Robins Air Force Base, Georgia

US Army Corps
Of Engineers
Savannah District

Solicitation Number
W912HN-26-R-A006
Building 110 Renovations
Volume 3 of 3: Specifications Divisions 25 - 33 and Appendices - Administration Building
PN UHHZ050507
January 2026

U.S. ARMY ENGINEER DISTRICT, SAVANNAH
CORPS OF ENGINEERS
100 WEST OGLETHORPE AVENUE
SAVANNAH, GEORGIA 31401-3640

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Ready To Advertise Specifications
Administration Building

US Army Corps of Engineers®

U.S. ARMY CORPS OF ENGINEERS (USACE)
Savannah District

Contract Number – W912HP20D5000
Task Order Number – W912HN24F2011

Robins AFB Building 110 Renovation
Warner Robins, GA

January 2026

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Ready To Advertise Specifications
Administration Building

Prepared for

U.S. Army Corps of Engineers (USACE)
Savannah District

Robins AFB Building 110 Renovation
Warner Robins, GA

January 2026

Prepared by

Burns & McDonnell
Kansas City, MO

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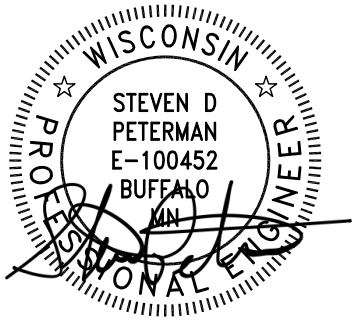
USACE
Robins AFB B110 Renovation
Warner Robins, GA

January 2026

SPECIFICATION CERTIFICATION PAGE

CIVIL 	**STRUCTURAL** 01/22/2026	**ARCHITECTURE** 01/22/2026
FIRE PROTECTION  22-Jan-2026	**MECHANICAL** 01/22/2026	**PLUMBING** 01/22/2026
ELECTRICAL 2026/01/22	**ELECTRONICS AND COMMUNICATIONS** 2026/01/22	

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SECTION 25 05 11.01

CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS - MOD HVAC DDC

PART 1 GENERAL

Many subparts in this Section contain text in curly braces ("{" and "}") indicating which cybersecurity control and control correlation identifier (CCI) the requirements of the subpart relate to. The text inside these curly braces is for Government reference only and enables coordination of the requirements of this Section with the RMF process throughout the design and construction process. Text in curly braces are not contractor requirements.

This Section refers to Security Requirements Guide (SRGs) and Security Technical Implementation Guide (STIGs). STIGs and SRGs are available online at the Information Assurance Support Environment (IASE) website at https://public.cyber.mil/stigs/downloads/ and an SRG/STIG Applicability Guide and Collection Tool is available at https://public.cyber.mil/stigs/SCAP/. Not all control system components have applicable STIGs or SRGs. The "Control Systems SRG" does not apply to work performed under this Section; all requirements within this section to apply applicable SRGs DO NOT include the "Control Systems SRG".

1.1 CONTROL SYSTEM APPLICABILITY

There are multiple versions of this Section associated with this project. Different versions have requirements applicable to different control systems. This specific Section applies only to the following control systems: HVAC Direct Digital Control.

1.2 RELATED REQUIREMENTS

This section does not contain sufficient requirements to procure a control system and must be used in conjunction with other Sections which specify control systems. This Section adds cybersecurity requirements to the control systems specified in other Sections, and as these requirements are conditioned on the control system being provided, there may be requirements in this Section that will not apply to this project. All Sections containing facility-related control systems or control system components are related to the requirements of this Section. Review all specification sections to determine related requirements.

In cases where a requirement is specified in both this Section and in another Section, the more stringent requirement must be met. In cases where a requirement in this Section conflicts with the requirements of another Section such that both requirements cannot be met at the same time, request direction from the Contracting Officer to determine which requirement applies to the project.

1.3 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 135	(2020; Interpretation 1-8 2021; Errata 1-2 2021; Addenda CD 2021; Addenda BV-CE 2022; Interpretation 9-12 2022; Interpretation 13-24 2023; Addenda BV-CF 2023; Errata 3 2023) BACnet—A Data Communication Protocol for Building Automation and Control Networks

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 802.1x	(2010) Local and Metropolitan Area Networks - Port Based Network Access Control

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST FIPS 140-2	(2001) Security Requirements for Cryptographic Modules
NIST FIPS 201-2	(2013) Personal Identity Verification (PIV) of Federal Employees and Contractors

U.S. DEPARTMENT OF DEFENSE (DOD)

DODI 8551.01	(2014) Ports, Protocols, and Services Management (PPSM)
DTM 08-060	(2008) Policy on Use of Department of Defense (DoD) Information Systems - Standard Consent Banner and User Agreement

1.4 DEFINITIONS

1.4.1 Administrator Account

An administrator account is an account with full permissions to a device, application, or operating system, including the ability to create and modify other user accounts.

Note that the operating system Administrator Account may be different than Administrator Accounts for applications hosted on that operating system. Also, most controllers will not have any support for accounts and will therefore not have an 'Administrator Account'.

1.4.2 Computer

A computer is one of the following:

a. a device running a non-embedded desktop or server version of Microsoft Windows

b. a device running a non-embedded version of MacOS

c. a device running a non-embedded version of Linux

d. a device running a version or derivative of the Android Operating

System, where Android is considered separate from Linux

e. a device running a version of Apple iOS

Unless otherwise indicated or clear from context use of the word "device" in this Section includes computers.

1.4.3 Controller

A device other than a computer or Ethernet switch.

1.4.4 Mission Space

A device or media is in mission space if physical access to the device or media is controlled by the organization served by the device. For example, a variable air volume (VAV) box controller in a suspended ceiling is in mission space if the VAV box serves that room; an electrical switchgear in an electrical room or an air handling unit (AHU) in a mechanical room or on a rooftop may still be considered to be in mission space if the organization (mission) served by that switchgear or AHU controls access to the electrical room, mechanical room or rooftop.

1.4.5 Network

A network is a group of two or more devices that can communicate using a network protocol. Network protocols must provide a method for addressing devices on the network; a communication method that does not provide an addressing scheme is not a networked form of communication. Devices that communicate using a method of communication that does not support device addressing are not using a network. Addresses may be other than IP addresses, and addressing may be at either Open Systems Interconnection (OSI) layer 2 or layer 3.

1.4.6 Network Connected

A component is network connected (or "connected to a network") only when the device has a network transceiver which is directly connected to the network and implements the network protocol. A device lacking a network transceiver (and accompanying protocol implementation) can never be considered network connected. Note that (unlike many IT definitions of "Network Connected") a device connected to a non-IP network is still considered network connected (an IP connection or IP address is not required for a device to be network connected).

1.4.6.1 Wireless Network Connected

Any device that supports wireless network communication is network connected to a wireless network, regardless of whether the device is communicating using wireless. Unless physically disabled, devices with wireless transceivers support wireless, it is not sufficient to disable the wireless in software.

1.4.7 Network Media

The thing that provides the communication channel between the devices on a network. Typically wire, but might include wireless, fiber optic, or even power line (some network protocols allow sending network signals over power wiring).

1.4.8 User Account Support Levels

The support for user accounts is categorized in this Section as one of three levels:

1.4.8.1 FULLY Supported

Device supports configurable individual accounts. Accounts can be created, deleted, modified, etc. Privileges can be assigned to accounts. These devices support user-based (as opposed to role-based) authentication.

1.4.8.2 MINIMALLY Supported

Device supports a small, fixed number of accounts (perhaps only one). Accounts cannot be modified. A device with only a "User" and an "Administrator" account would fit this category. Similarly, a device with two PINs for logon - one for restricted and one for unrestricted rights would fit here (in other words, the accounts do not have to be the traditional "username and password" structure). These devices typically only support role-based authentication.

Examples of devices which MINIMALLY support accounts are a) a variable frequency drive with a single account which requires a PIN for access to configuration; and b) a room lighting control touchpad interface that has a single account.

1.4.8.3 NOT Supported

Device does not support any Access Enforcement therefore the whole concept of "account" is meaningless.

1.4.9 Manual Local Input

Manual Local Inputs are system analog or binary inputs that are adjustable by a person but are, by intrinsic hardware design, very limited in potential capabilities. Manual Local Inputs do not have touch screens or full keyboards, but may have a few buttons or dials to allow input. Manual Local Inputs do not have full graphic screens or dot-matrix displays, but may have simple lights (LEDs) or 7-segment displays. Manual Local Inputs do not have any sort of menu structure, each button has a single well-defined function.

Examples of Manual Local Inputs are H-O-A switches, simple thermostats, and disconnect switches.

1.4.10 Card Reader

A card reader is an input/output device whose primary function is to assist in two-factor authentication. A card reader must have an interface to read data from a card and may be able to write data to a card. A card reader may have a means (such as buttons, keypad, touchscreen, etc.) for a user to input a PIN or password, as well as a limited display.

1.4.11 User Interface

A User Interface (UI) is something other than a Manual Local Input or Card Reader that allows a person to interact with the system or device. Note that while a Card Reader is not by itself a User Interface, a User Interface may contain a Card Reader in order for it to authenticate its

user. Within control systems, there are a wide range of User Interfaces.

Two important distinctions are 1) whether the user interface is Local or Remote, and 2) the effective capabilities of the User Interface to alter data, which is the "privilege" of the user interface (where effective privilege available to a specific user at a specific user interface is the combination of the greatest privilege offered by the user interface and the specific account the user is logged into).

1.4.11.1 Local User Interface

A Local User Interface is a user interface where the physical hardware the user interacts with (keyboard, buttons, display, etc.) is physically part of the device being affected. All of the relevant characteristics of the user interface are embodied within a single device.

Note that a Local UI may be able to access data in a different device, Local versus Remote in this context refers to the user interface itself; the capability to access data in a different device is covered under "Full User Interface".

1.4.11.2 Remote User Interface

A Remote User Interface implements a Client/Server model where the physical hardware the user interacts with (Client) is physically distinct from the device being affected (Server). Most or all of the security and functionality characteristics of the user interface are defined by the Server, not the Client. The Client and Server communicate via a network connection. A common example of a remote user interface is a web-based interface where the browser (client) is generally on different hardware than the web server (server). A Remote UI remains a Remote UI even if the user happens to be at a Client on the same hardware as the Server. What is important is that a) the Client may be on different hardware than the Server and b) the majority of the security and functional characteristics of the interface are defined at the Server.

Note that this definition of "remote" is consistent with that generally used in the control industry but is not aligned with the NIST 800-53 definition of "Remote", which refers to "outside the system". The term "Remote" here better aligns with the NIST 800-53 definition of "Network" (remote from within the system) Access.

1.4.11.3 Types of User Interface (by capability)

User interfaces are also categorized by their capabilities as being Read Only, Limited, or Full.

1.4.11.3.1 Read-Only User Interface

A Read Only User Interface (also referred to as a View-Only User Interface) is a user interface that only allows for reading data, it does not allow (have the capability to) modify data. A Read Only User Interface may be either Local or Remote. A User Interface that is configured to be Read Only (by some other means than the interface itself, such as using configuration software on a laptop) is a Read-Only Interface. Note a Read Only User Interface may have buttons (or touch screen, etc.) allowing the user to navigate through the presentation of data.

Examples of a Read Only User Interfaces are a) a publicly viewable "energy dashboard" showing weather data and energy usage within a building and b) digital wayfinding signage.

1.4.11.3.2 Limited User Interface

A Limited User Interface is a user interface that - by design - can only alter information local to the user interface. Note that the determination of "alter" includes only direct interactions, it explicitly excludes interactions that might occur as secondary effects. For example, an interface changing the flow setpoint in a pump controller is a direct interaction, the subsequent change in flow (as well as any subsequent downstream changes in valve position) are not direct interactions.

