is removed from the cable reel. For cables with factory installed pulling eyes, these tests must be performed at the factory and certified test results must accompany the cable.

3.4.1.1 Cable Capacitance

Perform capacitance tests on at least 10 percent of the pairs within a cable to determine if cable capacitance is within the limits specified.

3.4.1.2 Loop Resistance

Perform DC-loop resistance on at least 10 percent of the pairs within a cable to determine if DC-loop resistance is within the manufacturer's calculated resistance.

3.4.1.3 Pre-Installation Test Results

Provide results of pre-installation tests to the Contracting Officer at least 5 working days before installation is to start. Results must indicate reel number of the cable, manufacturer, size of cable, pairs tested, and recorded readings. When pre-installation tests indicate that cable does not meet specifications, remove cable from the job site.

3.4.2 Acceptance Tests

Perform acceptance testing in accordance with RUS Bull 1753F-201 and as further specified in this section. Provide personnel, equipment, instrumentation, and supplies necessary to perform required testing. Notification of any planned testing must be given to the Contracting Officer at least 14 days prior to any test unless specified otherwise. Testing must not proceed until after the Contractor has received written Contracting Officer's approval of the test plans as specified. Test plans must define the tests required to ensure that the system meets technical, operational, and performance specifications. The test plans must define milestones for the tests, equipment, personnel, facilities, and supplies required. The test plans must identify the capabilities and functions to be tested. Provide test reports in booklet form showing all field tests performed, upon completion and testing of the installed system. Measurements must be tabulated on a pair by pair or strand by strand basis.

3.4.2.1 Fiber Optic Cable

Test fiber optic cable in accordance with TIA/EIA-455 and as further specified in this section. Two optical tests must be performed on all optical fibers: Optical Time Domain Reflectometry (OTDR) Test, and Attenuation Test. In addition, a Bandwidth Test must be performed on all multimode optical fibers. These tests must be performed on the completed end-to-end spans which include the near-end pre-connectorized single fiber cable assembly, outside plant as specified, and the far-end pre-connectorized single fiber cable assembly.

a. OTDR Test: The OTDR test must be used to determine the adequacy of the cable installations by showing any irregularities, such as discontinuities, micro-bendings or improper splices for the cable span under test. Hard copy fiber signature records must be obtained from the OTDR for each fiber in each span and must be included in the test results. The OTDR test must be measured in both directions. A reference length of fiber, feet minimum, used as the delay line must be placed before the new end connector and after the far end patch panel connectors for inspection of connector signature. Conduct OTDR test and provide calculation or interpretation of results in accordance with ANSI/TIA-526-7 for single-mode fiber and ANSI/TIA-526-14 for multimode fiber. Splice losses must not exceed 0.3 db.

b. Attenuation Test: End-to-end attenuation measurements must be made on all fibers, in both directions, using a 1310 nanometer light source at one end and the optical power meter on the other end to verify that the cable system attenuation requirements are met in accordance with ANSI/TIA-526-7 for single-mode fiber optic cables. The measurement method must be in accordance with TIA-455-78-B. Attenuation losses must not exceed 0.5 db/km at 1310 nm for single-mode fiber.

c. Bandwidth Test: The end-to-end bandwidth of all multimode fiber span links must be measured by the frequency domain method. The bandwidth must be measured in both directions on all fibers. The bandwidth measurements must be in accordance with TIA/EIA-455-204.

-- End of Section --

Jacobs