Two examples of LIMITED UIs are: a) a variable speed drive has a Limited Local User Interface which allows the user to change properties within the drive, but does not allow affecting things outside the drive; and b) a typical home WiFi Router has a Limited Remote User Interface which allows configuration of the Router, but does not allow direct interaction with other devices.

1.4.11.3.3 Full User Interface

A Full User Interface can alter information in devices outside the device with the user interface. For example, a typical Local Display Panel is a Full Local User Interface while a browser-based front end is a Full Remote User Interface.

1.4.11.3.4 View-Only User Interface

See Read-Only User Interface

1.4.11.4 Other User Interface Terminology

In addition to defining whether a user interface is a Hardware Limited, Read-Only, Limited or Full, and whether it is Local or Remote, user interfaces are classified by whether they are writable or privileged.

1.4.11.4.1 Writable User Interface

Any User Interface that is not Read-Only is Writable. (Limited User Interfaces and Full User Interfaces are both writable user interfaces (as they are capable of changing a value)).

1.4.11.4.2 Privileged User Interface

A Privileged UI is a UI that has sufficient capabilities or functionality that it requires specific cybersecurity measures to be put in place to limit its unauthorized use. Ultimately, whether a specific user interface is considered a Privileged User Interface must be determined by usage. Unless otherwise specified, user interfaces can be determined to be privileged or not using the following:

a. Read-Only User Interfaces are not privileged user interfaces.

b. Full User Interfaces are privileged user interfaces.

c. User interfaces that allow for configuration of auditing or allows for modification or deletion of audit logs are privileged user interface.

d. User interfaces that allow for reprogramming a network connected device is a privileged user interface.

e. Except as specified above, a Limited User Interface must be determined to be privileged or not based on the specific capabilities and use case of the user interface. In general however, user interfaces that do not offer significant capabilities above and beyond those available at that location via other means (e.g. such as a disconnect switch, breaker, or hand-off-auto switch, or physical attack) are not privileged.

1.4.12 Wireless Network

Any network that communicates without using wires or fiber optics as the communication media. Wireless networks include: WiFi, Bluetooth, ZigBee, cellular, satellite, long and short wave radio, 2.4 GHz, free space optical, point-to-point laser, microwave, and IR.

1.4.13 Wired Broadcast Network

Wired Broadcast Networks are any network, such as powerline carrier networks and modem (wired telephony), that use wire-based technologies where there is not a clearly defined boundary for signal propagation.

1.5 ADMINISTRATIVE REQUIREMENTS

1.5.1 Points of Contact

Coordinate with the following Points of Contact as indicated in this Section and as required. Not all projects will require coordination with all Points of Contact. When coordination is required and no Point of Contact is indicated, coordinate with the Contracting Officer (KO).

a. Government Computer Access Point of Contact: Contracting Office (KO).

b. HTTPS Certificate Point of Contact: Contracting Officer (KO).

c. Email Address Point of Contact: Contracting Officer (KO).

d. Password Point of Contact: Contracting Officer (KO).

e. Mobile Code Point of Contact: Contracting Officer (KO).

f. PKI Infrastructure Point of Contact: Contracting Officer (KO).

1.5.2 Coordination

Coordinate the execution of this Section with the execution of all other Sections related to control systems as indicated in the paragraph RELATED REQUIREMENTS. Items that must be considered when coordinating project efforts include but are not limited to:

a. If requesting permission for wireless or wired broadcast communication, the Wireless and Wired Broadcast Communication Request submittal must be approved prior to control system device selection and installation.

b. If requesting permission for alternate account lock permissions, the

Device Account Lock Exception Request must be approved prior to control system device selection and installation.

c. If requesting permission for the use of a device with multiple physical connections to IP networks, the Multiple IP Connection Device Request must be approved prior to control system device selection and installation.

d. Wireless testing may be required as part of the control system testing. See requirements for the Wireless Communication Test Report submittal.

e. If the Device Audit Record Upload Software is to be installed on a computer not being provided as part of the control system, coordination is required to identify the computer on which to install the software.

f. The Cybersecurity Interconnection Schedule must be coordinated with other work that will be interconnected to, and interconnections must be approved by the Government before relying on them for system functionality.

g. Cybersecurity testing support must be coordinated across control systems and with the Government cybersecurity testing schedule.

h. Passwords must be coordinated with the indicated contact for the project site.

i. If applicable, HTTPS web server certificates must be obtained from the indicated HTTPS Certificate Point of Contact.

j. Contractor Computer Cybersecurity Compliance Statements must be provided for each contractor using contractor owned computers.

1.6 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

Wireless and Wired Broadcast Communication Request; G

Device Account Lock Exception Request; G

Multiple Ethernet Connection Device Request; G

Contractor Computer Cybersecurity Compliance Statements; G

Contractor Temporary Network Cybersecurity Compliance Statements; G

Cybersecurity Interconnection Schedule ; G

Protection of Information At Rest Proposal; G

Proposed STIG and SRG Applicability Report; G

Pre-Construction Control System Inventory Report ; G

Contractor Personnel Certifications; G

SD-02 Shop Drawings

Network Communication, Ports, Protocols and Services Report; G, AE

Cybersecurity Network (Riser) Diagram ; G, AE

SD-03 Product Data

Control System Cybersecurity Documentation; G, AE

SD-06 Test Reports

Wireless Communication Test Report; G

Control System Cybersecurity Testing Procedures; G

Control System Cybersecurity Testing Report; G

SD-07 Certificates

Software Licenses; G

SD-11 Closeout Submittals

Password Change Summary Report; G

Enclosure Keys; G

Software and Configuration Backups; G

Auditing Front End Software; G

Device Audit Record Upload Software; G

System Maintenance Tool Software; G

Control System Scanning Tools; G

STIG, SRG and Vendor Guide Compliance Result Report; G

Final Control System Inventory Report; G

Integrity Verification Software; G

1.7 QUALITY CONTROL

1.7.1 Certifications

For the HVAC Direct Digital Control control system: Cybersecurity Subject Matter Expert:

This individual will oversee all work within this specification and is responsible for verifying all submittals of the integrator and overseeing any system hardening. Personnel performing this role must have current approved DoD IA baseline certifications in accordance with DoDI 8140

Cyberspace Workforce Improvement Program. Provide Contractor Personnel Certifications no later than 30 days following Notice To Proceed. Individuals for this position should have experience securing DoD Systems and with the Risk Management Framework (RMF). Control System experience is required.

See https://public.cyber.mil/wid/dod-cyber-workforce-framework/.

1.8 CYBERSECURITY DOCUMENTATION

{For Government Reference Only: This subpart (and its subparts) relates to PL-7; CCI-003071}

1.8.1 Proposed STIG and SRG Applicability Report

For each model of network connected or network infrastructure device, use the DISA SRG/STIG Applicability Guide and Collection Tool (available at https://public.cyber.mil/stigs/SCAP/to identify applicable STIGs or SRGs and provide a report indicating applicable STIGs and SRGs for each model. Provide the Proposed STIG and SRG Applicability Report concurrently with the Pre-Construction Control System Inventory Report.

1.8.2 Cybersecurity Interconnection Schedule

{For Government Reference Only: This subpart relates to CA-3(b), PL-8, SC-7(9), SC-7(11); CCI-000258, CCI-003072, CCI-003073, CCI-003075, CCI-002398, CCI-002399, CCI-002401, CCI-002402, CCI-002403. For MODERATE Impact systems, this subpart also relates to SC-7; CCI-001126, CCI-001109}

Provide a completed Cybersecurity Interconnection Schedule documenting network connections between the installed system and other systems. Provide the following information for each device directly communicating between systems: Device Identifier, Device Manufacturer, Device Description, Transport layer Protocol, Network Address, Port (if applicable), MAC (Layer 2) address (if applicable), Media, Application Protocol, Service (if applicable), Descriptive Purpose of communication. For communication with other authorized systems also provide the Foreign Destination and POC for Destination. For MODERATE Impact Systems: Also describe the impact of loss of the connection on the control system. If other control system Sections used on this project include submittals documenting this information, provide copies of those submittals to meet this requirement.

In addition to the requirements of Section 01 33 00 SUBMITTAL PROCEDURES, provide the Cybersecurity Interconnection Schedule as an editable Microsoft Excel file (a template Cybersecurity Interconnection Schedule in Excel format is available athttps://www.wbdg.org/dod/ufgs/ufgs-25-05-11.)

1.8.3 Network Communication, Ports, Protocols and Services Report

{For Government Reference Only: This subpart (and its subparts) relates to CA-9, PL-8; CCI-002102, CCI-002103, CCI-002104, CCI-002105, CCI-003072, CCI-003073, CCI-003075 and also the submittal requirements associated with CM-6, CM-7, including CM-7(3), CCI-000388.}

Provide a Network Communication, Ports, Protocols and Services Report. For each networked device, document device identifier and the communication characteristics of the device including communication protocols, services used, encryption employed, and a general description

of what information is communicated over the network. For each device using IP communication, document all TCP and UDP ports used. For each device using non-IP communication, document communication protocol and media used. If other control system Sections used on this project include submittals documenting this information, provide copies of those submittals to meet this requirement.

In addition to the requirements of Section 01 33 00 SUBMITTAL PROCEDURES, provide the Network Communication, Ports, Protocols and Services Report as an editable Microsoft Excel file.

1.8.4 Control System Inventory Reports

{For Government Reference Only: This subpart (and its subparts) relates to CM-8(a), SI-17, IA-3; CCI-000389, CCI-000392, CCI-000398, CCI-002773, CCI-002774, CCI-002775, CCI-000777, CCI-000778, CCI-001958}

Provide a Pre-Construction Control System Inventory Report report and a Final Control System Inventory Report, using the Inventory Spreadsheet listed under this Section at https://www.wbdg.org/dod/ufgs/ufgs-25-05-11. In the Control System Inventory Reports, document all devices, including networked devices, network infrastructure devices, non-networked devices, input devices (e.g. sensors) and output devices (e.g. actuators). For each device provide all applicable information for which there is a field on the spreadsheet in accordance with the instructions on the spreadsheet.

In addition to the requirements of Section 01 33 00 SUBMITTAL PROCEDURES, provide the Control System Inventory Reports as editable Microsoft Excel files. Provide the Pre-Construction Control System Inventory Report concurrently with the Proposed STIG and SRG Applicability Report

1.8.5 Software and Configuration Backups

{For Government Reference Only: This subpart (and its subparts) relates to CP-10; CCI-000550, CCI-000551, CCI-000552}

For each computer on which software is installed under this project, provide a recovery image of the final as-built computer . This image must allow for bare-metal restore such that restoration of the image is sufficient to restore system operation to the imaged state without the need for re-installation of software. If additional user permissions are required to meet this requirement, coordinate the creation of the image with the identified Government Computer Access Point of Contact.

For all Ethernet switches provide a backup of the switch configuration. For all controllers, provide a backup of the controller configuration and the source code for all loaded application programs (all software that is not common to every controller of the same manufacturer and model).

If any or all of these are provided under another Section, provide documentation indicating this and referencing those submittals.

1.8.6 Cybersecurity Network (Riser) Diagram

{For Government Reference Only: This subpart (and its subparts) relates to PL-2(a), PL-8; CCI-003051, CCI-003053, CCI-003072, CCI-003073, CCI-003075}

Provide a cybersecurity network (riser) diagram of the complete control system including all network and device hardware. For each device, include the device identifier, device type, and manufacturer. If the control system specifications require a riser diagram submittal, provide a copy of that submittal as the cybersecurity riser diagram. Otherwise, provide a riser diagram in one-line format.

1.8.7 STIG, SRG and Vendor Guide Compliance Result Report

For every component (device or software) with an applicable STIG or SRG in the Proposed STIG and SRG Applicability Report, document compliance with the STIG or SRG requirements.

a. For components which are scannable by the Evaluate-STIG tool (available online at (CAC Required), include the Evaluate-STIG report and raw scan results in addition to the final, manually reviewed and revised, documentation of compliance with STIG and SRG requirements. Checklist files should not contain any findings with a Not Reviewed (NR) status after manual reviews.

b. For components which do not support automated scanning, a manual review using the General Purpose STIG option should be done. A completed Checklist file should not contain any findings with a Not Reviewed (NR) status after manual reviews

For every component (device or software) with manufacturer provided cybersecurity documentation, procedure, or method for secure configuration or installation, provide a report documenting how the component was configured and any deviation from the manufacturer instructions.

1.8.8 Control System Cybersecurity Documentation

{For Government Reference Only: This subpart (and its subparts) relates to SA-5(a),SA-5(b),SA-5(c), SA-22(b); CCIs: CCI-003124, CCI-003125, CCI-003126, CCI-003127, CCI-003128, CCI-003129, CCI-003130, CCI-003131, CCI-003374}

Provide a Control System Cybersecurity Documentation submittal containing the indicated information for each device and software application.

1.8.8.1 Software Applications

For all software applications running on computers provide:

a. administrator documentation that describes secure configuration of the software {For Government Reference Only: relates to CCI-003124}

b. administrator documentation that describes secure installation of the software and software updates. {For Government Reference Only: relates to CCI-003125}

c. administrator documentation that describes secure operation of the software {For Government Reference Only: relates to CCI-003124}

d. administrator documentation that describes effective use and maintenance of security functions or mechanisms for the software {For Government Reference Only: relates to CCI-003127}

e. administrator documentation that describes known vulnerabilities regarding configuration and use of administrative (i.e. privileged) functions for the software {For Government Reference Only: relates to CCI-003128}

f. user documentation that describes user-accessible security functions or mechanisms in the software and how to effectively use those security functions or mechanisms {For Government Reference Only: relates to CCI-003129}

g. user documentation that describes methods for user interaction which enables individuals to use the software in a more secure manner {For Government Reference Only: relates to CCI-003130}

h. user documentation that describes user responsibilities in maintaining the security of the software {For Government Reference Only: relates to CCI-003131}

1.8.8.2 For HVAC Control System Devices

1.8.8.2.1 HVAC Control System Devices FULLY Supporting User Accounts

For all HVAC Control System Devices which FULLY support user accounts, provide:

a. Documentation that describes secure configuration of the device {For Government Reference Only: relates to CCI-003124}

b. Documentation that describes secure operation of the device {For Government Reference Only: relates to CCI-003124}

c. Documentation that describes effective use and maintenance of security functions or mechanisms for the device {For Government Reference Only: relates to CCI-003127}

d. Documentation that describes known vulnerabilities regarding configuration and use of administrative (i.e. privileged) functions for the device {For Government Reference Only: relates to CCI-003128}

e. Documentation that describes user-accessible security functions or mechanisms in the device and how to effectively use those security functions or mechanisms; or a specific indication that there are no user-accessible security functions or mechanisms in the device {For Government Reference Only: relates to CCI-003129}

f. Documentation that describes methods for user interaction which enables individuals to use the device in a more secure manner {For Government Reference Only: relates to CCI-003130}

1.8.8.2.2 All Other HVAC Control System Devices

For all HVAC Control System Devices which do not FULLY support user accounts, provide:

a. Documentation that describes secure configuration of the device; or a specific indication that there are no secure configuration steps that apply {For Government Reference Only: relates to CCI-003124}

b. Documentation that describes effective use and maintenance of security

functions or mechanisms for the device; or a specific indication that there are no security functions or mechanisms in the device {For Government Reference Only: relates to CCI-003127}

c. For devices which include a user interface, documentation that describes methods for user interaction which enables individuals to use the device in a more secure manner {For Government Reference Only: relates to CCI-003130}

1.9 SOFTWARE LICENSING

{For Government Reference Only: This subpart (and its subparts) relates to SI-2(a), SI-2(c), SI-7(14); CCI-001227, CCI-002605, CCI-002737}

For all software provided that has not already been licensed to the government or project site, provide a license to the Government for a period of no less than 5 years, and the license must also include the following software updates:

a. Security and bug-fix patches issued by the software manufacturer.

b. Security patches to address any vulnerability identified in the National Vulnerability Database at http://nvd.nist.gov with a Common Vulnerability Scoring System (CVSS) severity rating of MEDIUM or higher.

Provide a single Software Licenses submittal with documentation of the software licenses for all software provided

1.10 CYBERSECURITY DURING CONSTRUCTION

{For Government Reference Only: This subpart (and its subparts) relates to AC-18, CA-3; CCI-000258}

In addition to the control system cybersecurity requirements indicated in this section, meet following requirement throughout the construction process.

1.10.1 Contractor Computer Equipment

Contractor owned computers may be used for construction. Contractor computers connected to the control system, control system network, or a control system component at any point during construction must meet the following requirements:

1.10.1.1 Operating System

The operating system must be an operating system currently supported by the manufacturer of the operating system. The operating system must be current on security patches and operating system manufacturer required updates.

1.10.1.2 Anti-Malware Software

The computer must run anti-malware software from a reputable software manufacturer. Anti-malware software must be a version currently supported by the software manufacturer, must be current on all patches and updates, and must use the latest definitions file. Computers used on this project must perform a full antivirus scan at least once per day. Computers which

have connected to any other network since the last full antivirus scan must perform a full antivirus scan prior to connection to the control system network or to the temporary contractor-installed IP network. Perform an antivirus scan on all removable media (e.g., external hard drives, CDs, DVDs, USB flash drives) prior to connecting to the control system environment.

1.10.1.3 Passwords and Passphrases

The passwords and passphrases for computers, applications, and web-based applications supporting passwords must be changed from their default values. Passwords must be a minimum of eight characters with a minimum of one uppercase letter, one lowercase letter, one number and one special character.

1.10.1.4 User-Based Authentication

Each user must have a unique account; sharing of a single account between multiple users is prohibited.

1.10.1.5 Demonstration of Compliance

The Government has the right to require demonstration of computer compliance with these requirements at any time during the project.

1.10.1.6 Contractor Computer Cybersecurity Compliance Statements

Provide a single submittal containing completed Contractor Computer Cybersecurity Compliance Statements for each company using contractor owned computers. Contractor Computer Cybersecurity Compliance Statements must use the template published at https://www.wbdg.org/dod/ufgs/ufgs-25-05-11. Each Statement must be signed by a cybersecurity representative for the relevant company.

1.10.2 Temporary IP Networks

Temporary contractor-installed IP networks may be used during construction. When used, temporary contractor-installed IP networks connected to the control system, control system network, or a control system component at any point during construction must meet the following requirements:

1.10.2.1 Network Boundaries and Connections

The network must not extend outside the project site and must not connect to any IP network other than those specifically provided or furnished for this project. Any and all access to the network from outside the project site is prohibited.

1.10.3 Government Access to Network

Government personnel must be allowed to have complete and immediate access to the network at any time in order to verify compliance with this specification.

1.10.4 Temporary Wireless IP Networks

In addition to the other requirements on temporary IP networks, temporary wireless IP (WiFi) networks, when permitted, must not interfere with

existing wireless networks, must use WPA2 security and must not broadcast the network name (SSID). Network names (SSID) for wireless networks must be changed from their default values.

1.10.5 Passwords and Passphrases

The passwords and passphrases for all network devices and network access must be changed from their default values. Passwords must be a minimum 8 characters with a minimum of one uppercase letter, one lowercase letter, one number and one special character.

1.10.6 Contractor Temporary Network Cybersecurity Compliance Statements

Provide a single submittal containing completed Contractor Temporary Network Cybersecurity Compliance Statements for each company implementing a temporary IP network. Contractor Temporary Network Cybersecurity Compliance Statements must use the template published at https://www.wbdg.org/dod/ufgs/ufgs-25-05-11. Each Statement must be signed by a cybersecurity representative for the relevant company. If no temporary IP networks will be used, provide a single copy of the Statement indicating this.

1.11 CYBERSECURITY DURING WARRANTY PERIOD

All work performed on the control system after acceptance must be performed using Government Furnished Equipment or equipment specifically and individually approved by the Government.

PART 2 PRODUCTS

2.1 DATABASE AND WEB SERVER SOFTWARE FOR MODERATE IMPACT SYSTEMS

{For Government Reference Only: This subpart (and its subparts) relate to RA-5(1), RA-5(5); CCI-001062, CCI-001067, CCI-001645, CCI-002906}

All computer-based databases must use Microsoft SQL Server or Oracle. All computer-based web interfaces must use Internet Information Services (IIS) or Apache as the web server.

PART 3 EXECUTION

3.1 CYBERSECURITY HARDENING AND CONFIGURATION GUIDES

Install, configure, and harden all hardware and software furnished on this project in accordance with manufacturer provided documentation, procedures, or methods for secure configuration or installation. Do not implement specific hardening actions if that action would conflict with required functionality or another requirement of this Section.

3.2 NETWORK REQUIREMENTS

3.2.1 Information Flow Enforcement In MODERATE Impact Systems

{For Government Reference Only: This subpart (and its subparts) relate to AC-4; CCI-001368, CCI-001414, CCI-001548, CCI-001549, CCI-001550, CCI-001551}

Install and configure Ethernet switches to block all traffic on all ports not required by the control protocol.

3.2.2 Wireless and Wired Broadcast Communication

{For Government Reference Only: This subpart (and its subparts) relates to AC-18, AC-18(3); CCI-001438, CCI-001439, CCI-002323, CCI-001441, CCI-001449}

Unless explicitly authorized by the Government, do not use any wireless or wired broadcast communication. If requesting authorization for wireless or wired broadcast communication, wired broadcast media such as powerline carrier is preferred to wireless.

3.2.2.1 Wireless and Wired Broadcast IP Communications

Do not install wireless or wired broadcast IP networks, including: do not install a wireless access point; do not install or configure an ad-hoc wireless network; do not install or configure a WiFi Direct communication.

When explicitly authorized by the Government, wireless IP communication may be used to communicate with an existing wireless network.

3.2.2.2 Non-IP Wireless Communication

For MODERATE Impact Systems: When non-IP wireless communication is explicitly authorized by the Government, the radios must meet NIST FIPS 140-2 Level 2.

3.2.2.3 Wireless and Wired Broadcast Communication Request

Provide a report documenting the proposed use of wireless or wired broadcast communication prior to device selection using the Wireless and Wired Broadcast Communication Request Schedule at https://www.wbdg.org/dod/ufgs/ufgs-25-05-11. If there is no proposed use of wireless or wired broadcast communication, provide a document indicating this instead of the Request Schedule.

For each device proposed to use wireless or wired broadcast communication show: the device identifier, a description of the device, the location of the device, the device identifiers of other devices communicating with the device, the protocol used for communication, encryption type and strength. For wireless communication, also show: RF Frequency, Radiated Power in dBm (decibel with a milliwatt reference), free-space range, and the expected as-installed range.

3.2.2.4 Wireless Communication Testing

As part of Performance Verification Testing (PVT), conduct testing of wireless communication for all devices indicated on the approved Wireless and Wired Broadcast Communication Request as requiring testing.

To test wireless communication, test for wireless network reception at multiple points along the wireless test boundary in the vicinity of the wireless device, and record whether a network connection can be established at each point. The wireless test boundary is the facility fence line. If wireless testing is required, provide a Wireless Communication Test Report documenting the testing points and results at each point for each wireless device.

3.2.3 Non-IP Control Networks

When control system specifications require particular communication protocols, use only those communication protocols and only as specified. Do not implement any other communication protocol.

When control system specifications do not indicate requirements for communication protocols, use only those protocols required for operation of the system as specified.

3.2.4 IP Control Networks

{For Government Reference Only: This subpart relates to CM-6(a), CM-7(a), CM-7(b), CM-7(1)(b), SC-41; CCI-001588, CCI-000381, CCI-000380, CCI-000381, CCI-000382, CCI-001761, CCI-001762, CCI-002544, CCI-002545, CCI-002546. For Moderate Impact Systems, this subpart (and its subparts) also relates to SC-5(1), SC-5(2); CCI-001094 CCI-001095}

IP Networks must be Ethernet networks and must use switches which are Ethernet Switches or Daisy Chain IP Controllers as defined in this Section. Do not use nonsecure functions, ports, protocols and services as defined in DODI 8551.01 unless those ports, protocols and services are specifically required by the control system specifications or otherwise specifically authorized by the Government. Do not use ports, protocols and services that are not specified in the control system specifications or required for operation of the control system.

For MODERATE Impact Systems, unless explicitly authorized, do not use IP networks if the same control functionality is available through the use of non-IP networks.

3.2.4.1 IP Network Routers

Do not install any device that performs IP routing.

3.2.4.2 IP Devices With Multiple Ethernet Connections

Except for Ethernet Switches and Daisy Chain IP Controllers, devices must not have more than one Ethernet connection to IP networks unless doing so is required by the project specifications and the specific application is approved. If a device with Multiple Ethernet Connections to IP networks is required, provide a Multiple Ethernet Connection Device Request using the Multiple Ethernet Connection Device Request Template at https://www.wbdg.org/dod/ufgs/ufgs-25-05-11 to request approval for each device. If a device with Multiple Ethernet Connections to IP networks is not required, instead provide a document stating that no approval is being requested.

3.2.5 Cryptographic Protection

{For Government Reference Only: This subpart relates to IA-2(9), IA-3(1), SC-8, SC-13, SC-23(1), SC-23(3); CCI-001942, CCI-001959, CCI-001967, CCI-002418, CCI-002449, CCI-002450, CCI-001185, CCI-001188, CCI-001664.}

All remote user interfaces must use HTTPS for all traffic between the user interface client and user interface server.

For devices that have STIG/SRGs related to cryptographic protection (CCI-002450), comply with the requirements of those STIG/SRGs. Ensure

that all network traffic is encrypted using NSA-approved cryptography; provision of digital signatures and hashing, and FIPS-validated cryptography.

3.2.6 Device Identification and Authentication

{For Government Reference Only: This subpart (and its subparts) relates to IA-3; CCI-000777, CCI-000778, CCI-001958. For MODERATE Impact systems, this subpart (and its subparts) also relates to SC-23, SC-23(5); CCI-001184, CCI-002470.}

All computers must support and implement IEEE 802.1x for device authentication to the network.

3.2.6.1 For HVAC Control System Devices

Devices using HTTP as a control protocol must use HTTPS instead. Devices using Ethernet must support IEEE 802.1x. Devices using BACnet must support network security as specified for BACnet Secure Connect in ASHRAE 135.

3.2.7 Cryptographic Module Authentication

{For Government Reference Only: This subpart (and its subparts) relates to IA-7; CCI-000803}

For devices (including but not limited to NIST FIPS 140-2 compliant radios) that have STIG/SRGs related to cryptographic module authentication (CCI-000803), comply with the requirements of those STIG/SRGs.

3.3 ACCESS CONTROL REQUIREMENTS

3.3.1 User Accounts

{For Government Reference Only: This subpart (and its subparts) relate to AC-2(a), AC-3, AC-6(1), AC-6(10), AC-6(2), AC-6(9), CM-11(2), and IA-2; CCI-002110, CCI-000213, CCI-001558, CCI-002221, CCI-002222, CCI-002223, CCI-002235, CCI-000039, CCI-001419, CCI-002234, CCI-001812, and CCI-000764. For MODERATE Impact systems, this subpart (and its subparts) also relate to AC-2 (2), AC-2(3), AC-2(4), AC-6(1), and CM-5(1); CCI-001361, CCI-000017, CCI-000217, CCI-000018, CCI-001403, CCI-001404, CCI-001405, CCI-002130, CCI-001683, CCI-001684, CCI-001685, CCI-001686, CCI-002132, CCI-001558, CCI-002221, CCI-002222, CCI-002223, CCI-001813.}

Any user interface supporting user accounts (either FULLY or MINIMALLY) must limit access according to specified limitations for each account. Install and configure any device having a STIG or SRG in accordance with that STIG or SRG.

All user interfaces FULLY supporting accounts must implement user-based authentication where each account is uniquely assigned to a specific user. User interfaces FULLY supporting accounts must implement at least three (3) levels of user account privilege including: 1) an account with read-only permissions 2) an account with full permissions including account creation and modification and 3) an account with greater permissions than read-only but without account creation and modification. Disable any unnecessary or unused accounts. Disable any "guest-level" accounts that are created on the system by default.

3.3.1.1 Computers

All computer operating systems must FULLY support user accounts and implement accounts for access. Each control system software application not supporting accounts and running on a computer must be installed such that use of the software is restricted by the computer operating system to specific users.

Applications running on computers must not require the user be logged in to a computer operating system administrator account for normal operation. It is permissible to require the computer operating system administrator account for initial application installation and configuration.

3.3.1.2 Controllers

For user interfaces provided by controllers, provide access control in accordance with the User Interface Requirements table for the applicable control system and user interface type.

a. For table entries of "NA": NA means Not Applicable, there are no interfaces in this category.

b. For table entries of "None Required": The user interface is not required to support user accounts.

c. For table entries of "MINIMALLY": The user interface must at least MINIMALLY support user accounts.

d. For table entries of "FULLY": The user interface must at FULLY support user accounts.

e. For table entries of "KEY": The user interface must have physical security in the form of either a key lock on the interface itself or be furnished inside a lockable enclosure. Where this is required for a read only interface, the lockable enclosure must prevent viewing of data on the interface; for other interfaces, this lockable enclosure must prevent using the interface to alter data.

f. For table entries of "Physical Security": For Local FULL interfaces, the interface must be located inside mission space. For Local Limited (not FULL) interfaces, the user interface must either a) be located within mission space or b) be protected by physical security at least as good as the control devices (and equipment controlled by the control devices) affected by the interface. For purposes of this requirement, 'affected' includes controllers with data that can be directly altered by the interface, as well as mechanical and/or electrical equipment directly controlled by those controllers, but does not include other interactions.

g. Entries of the form "X and Y" must meet both the requirement indicated for X and the requirement indicated for Y. For example, an entry of "MINIMALLY and Physical Security" indicates the user interface must both MINIMALLY support accounts and have physical security.

h. Entries of the form "X or Y" must meet either the requirement indicated for X or the requirement indicated for Y.

3.3.1.2.1 HVAC Control Systems

User Interface Requirements for MODERATE Impact HVAC Control Systems	
User Interface Type	**Access Control Requirement** (See note 3)
Local Read Only (see note 1)	None Required
Local Limited, Non-privileged	None Required
Local Limited, Privileged	MINIMALLY and Physical Security
Local Full	MINIMALLY and Physical Security
Remote Read Only	MINIMALLY
Remote Limited, Non-Privileged	FULLY
Remote Limited, Privileged AND Remote Full (see note 2)	FULLY

Notes:
1)Local Read Only User Interfaces are always Non-Privileged
2)Remote Full User Interfaces are always Privileged
3)Devices outside mission space require physical security protections as indicated (in "PHYSICAL SECURITY IN MODERATE IMPACT SYSTEMS")

3.3.1.3 Additional User Account Expiration Requirements In MODERATE Impact Systems:

In addition to other user account requirements, user account expiration and auditing must be configured as indicated.

3.3.1.3.1 For Control System Applications Running on Computers

If temporary accounts are supported, expire temporary accounts 72 hours after creation. Expire all other accounts after 35 days of inactivity.

3.3.1.3.2 For Other Control System Devices FULLY Supporting Accounts

If temporary accounts are supported, expire temporary accounts 72 hours after creation. Expire all other accounts after 365 days of inactivity.

3.3.2 Unsuccessful Logon Attempts

{For Government Reference Only: This subpart (and its subparts) relate to AC-7 (a), AC-7 (b); CCI-000043, CCI-000044, CCI-001423, CCI-002236, CCI-002237, CCI-002238}

Except for high availability user interfaces indicated as exempt, devices must meet the indicated requirements for handling unsuccessful logon attempts. If a device cannot meet these requirements, document device capabilities to protect from subsequent logon attempts and propose alternate protections in a Device Account Lock Exception Request

submittal. Do not implement alternate protection measures in lieu of the indicated requirements without explicit permission from the Government. If no Device Account Lock Exceptions are requested, provide a document stating that no approval is being requested as the Device Account Lock Exception Request.

3.3.2.1 Devices MINIMALLY Supporting Accounts

For MODERATE Impact Systems: Devices which MINIMALLY (but not FULLY) support accounts must lock the user account after five consecutive failed login attempts and must unlock the user account after 60 minutes have elapsed without an unsuccessful login attempt or by a successful login to a separate administrator account.

3.3.2.2 Devices FULLY Supporting Accounts

Devices which FULLY support accounts must meet the following requirements.

a. It must lock the user account when three unsuccessful logon attempts occur within a 15 minute interval.

b. Once an account is locked, the account must stay locked until unlocked by an administrator. If the account being locked is the sole administrator account on the device, the account must stay locked for 1 hour and then automatically unlock.

c. Once the indicated number of unsuccessful logon attempts occurs, delay further logon prompts by 5 seconds.

3.3.3 System Use Notification

{For Government Reference Only: This subpart (and its subparts) relates to AC-8; CCI-000048, CCI-002247, CCI-002243, CCI-002244, CCI-002245, CCI-002246, CCI-000050, CCI-002248}

3.3.3.1 System Use Notification for Remote User Interfaces

Remote user interfaces must display a warning banner meeting the requirements of DTM 08-060 on screen.

3.3.3.2 System Use Notification for Local User Interfaces

Devices which are connected to a network and have a local user interface must display a warning banner meeting the requirements of DTM 08-060 on the user interface screen if capable of doing so and must have a permanently affixed label with an approved banner from DTM 08-060 if unable to display the warning banner on the screen. Where it is impractical (perhaps due to device size) to affix the label to the device, affix the label to the device enclosure.

Labels must be machine printed or engraved, plastic or metal, designed for permanent installation, must use a font no smaller than 14 point, and must provide a high contrast between font and background colors.

3.3.4 Session Lock and Session Termination Requirements In MODERATE Impact Systems:

{For Government Reference Only: This subpart (and its subparts) relates to AC-11(a), AC-11(b), AC-11(1), AC-12, SC-10; AC-10; CCI-000058,

CCI-000059, CCI-000056, CCI-000057, CCI-000060, CCI-002360, CCI-002361, CCI-001133, CCI-001134, CCI-000054, CCI-000055, CCI-002252}

3.3.4.1 Session Termination

When session termination is required for a User Interface, the User Interface must implement session termination a) based on manual initiation, or b) based on lack of activity, or c) based on either manual initiation or lack of activity, as indicated.

Session Termination must result in logging out the user. A logged out User Interface may only perform actions as indicated in the "Permitted Actions Without Identification or Authentication" subpart of this Section or display a publicly viewable image or blank screen. User Interfaces must remain logged out (session terminated) until a user enters correct authentication information, which must initiate a new session. All User Interfaces running on computers and all Remote User Interfaces must also terminate network connections as part of session termination.

3.3.4.2 Session Lock

When session lock is required for a User Interface, the User Interface must implement session lock a) based on manual initiation, or b) based on lack of activity, or c) based on either manual initiation or lack of activity, as indicated.

Session lock must result in the User Interface being suspended and the user interface must display a publicly viewable image or blank screen. No interaction with the user interface must be possible until either a) the same user enters valid authentication information, in which case that session must be continued, or b) until a different user enters valid authentication information at which point the first session must be terminated and a new session initiated for the new user.

3.3.4.3 Session Lock and Termination for Computers

User Interface sessions provided by computer operating systems must support the requirement for both Session Lock and Session Termination. Session Lock and Session Termination must be capable of being initiated by the user and must also be initiated by lack of activity. Session Lock must occur after 15 minutes of inactivity, and Session Termination must occur after 30 minutes total of inactivity (including, not in addition to, the time for Session Lock). When a user initiates a new session, terminate existing sessions if necessary to limit the total number of concurrent sessions to 1.

Other User Interface sessions running on computers (for local user interfaces) or hosted on a computer (for remote user interfaces) and supporting accounts must support user initiation of Session Termination and session lock. Session lock may be initiated by user initiation or automatically after 15 minutes of inactivity. In addition, remote User Interface sessions must also initiate Session Termination after 30 minutes of inactivity.

3.3.4.4 Session Lock and Termination for Controllers

Writable Remote User Interfaces must support requirements for Session Termination, and must both be capable of being initiated by the user and initiated by lack of activity. Session Termination must initiate after 30

minutes of inactivity.

Local User Interfaces supporting accounts must support manual initiation of Session Termination. Privileged Local User Interfaces must also support timed initiation of Session Termination, with Session Termination initiated at 30 minutes of inactivity. They must also support session lock, where session lock may be initiated by user initiation or automatically after 15 minutes of inactivity.

3.3.5 Permitted Actions Without Identification or Authentication

{For Government Reference Only: This subpart (and its subparts) relates to AC-14; CCI-000061, CCI-000232}

The control system must require identification and authentication before allowing any actions by a user acting from a user interface which MINIMALLY or FULLY supports accounts.

3.3.6 Physical Security in MODERATE Impact Systems

{For Government Reference Only: This subpart relates to PE-3(1), PE-4, PE-5, SC-7(a), SC-7(c), SC-8, SC-8(1); CCI-000928, CCI-002926, CCI-000936, CCI-002930, CCI-002931, CCI-000937, CCI-001097, CCI-001109, CCI-002418, CCI-002419, CCI-002421.}

3.3.6.1 Physical Security for Media

3.3.6.1.1 Physical Security for Media Inside Mission Space

Install all non-IP network media located inside of the mission space in conduit. Install all IP network media located inside of the mission space in intermediate metallic conduit.

3.3.6.1.2 Physical Security for Media Outside Mission Space

Install all network media (both IP and non-IP) located outside of the mission space in rigid metallic conduit.

3.3.6.2 Physical Security for Devices

Install all devices (computers and controllers) which are located outside of mission space in lockable enclosures. (Recall that per definition of mission space, a room controlled by the mission is mission space regardless of whether it is contiguous with other mission space.)

Install all controllers connected to an IP network in lockable enclosures (both inside and outside of mission space).

3.3.6.3 Physical Security for User Interfaces

Physical security requirements for User Interfaces are specified in the preceding paragraphs of this Section.

3.3.7 Enclosures

Prior to final acceptance of the system, lock all lockable enclosures. Submit an Enclosure Keys submittal with all copies of keys for all enclosures and a key inventory list documenting all keys. Label each key with the matching enclosure identifier.

3.4 USER IDENTIFICATION AND AUTHENTICATION

{For Government Reference Only: This subpart (and its subparts) relates to IA-2, IA-2(1),IA-2(12), IA-5 IA-5(b), IA-5(c), IA-5(e), IA-5(g), IA-5(1), IA-5(11); CCI-000764, CCI-000765, CCI-001953, CCI-001954, CCI-001544, CCI-001989, CCI-000182, CCI-001610, CCI-000192, CCI-000193, CCI-000194, CCI-000205, CCI-001619, CCI-001611, CCI-001612, CCI-001613, CCI-001614, CCI-000195, CCI-001615, CCI-000196, CCI-000197, CCI-000199, CCI-000198, CCI-001616, CCI-001617, CCI-000200, CCI-001618, CCI-002041, CCI-002002, CCI-002003. For MODERATE Impact systems, this subpart also relates to AC-6 (1), AC-6(10), AC-6(2), AC-6(9)-IA-2(4), IA-5(13); CCI-001558, CCI-002221, CCI-002222, CCI-002223, CCI-002235, CCI-000039, CCI-001419, CCI-002234, CCI-000768, CCI-002007.}

This subpart indicates requirements for specific methods of identification and authentication for users and user accounts. Where these requirements conflict apply the following order of precedence: 1) If present, Device Specific Requirements take precedence over any other requirements; and then 2) multifactor authentication requirements take precedence over password requirements.

3.4.1 User Identification and Authentication for All System Types

Unless otherwise indicated, all user interfaces supporting accounts (either FULLY or MINIMALLY) must implement Identification and Authorization via passwords.

For MODERATE Impact Systems: User interfaces provided by computer operating systems must implement multifactor authentication via PIV. User interfaces supporting accounts (FULLY or MINIMALLY) on computers must implement multifactor authentication via PIV. Devices with writable remote user interfaces must implement multifactor authentication via PIV. Devices with Privileged Remote User Interfaces must implement multifactor authentication via PIV. Software running on computers and computer operating systems must manage cached authenticators in accordance with the relevant STIGs. All other devices and software must not use cached authenticators.

3.4.2 User Identification and Authentication for Specific System Types

System specific requirements are in addition to and supersede those indicated for all system types. When no additional requirements are indicated for a specific system type the requirements for all systems still apply to that system type.

3.4.2.1 HVAC Control Systems Devices

No additional system specific requirements apply.

3.4.3 Implementation of Identification and Authorization Requirements

Identification and Authorization must be met by one of the following methods:

a. Direct implementation in the user interface.

b. For user interfaces on a computer: inheriting the Identification and Authorization from the computer operating system, either by the

operating system limiting access to specific applications by user, or by the application itself having permissions based on the user logged into the computer.

c. For remote interfaces: an implementation shared between the remote user interface server and the remote user interface client. For example, a requirement for PIV authentication may be met on a remote user interface by a PIV reader on a web browser client which sends the authentication information via HTTPS to the remote server.

3.4.4 Password-Based Authentication Requirements

3.4.4.1 Passwords for Software and Applications Running on Computers

All software and applications running on computers supporting password-based authentication must enforce the following requirements:

a. Minimum password length of 12 characters

b. Password must contain at least one uppercase character.

c. Password must contain at least one lowercase character.

d. Password must contain at least one numeric character.

e. Password must contain at least one special character. The list of supported special characters must include at least 4 separate characters.

f. Password must have a minimum lifetime of 24 hours.

g. Password must have a maximum lifetime of 60 days. When passwords expire, prompt users to change passwords. Do not lock accounts due to expired passwords.

h. Password must differ from previous five passwords, where differ is defined as changing at least 50 percent of the characters (where location is significant, a character may be reused if it is in a different position).

i. Passwords must be cryptographically protected during storage and transmission.

3.4.4.2 Passwords for Controllers FULLY Supporting Accounts

All controllers FULLY supporting accounts and supporting password-based authentication must enforce the following requirements:

a. Minimum password length of 12 characters

b. Password must contain at least one uppercase character.

c. Password must contain at least one lowercase character.

d. Password must contain at least one numeric character.

e. Password must contain at least one special character. The list of supported special characters must include at least 4 separate characters.

f. Password must have a maximum lifetime of sixty (60) days. When passwords expire, prompt users to change passwords. Do not lock accounts due to expired passwords.

g. Password must differ from previous five passwords, where differ is defined as changing at least 50 percent of the characters.

h. Passwords must be cryptographically protected during storage and transmission.

3.4.4.3 Passwords for Remote Interfaces

Passwords for connecting to a Remote User Interface supporting password-based authentication must enforce the following requirements:

a. Minimum password length of 12 characters

b. Password must contain at least one uppercase character.

c. Password must contain at least one lowercase character.

d. Password must contain at least one numeric character.

e. Password must contain at least one special character. The list of supported special characters must include at least 4 separate characters.

f. Password must have a maximum lifetime of 60 days. When passwords expire, prompt users to change passwords. Do not lock accounts due to expired passwords.

g. Password must differ from previous five passwords, where differ is defined as changing at least 50 percent of the characters (where location is significant, a character may be reused if it is in a different position).

h. Passwords must be cryptographically protected during storage and transmission.

3.4.4.4 Passwords for Devices Minimally Supporting Accounts

Devices MINIMALLY supporting accounts must support passwords with a minimum length of four characters.

3.4.4.5 Password Configuration and Reporting

For all devices with a password, change the password from the default password. Coordinate selection of passwords with the Password Point of Contact. Do not use the same password for more than one device unless specifically instructed to do so.

Do not provide the Password Summary Report in electronic format. Provide two hardcopies of the Password Summary Report, each copy in its own sealed envelope.

For all devices with a password, coordinate the changing of passwords with the project site following testing of the system but prior to turnover to the Government. Coordinate with Password Point of Contact to determine

appropriate project site personnel to complete password changes. Accompany identified personnel to each device with a password and instruct personnel on the process of changing password. Record the time, date and personnel present when each device's password is changed and submit a Password Change Summary Report documenting this information.

3.4.5 Authenticator Feedback

{For Government Reference Only: This subpart relates to IA-6; CCI-000206}

Devices must never show authentication information, including passwords, on a display. Devices that momentarily display a character as it is entered, and then obscure the character, are acceptable. For devices that have STIGs or SRGs related to obscuring of authenticator feedback (CCI-000206), comply with the requirements of those STIGS/SRGs.

3.4.6 Implementation of PKI Infrastructure in Moderate Impact Systems

Coordinate with the PKI Infrastructure Point of Contact to configure the system to implement PKI such that the system validates certifications by constructing and verifying a certification path to an accepted trust anchor including checking certificate status information; the system enforces authorized access to the corresponding private key; the system maps the authenticated identity to the account of the individual or group; and the system implements a local cache of revocation data to support path discovery and validation in case of inability to access revocation information via the network.

3.5 CYBERSECURITY AUDITING

Where an auditing requirement exists for email notification, notify via email the application administrator and Information System Security Officer (ISSO) of the event. Coordinate with the Email Address Point of Contact for email addresses. If outgoing email is not available to the system, disable email notifications.

3.5.1 Audit Events, Content of Audit Records, and Audit Generation

{For Government Reference Only: This subpart (and its subparts) relates to AU-2(a), AU-2(c), AU-2(d), AU-3, AU-10, AU-12, AU-14(b), AU-14(1), AU-14(2), AU-14(3), CM-5(1), SC-7 (9); CCI-000123, CCI-001571, CCI-000125, CCI-001485, CCI-000130, CCI-000131, CCI-000132, CCI-001230, CCI-000133, CCI-000134, CCI-001487, CCI-000166, CCI-001899, CCI-000169, CCI-001459, CCI-000171, CCI-000172, CCI-001910, CCI-001914, CCI-001919, CCI-001464, CCI-001462, CCI-001920, CCI-001814, CCI-002400. For MODERATE Impact systems, this subpart (and its subparts) also relates to AU-3 (1); CCI-000135, CCI-001488}

For devices that have STIG/SRGs related to audit events, content of audit records or audit generation, comply with the requirements of those STIG/SRGs.

If auditing requirements can be met using existing control system alarm or event capabilities, those existing capabilities may be used to meet these requirements.

3.5.1.1 Computers

For each computer, provide the capability to select audited events and the

content of audit logs. Configure computers to audit the indicated events, and to record the indicated information for each auditable event. Send logs to a syslog server that is only accessible via accounts on the system with privileged level access.

3.5.1.1.1 Audited Events

Configure each computer to audit the following events:

a. Successful and unsuccessful attempts to access, modify, or delete privileges, security objects, security levels, or categories of information (e.g. classification levels)

b. Successful and unsuccessful logon attempts

c. Successful logouts

d. Privileged activities or other system level access

e. Concurrent logons from different workstations

f. Successful and unsuccessful accesses to objects

g. Program initiations

h. Direct access to the information system

i. Account creations, modifications, disabling, and terminations. For MODERATE Impact Systems, also provide email notification when these audit events occur.

j. Kernel module load, unload, and restart

3.5.1.1.2 Audit Event Information To Record

Configure each computer to record, for each auditable event, the following information (where applicable to the event):

a. What type of event occurred

b. When the event occurred

c. Where the event occurred

d. The source of the event

e. The outcome of the event

f. The identity of any individuals or subjects associated with the event

g. For MODERATE Impact Systems: For all privileged commands, full-text recording of the executed command and the user executing the command

For MODERATE Impact Systems: Audit records must provide sufficient detail to reconstruct events to determine cause of compromise and magnitude of damage, malfunction, or security violation.

3.5.1.2 For HVAC Control System Controllers

3.5.1.2.1 HVAC Control System Controllers FULLY Supporting User Accounts

For each controller which FULLY supports accounts, provide the capability to select audited events and the content of audit logs. Configure controllers to audit the indicated events, and to record the indicated information for each auditable event.

3.5.1.2.1.1 Audited Events

Configure each controller to audit the following events:

a. Successful and unsuccessful logon attempts to the controller

b. Successful logouts

c. All account creations, modifications, disabling, and terminations. For MODERATE Impact Systems, also provide email notification when these audit events occur.

d. All controller shutdown and startup

e. For privileged user interfaces in MODERATE Impact Systems: All user commands.

3.5.1.2.1.2 Audit Event Information To Record

Configure each controller to record, for each auditable event, the following information (where applicable to the event):

a. what type of event occurred

b. when the event occurred

c. the identity of any individuals or subjects associated with the event

d. For privileged user interfaces in MODERATE Impact Systems: Full text recording of the executed command and the user executing the command.

For MODERATE Impact Systems: Audit records must provide sufficient detail to reconstruct events to determine cause of compromise and magnitude of damage, malfunction, or security violation.

3.5.1.2.2 Other HVAC Control System Controllers

There are no requirements to perform auditing at HVAC field controllers that do not FULLY support accounts.

3.5.2 Audit Time Stamps

{For Government Reference Only: This subpart (and its subparts) relates to AU-8; CCI-000159, CCI-001889, CCI-001890. For MODERATE Impact systems, this subpart (and its subparts) also relates to AU-8 (1); CCI-001891, CCI-001892, CCI-002046.}

Any device (computer or controller) generating audit records must have an internal clock capable of providing time with a resolution of one second. Clocks must not drift more than 10 seconds per day. Configure the system

so that each device (computer or controller) generating audit records maintains accurate time to within 1 second. Note that if the control system specifications include requirement for clocks, the most stringent requirement applies.

3.5.3 Auditing Front End Software

If there is no existing auditing front end software or the software is not compatible with the provided control systems, provide Auditing Front End Software with audit log import and upload, export, notification, and analysis functionality. The Auditing Front End Software may be provided as a component of the control system front end or as a separate software package, and a single package may serve multiple control systems provided under the same projects if they are sharing a cybersecurity authorization.

When the Auditing Front End Software is neither existing nor installed under the requirements of another Section, furnish the Auditing Front End Software media and license for subsequent Government installation and install the software on the control system front end computer. Submit copies of Auditing Front End Software if this function is not part of the software provided with the control system to meet requirements of other Sections.

3.5.3.1 Import and Upload Requirements

Auditing Front End Software must be capable of importing audit logs from the Device Audit Record Upload Software and of uploading audit logs over the network from all control system devices supporting network upload of audit logs.

3.5.3.2 Export Requirements

Auditing Front End Software must be capable of exporting to a file format supported by Microsoft Excel.

3.5.3.3 Notification Of Audit Failure in Devices in MODERATE Impact Systems

The auditing front end software must be capable of receiving notifications of audit failure from control system devices and computers and be able to provide email notification based on receipt of the notification.

3.5.3.4 Audit Reduction and Report Generation In MODERATE Impact Systems

{For Government Reference Only: This subpart (and its subparts) relates to AU-6(4), AU-7(a), AU-7(b), AU-7(1), AU-12(1); CCI-000154, CCI-001875, CCI-001876, CCI-001877, CCI-001878, CCI-001879, CCI-001880, CCI-001881, CCI-001882, CCI-000158, CCI-000173, CCI-000174, CCI-001577.}

Auditing Front End Software must provide audit reduction and reporting capabilities that supports on-demand review and analysis, on demand reporting, and after the fact investigations of security incidents. The software must be able to combine audit records from all components within the system and analyze them as a single audit record. The software must correct for discrepancies in timestamps of audit logs from different sources and be able to account for discrepancies up to 2 seconds between sources. The software must not alter original audit record content or time ordering of audit records. The software must have the capability to filter audit records using user-defined fields within the audit records.

The audit reduction and reporting capabilities may incorporate third party application, such as Excel or Access.

3.5.4 Audit Storage Capacity and Audit Upload

{For Government Reference Only: This subpart (and its subparts) relates to AU-4; CCI-001848, CCI-001849}

The creation of audit records must never interfere with normal device operation. Devices must cease collection of auditing information if required to maintain normal operation.

a. For devices that have STIG/SRGs related to audit storage capacity (CCI-001848 or CCI-001849) comply with the requirements of those STIG/SRGs.

b. For controllers capable of generating audit records, provide 60 days worth of secure local storage, assuming 10 auditable events per day.

c. For computers, provide storage for at least 60 days worth of audit records.

3.5.4.1 Audit Log Storage Notification In MODERATE Impact Systems

{For Government Reference Only: This subpart (and its subparts) relates to AU-5(1); CCI-001855.}

Controllers storing audit logs must provide notification when audit logs reach 75 percent of capacity either directly through email or indirectly by sending a notification to a computer, and the computer sending an email. Computers storing audit logs must provide notification when audit logs reach 75 percent of capacity directly through email.

3.5.4.2 Device Audit Record Upload Software

For each device (computer or controller) required to audit events and for which audit logs cannot be uploaded over the network by the Auditing Front End Software, provide and license to the Government software implementing a secure mechanism of uploading audit records from the device and exporting them to the Auditing Front End Software. Where different devices use different software, provide software of each type required to upload audit logs from all devices.

When Device Audit Record Upload Software is capable of uploading audit logs over the network, install Device Audit Record Upload Software on the same computer as the Auditing Front End Software. Submit copies of device audit record upload software if this function is not part of the software provided with the control system to meet requirements of other Sections. If there are no devices requiring this software, provide a document stating this in lieu of this submittal.

3.5.5 Response to Audit Processing Failures

{For Government Reference Only: This subpart (and its subparts) relates to AU-5; CCI-000139, CCI-000140, CCI-001490.}

In the case of a failure in the auditing system, computers associated with auditing must provide email notification. For MODERATE Impact systems, the computer must also notify the associated auditing front end software.

In case of an audit failure, if possible, continue to collect audit records by overwriting existing audit records.

For MODERATE Impact Systems: In the case of an audit failure at a controller performing auditing, the device must notify the associated auditing front end software of the audit failure if able, and must continue to collect audit records by overwriting existing audit records if able. The auditing front end software must provide notification as indicated, treating the notification of failure from the device as a failure in the auditing system.

3.6 REQUIREMENTS FOR LEAST FUNCTIONALITY

{For Government Reference Only: This subpart (and its subparts), along with the Network Communication, Ports, Protocols and Services Report submittal specified elsewhere in this section, relates to CM-6(a), CM-6(c), CM-7, CM-7(1)(b), SC-41; CCI-000363, CCI-000364, CCI-000365, CCI-001588, CCI-001755, CCI-000381, CCI-000380, CCI-000382, CCI-001761, CCI-001762, CCI-002544, CCI-002545, CCI-002546. For MODERATE Impact systems, this subpart (and its subparts) also relates to CM-7(2), CM-7(5)(a), CM-7(5)(b); CCI-000381, CCI-000380, CCI-000382, CCI-001761, CCI-001762}

For devices that have a STIG or SRG related to Requirements for Least Functionality (such as configuration settings and port and device I/O access for least functionality), install and configure the device in accordance with that STIG or SRGs.

3.6.1 Device Capabilities

For HVAC Control Systems: Do not provide devices with remote user interfaces or with full user interfaces where one was not required. Do not use a networked sensor or actuator where a non-networked sensor or actuator would suffice.

For Other Control Systems: Do not provide devices with remote user interfaces or full user interfaces where one was not required. Do not use a networked sensor or actuator where a non-networked sensor or actuator would suffice.

For all MODERATE Impact Systems: Unless specifically required by the government, do not provide a capability to update device firmware over the network.

3.6.2 Software

For software that has a STIG or SRG related to Requirements for Least Functionality (such as configuration settings and port access for least functionality), install and configure the software in accordance with that STIG or SRG.

Do not install software that is not specifically required to meet a contract requirement. Remove any previously installed that is not specifically required to meet a contract requirement. Do not implement functionality within software
that is not specifically required to meet contract requirements.

3.7 SYSTEM AND COMMUNICATION PROTECTION

3.7.1 Collaborative Computing

{For Government Reference Only: This subpart relates to SC-15(a), SC-15(b); CCI-001150, CCI-001152.}

Without explicit approval from the project site, control systems must not use collaborative computing technologies.

3.7.2 Denial of Service Protection and Application Partitioning In MODERATE Impact Systems:

{For Government Reference Only: This subpart relates to SC-5, SC-12, SC-7(a); CCI-001093, CCI-002385, CCI-002386, CCI-002430, CCI-001097. For MODERATE Impact systems, this subpart also relates to SC-2; CCI-001082.}

To the greatest extent practical, implement control logic without reliance on the network. Except when required to meet the requirements of the control system Section (where the requirement can only be met using computer hardware), do not implement control logic in computers. For MODERATE Impact systems, do not implement control logic in a device providing (i.e. acting as a server for) a Full Remote User Interface.

3.7.2.1 Network Reliance in MODERATE Impact HVAC Control Systems

Except for networked input and outputs on input-output buses specifically designed to provide high reliability or redundancy, sensors and actuators must not rely on the network to exchange data with the controller executing the sequence of operation which uses the sensor value or determines the actuator command.

Sensor values required by multiple devices may be shared over the network provided they are connected to a controller requiring the value for execution of the sequence and that controller shares the value on the network.

3.7.3 Mobile Code In MODERATE Impact Systems

{For Government Reference Only: This subpart relates to SC-18(a), SC-18(b), SC-18(c), SC-18(1), SC-18(3), SC-18(4); CCI-001160, CCI-001161, CCI-001162, CCI-001163, CCI-001164, CCI-001165, CCI-001166, CCI-001662, CCI-002457, CCI-002458, CCI-001169, CCI-001695, CCI-001170, CCI-002469}

Devices with STIGs/SRGs related to Mobile Code and to Security Control SC-18 must be installed in accordance with the relevant STIGs/SRGs. All remote user interfaces must meet the requirements of the "Web Browsers and Application SRG".

Mobile code may only be downloaded from a specifically authorized mobile code repository. Coordinate with the Mobile Code Point of Contact for the location of a repository.

3.7.4 Protection of Information at Rest In MODERATE Impact Systems

{For Government Reference Only: This subpart relates to SC-28, SC-28(1); CCI-001199, CCI-002472, CCI-002475, CCI-002476}

Computers must protect information at rest in accordance with applicable

STIGs.

Any control system device storing personally identifiable information (PII), controlled unclassified information (CUI), or classified information must be protected by an Information At Rest encryption solution or by a physical security solution. Provide a Protection of Information At Rest Proposal indicating each device storing PII, CUI, or classified information and the encryption or physical security solution proposed for that device for government approval. If no devices stores PII, CUI, or classified information, provide a document stating this as the Protection of Information At Rest Proposal submittal. Do proceed with device selection and installation until the Protection of Information At Rest Proposal is approved. Once approved, implement approved Information At Rest protections.

3.8 SAFE MODE AND FAIL SAFE OPERATION

{For Government Reference Only: This subpart (and its subparts) relates to CP-12, SI-10(3), SI-17; CCI-002855, CCI-002856, CCI-002857, CCI-002754, CCI-002773, CCI-002774, CCI-002775}

For all control system components with an applicable STIG or SRG, configure the component in accordance with all applicable STIGs and SRGs.

3.9 SYSTEM MAINTENANCE TOOL SOFTWARE

{For Government Reference Only: This subpart (and its subparts) relates to MA-3; CCI-000865.}

Submit and license to the Government all software required to operate, maintain and modify the control system such the Government or their agents are able to perform repair, replacement, upgrades, and expansions of the system without subsequent or future dependence on the Contractor, Vendor or Manufacturer. Submit hard copies of user manuals for each software with the software submittal. Provide any hardware keys or dongles, software keys, license numbers, and other information required to enable the Government to access or change the system.

For software provided and licensed to the Government under the requirements of another Section, submit a statement indicating the Section and Submittal under which the software was provided. For software provided to meet the requirements of this Section and not provided and licensed under another Section, submit software and software user manuals on DVD or CD as a Technical Data Package and submit one hard copy of the software user manual for each piece of software.

3.10 DEVICE POWER

{For Government Reference Only: This subpart (and its subparts) relates to PE-11, PE-11(1); CCI-002955, CCI-000961. For MODERATE Impact systems, this subpart (and its subparts) also relates to PE-9, PE-9(1); CCI-000952, CCI-002953, CCI-002954.}

For MODERATE Impact Systems: Provide control system with power supply meeting or exceeding the reliability of the controlled equipment. Powering control system devices using the same power source as the equipment controlled by the device is a permissible method of meeting this requirement. Without explicit approval from the government, do not install local uninterruptible power supplies (UPSes) as a source of device

power.

3.10.1 Device Behavior on Loss of Power In MODERATE Impact Systems:

Application programs and configuration settings must be stored in devices in manner such that a loss of power does not result in a loss of the application program or configuration settings: Loss of power must never result in the loss of application programs, regardless of the length of time power is lost; and loss of power for less than 2,500 hours must not result in the loss of configured settings.

In the event of a loss of power, when power is restored, controllers and computers executing control logic (and the underlying equipment) must recover and resume their normal sequences of operation. Note that the sequence of operation may require specific actions (e.g. startup sequences) upon recovery from loss of power.

3.11 VULNERABILITY SCANNING

{For Government Reference Only: This subpart (and its subparts) relates to RA-5 RA-5(a),RA-5(b),RA-5(c),RA-5(d); CCI-001054, CCI-001055, CCI-000156, CCI-001641, CCI-001643, CCI-001057, CCI-001058, CCI-001059. For MODERATE Impact systems, this subpart (and its subparts) also relates to RA-5(1), RA-5(5); CCI-001062, CCI-001067, CCI-001645, CCI-002906.}

All IP devices must be scannable, such that the device can be scanned by industry standard IP network scanning utilities without harm to the device, application, or functionality.

3.11.1 Computers and Software Running on Computers

Computers and applications running on computers must meet relevant vulnerability scanning STIGs/SRGs and respond to approved DoD vulnerability scanning tools.

3.11.2 Controllers

Provide controllers that are scannable by standard control system discovery tools or control system browsers and return meaningful status information including the network inputs and outputs for the controller. This information must contain sufficient detail to detect vulnerabilities or exploits of the controller.

Provide all software needed to scan the control system as the Control System Scanning Tools submittal. If the software required to scan the system is already installed at the project site or is provided under a separate section instead provide a statement indicating this.

3.12 FIPS 201-2 REQUIREMENT

{For Government Reference Only: This subpart (and its subparts) relates to SA-4 (10); CCI-003116}

Devices in the following systems which implement PIV must be on the NIST FIPS 201-2 approved product list (https://www.idmanagement.gov/approved-products-list/): HVAC Direct Digital Control.

3.13 SYSTEM AND INTEGRATION INTEGRITY

3.13.1 Malicious Code Protection

{For Government Reference Only: This subpart (and its subparts) relates to SI-3(c); CCI-001241, CCI-002623}

For all computers installed under this project, provide malware protection software media, provide licenses, and install and configure malware protection software as indicated. Coordinate with the Government Computer Access Point of Contact as required.

a. Provide malware protection software licenses.

b. Provide malware protection software media.

c. Install and configure malware protection software in accordance with the relevant STIGs.

3.13.2 Software, Firmware, and Information Integrity In MODERATE Impact Systems:

{For Government Reference Only: This subpart relates to CM-5(3); CCI-001749, CCI-002704, CCI-002726}

If there exists Integrity Verification Software that can check boot process, software, firmware, or information in the control system and verify its integrity, provide it. If no such software exists, provide a statement to this affect in lieu of the software.

The system prevents the installation of software and firmware without verification of the digital signature using an approved certificate.

3.14 CONTROL SYSTEM CYBERSECURITY TESTING

{For Government Reference Only: For MODERATE Impact systems, this subpart (and its subparts) relates to SA-11(a), SA-11(b), SA-11(c), SA-11(d), SA-11(e); CCI-003171, CCI-003172, CCI-003173, CCI-003174, CCI-003175, CCI-003176, CCI-003177, CCI-003178.}

3.14.1 Control System Cybersecurity Testing Procedures

Prepare and submit Control System Cybersecurity Testing Procedures explaining step-by-step, the actions and expected results that will demonstrate that the control system meets the requirements of this Section. The Control System Cybersecurity Testing Procedures may be submitted as a Technical Data Package.

3.14.2 Control System Cybersecurity Testing Execution

Using the Control System Cybersecurity Testing Procedures verify that the control system meets the requirements of this Section. UNLESS GOVERNMENT WITNESSING OF A TEST IS SPECIFICALLY WAIVED BY THE GOVERNMENT, PERFORM ALL TESTS WITH A GOVERNMENT WITNESS. If testing reveals deficiencies in the system, correct the deficiency and retest until successful.

3.14.3 Control System Cybersecurity Testing Report

Prepare and submit a Control System Cybersecurity Testing Report

documenting all tests performed and their results. Include all tests in the Control System Cybersecurity Testing Procedures and any additional tests performed during testing. Document test failures and repairs conducted with the test results. The Control System Cybersecurity Testing Report may be submitted as a Technical Data Package.

3.15 FIELD QUALITY CONTROL, CYBERSECURITY VALIDATION SUPPORT

In addition to testing and testing support required by other Sections, provide a minimum of 16 hours of technical support for cybersecurity testing of control systems to support the DoD Risk Management Framework process Cybersecurity assessment of the control system. This support is independent of (and in addition to) the Control System Cybersecurity Testing specified in this section.

3.16 CYBERSECURITY TRAINING

Provide eight hours of classroom and hands-on training for six Government personnel on the cybersecurity operation and maintenance of the control system provided. This training is in addition to and must be coordinated with control system training specified in other Sections.

The Government will provide the training location. Training must cover, at a minimum: (a) applying software and firmware updates, (b) user account creation, modification and deletion, (c) audit log upload procedures and (d) identification of privileged user interfaces and system impact of those interfaces. Training session must include a question and answer period during which government staff questions about cybersecurity aspects of the control system are answered.

-- End of Section --

SECTION 25 05 11.02

CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS - MOD FIRE

PART 1 GENERAL

Many subparts in this Section contain text in curly braces ("{" and "}") indicating which cybersecurity control and control correlation identifier (CCI) the requirements of the subpart relate to. The text inside these curly braces is for Government reference only and enables coordination of the requirements of this Section with the RMF process throughout the design and construction process. Text in curly braces are not Contractor requirements.

This Section refers to Security Requirements Guide (SRGs) and Security Technical Implementation Guide (STIGs). STIGs and SRGs are available online at the Information Assurance Support Environment (IASE) website at https://public.cyber.mil/stigs/downloads/ and an SRG/STIG Applicability Guide and Collection Tool is available at https://public.cyber.mil/stigs/SCAP/. Not all control system components have applicable STIGs or SRGs. The "Control Systems SRG" does not apply to work performed under this Section; all requirements within this section to apply applicable SRGs DO NOT include the "Control Systems SRG".

1.1 CONTROL SYSTEM APPLICABILITY

There are multiple versions of this Section associated with this project. Different versions have requirements applicable to different control systems. This specific Section applies only to the following control systems: Fire Protection.

1.2 RELATED REQUIREMENTS

This section does not contain sufficient requirements to procure a control system and must be used in conjunction with other Sections which specify control systems. This Section adds cybersecurity requirements to the control systems specified in other Sections, and as these requirements are conditioned on the control system being provided, there may be requirements in this Section that will not apply to this project. All Sections containing facility-related control systems or control system components are related to the requirements of this Section. Review all specification sections to determine related requirements.

In cases where a requirement is specified in both this Section and in another Section, the more stringent requirement must be met. In cases where a requirement in this Section conflicts with the requirements of another Section such that both requirements cannot be met at the same time, request direction from the Contracting Officer Representative (COR) to determine which requirement applies to the project.

1.3 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.

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST FIPS 140-2	(2001) Security Requirements for Cryptographic Modules

U.S. DEPARTMENT OF DEFENSE (DOD)

DTM 08-060	(2008) Policy on Use of Department of Defense (DoD) Information Systems - Standard Consent Banner and User Agreement

1.4 DEFINITIONS

1.4.1 Administrator Account

An administrator account is an account with full permissions to a device, application, or operating system, including the ability to create and modify other user accounts.

Note that the operating system Administrator Account may be different than Administrator Accounts for applications hosted on that operating system. Also, most controllers will not have any support for accounts and will therefore not have an 'Administrator Account'.

1.4.2 Computer

A computer is one of the following:

a. A device running a non-embedded desktop or server version of Microsoft Windows.

b. A device running a non-embedded version of MacOS.

c. A device running a non-embedded version of Linux.

d. A device running a version or derivative of the Android Operating System, where Android is considered separate from Linux.

e. A device running a version of Apple iOS.

Unless otherwise indicated or clear from context use of the word "device" in this Section includes computers.

1.4.3 Controller

A device other than a computer or Ethernet switch. For Fire Protection systems this includes fire alarm control panels, remote operating consoles, and remote annunciators.

1.4.4 Mission Space

A device or media is in mission space if physical access to the device or media is controlled by the organization served by the device. For example, a variable air volume (VAV) box controller in a suspended ceiling is in mission space if the VAV box serves that room; an electrical switchgear in an electrical room or an air handling unit (AHU) in a mechanical room or on a rooftop may still be considered to be in mission space if the organization (mission) served by that switchgear or AHU controls access to the electrical room, mechanical room or rooftop.

1.4.5 Network

A network is a group of two or more devices that can communicate using a network protocol. Network protocols must provide a method for addressing devices on the network; a communication method that does not provide an addressing scheme is not a networked form of communication. Devices that communicate using a method of communication that does not support device addressing are not using a network. Addresses may be other than IP addresses, and addressing may be at either Open Systems Interconnection (OSI) layer 2 or layer 3.

1.4.6 Network Connected

A component is network connected (or "connected to a network") only when the device has a network transceiver which is directly connected to the network and implements the network protocol. A device lacking a network transceiver (and accompanying protocol implementation) can never be considered network connected. Note that (unlike many IT definitions of "Network Connected") a device connected to a non-IP network is still considered network connected (an IP connection or IP address is not required for a device to be network connected).

1.4.6.1 Wireless Network Connected

Any device that supports wireless network communication is network connected to a wireless network, regardless of whether the device is communicating using wireless. Unless physically disabled, devices with wireless transceivers support wireless, it is not sufficient to disable the wireless in software.

1.4.7 Network Media

The thing that provides the communication channel between the devices on a network. Typically wire, but might include wireless, fiber optic, or even power line (some network protocols allow sending network signals over power wiring).

1.4.8 User Account Support Levels

The support for user accounts is categorized in this Section as one of three levels:

1.4.8.1 FULLY Supported

Device supports configurable individual accounts. Accounts can be created, deleted, modified, etc. Privileges can be assigned to accounts. These devices support user-based (as opposed to role-based) authentication.

1.4.8.2 MINIMALLY Supported

Device supports a small, fixed number of accounts (perhaps only one). Accounts cannot be modified. A device with only a "User" and an "Administrator" account would fit this category. Similarly, a device with two PINs for logon - one for restricted and one for unrestricted rights would fit here (in other words, the accounts do not have to be the traditional "username and password" structure). These devices typically only support role-based authentication.

Examples of devices which MINIMALLY support accounts are a) a variable frequency drive with a single account which requires a PIN for access to configuration; and b) a room lighting control touchpad interface that has a single account.

1.4.8.3 NOT Supported

Device does not support any Access Enforcement therefore the whole concept of "account" is meaningless.

1.4.9 Manual Local Input

Manual Local Inputs are system analog or binary inputs that are adjustable by a person but are, by intrinsic hardware design, very limited in potential capabilities. Manual Local Inputs do not have touch screens or full keyboards, but may have a few buttons or dials to allow input. Manual Local Inputs do not have full graphic screens or dot-matrix displays, but may have simple lights (LEDs) or 7-segment displays. Manual Local Inputs do not have any sort of menu structure, each button has a single well-defined function.

Examples of Manual Local Inputs are H-O-A switches, simple thermostats, and disconnect switches.

1.4.10 Card Reader

A card reader is an input/output device whose primary function is to assist in two-factor authentication. A card reader must have an interface to read data from a card and may be able to write data to a card. A card reader may have a means (such as buttons, keypad, touchscreen, etc.), for a user to input a PIN or password, as well as a limited display.

1.4.11 User Interface

A User Interface (UI) is something other than a Manual Local Input or Card Reader that allows a person to interact with the system or device. Note that while a Card Reader is not by itself a User Interface, a User Interface may contain a Card Reader in order for it to authenticate its user. Within control systems, there are a wide range of User Interfaces.

Two important distinctions are 1) whether the user interface is Local or Remote, and 2) the effective capabilities of the User Interface to alter data, which is the "privilege" of the user interface (where effective privilege available to a specific user at a specific user interface is the combination of the greatest privilege offered by the user interface and the specific account the user is logged into).

1.4.11.1 Local User Interface

A Local User Interface is a user interface where the physical hardware the user interacts with (keyboard, buttons, display, etc.), is physically part of the device being affected. All of the relevant characteristics of the user interface are embodied within a single device.

Note that a Local UI may be able to access data in a different device, Local versus Remote in this context refers to the user interface itself; the capability to access data in a different device is covered under "Full User Interface".

1.4.11.2 Remote User Interface

A Remote User Interface implements a Client/Server model where the physical hardware the user interacts with (Client) is physically distinct from the device being affected (Server). Most or all of the security and functionality characteristics of the user interface are defined by the Server, not the Client. The Client and Server communicate via a network connection. A common example of a remote user interface is a web-based interface where the browser (client) is generally on different hardware than the web server (server). A Remote UI remains a Remote UI even if the user happens to be at a Client on the same hardware as the Server. What is important is that a) the Client may be on different hardware than the Server and b) the majority of the security and functional characteristics of the interface are defined at the Server.

Note that this definition of "remote" is consistent with that generally used in the control industry but is not aligned with the NIST 800-53 definition of "Remote", which refers to "outside the system". The term "Remote" here better aligns with the NIST 800-53 definition of "Network" (remote from within the system) Access.

1.4.11.3 Types of User Interface (by capability)

User interfaces are also categorized by their capabilities as being Read Only, Limited, or Full.

1.4.11.3.1 Read-Only User Interface

A Read Only User Interface (also referred to as a View-Only User Interface) is a user interface that only allows for reading data, it does not allow (have the capability to) modify data. A Read Only User Interface may be either Local or Remote. A User Interface that is configured to be Read Only (by some other means than the interface itself, such as using configuration software on a laptop) is a Read-Only Interface. Note a Read Only User Interface may have buttons (or touch screen, etc.), allowing the user to navigate through the presentation of data.

Examples of a Read Only User Interfaces are a) a publicly viewable "energy dashboard" showing weather data and energy usage within a building and b) digital wayfinding signage.

1.4.11.3.2 Limited User Interface

A Limited User Interface is a user interface that - by design - can only alter information local to the user interface. Note that the determination of "alter" includes only direct interactions, it explicitly excludes interactions that might occur as secondary effects. For example, an interface changing the flow setpoint in a pump controller is a direct interaction, the subsequent change in flow (as well as any subsequent downstream changes in valve position) are not direct interactions.

Two examples of LIMITED UIs are: a) A variable speed drive has a Limited Local User Interface which allows the user to change properties within the drive, but does not allow affecting things outside the drive; and b) a typical home WiFi Router has a Limited Remote User Interface which allows configuration of the Router, but does not allow direct interaction with other devices.

1.4.11.3.3 Full User Interface

A Full User Interface can alter information in devices outside the device with the user interface. For example, a typical Local Display Panel is a Full Local User Interface while a browser-based front end is a Full Remote User Interface.

1.4.11.3.4 View-Only User Interface

See Read-Only User Interface.

1.4.11.4 Other User Interface Terminology

In addition to defining whether a user interface is a Hardware Limited, Read-Only, Limited or Full, and whether it is Local or Remote, user interfaces are classified by whether they are writable or privileged.

1.4.11.4.1 Writable User Interface

Any User Interface that is not Read-Only is Writable. (Limited User Interfaces and Full User Interfaces are both writable user interfaces (as they are capable of changing a value)).

1.4.11.4.2 Privileged User Interface

A Privileged UI is a UI that has sufficient capabilities or functionality that it requires specific cybersecurity measures to be put in place to limit its unauthorized use. Ultimately, whether a specific user interface is considered a Privileged User Interface must be determined by usage. Unless otherwise specified, user interfaces can be determined to be privileged or not using the following:

a. Read-Only User Interfaces are not privileged user interfaces.

b. User Interfaces that can inhibit or force the activation of a fire suppression system (e.g., such as for a pre-action or deluge system) are always privileged user interfaces. Other Full User interfaces for Fire Alarm Systems are privileged user interfaces as indicated and shown, or when another requirement of this Section establishes they are privileged. For all other systems, Full User Interfaces are privileged user interfaces.

c. User interfaces that allow for configuration of auditing or allows for modification or deletion of audit logs are privileged user interface.

d. User interfaces that allow for reprogramming a network connected device is a privileged user interface.

e. Except as specified above, a Limited User Interface must be determined to be privileged or not based on the specific capabilities and use case of the user interface. In general however, user interfaces that do not offer significant capabilities above and beyond those available at that location via other means (e.g., such as a disconnect switch, breaker, or hand-off-auto switch, or physical attack) are not privileged.

1.4.12 Wireless Network

Any network that communicates without using wires or fiber optics as the

communication media. Wireless networks include: WiFi, Bluetooth, ZigBee, cellular, satellite, long and short wave radio, 2.4 GHz, free space optical, point-to-point laser, microwave, and IR.

1.4.13 Wired Broadcast Network

Wired Broadcast Networks are any network, such as powerline carrier networks and modem (wired telephony), that use wire-based technologies where there is not a clearly defined boundary for signal propagation.

1.5 ADMINISTRATIVE REQUIREMENTS

1.5.1 Points of Contact

Coordinate with the following Points of Contact as indicated in this Section and as required. Not all projects will require coordination with all Points of Contact. When coordination is required and no Point of Contact is indicated, coordinate with the Contracting Officer Representative (COR).

a. HTTPS Certificate Point of Contact: Contracting Office Representative (COR).

b. Email Address Point of Contact: Contracting Officer (KO).

c. Password Point of Contact: Contracting Officer Representative (COR).

1.5.2 Coordination

Coordinate the execution of this Section with the execution of all other Sections related to control systems as indicated in the paragraph RELATED REQUIREMENTS. Items that must be considered when coordinating project efforts include but are not limited to:

a. If requesting permission for alternate account lock permissions, the Device Account Lock Exception Request must be approved prior to control system device selection and installation.

b. If requesting permission for the use of a device with multiple physical connections to IP networks, the Multiple IP Connection Device Request must be approved prior to control system device selection and installation.

c. Wireless testing may be required as part of the control system testing. See requirements for the Wireless Communication Test Report submittal.

d. The Cybersecurity Interconnection Schedule must be coordinated with other work that will be interconnected to, and interconnections must be approved by the Government before relying on them for system functionality.

e. Cybersecurity testing support must be coordinated across control systems and with the Government cybersecurity testing schedule.

f. Passwords must be coordinated with the indicated contact for the project site.

g. If applicable, HTTPS web server certificates must be obtained from the

indicated HTTPS Certificate Point of Contact.

h. Contractor Computer Cybersecurity Compliance Statements must be provided for each contractor using contractor owned computers.

1.6 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

Device Account Lock Exception Request; G

Multiple Ethernet Connection Device Request; G

Contractor Computer Cybersecurity Compliance Statements; G

Contractor Temporary Network Cybersecurity Compliance Statements; G

Cybersecurity Interconnection Schedule ; G

Protection of Information At Rest Proposal; G

Proposed STIG and SRG Applicability Report; G

Pre-Construction Control System Inventory Report ; G

SD-02 Shop Drawings

Network Communication, Ports, Protocols and Services Report; G, AE

Cybersecurity Network (Riser) Diagram ; G, AE

SD-03 Product Data

Control System Cybersecurity Documentation; G

SD-06 Test Reports

Control System Cybersecurity Testing Procedures; G

Control System Cybersecurity Testing Report; G

SD-07 Certificates

Software Licenses; G

SD-11 Closeout Submittals

Password Change Summary Report; G

Enclosure Keys; G

Software and Configuration Backups; G

System Maintenance Tool Software; G

Control System Scanning Tools; G

Vendor Guide Compliance Result Report; G

Final Control System Inventory Report; G

Integrity Verification Software; G

1.7 CYBERSECURITY DOCUMENTATION

{For Government Reference Only: This subpart (and its subparts) relates to PL-7; CCI-003071.}

1.7.1 Proposed STIG and SRG Applicability Report

For each model of network connected or network infrastructure device, use the DISA SRG/STIG Applicability Guide and Collection Tool (available at https://public.cyber.mil/stigs/SCAP/to identify applicable SRGs and provide a report indicating applicable SRGs for each model. Provide the Proposed SRG Applicability Report concurrently with the Pre-Construction Control System Inventory Report.

1.7.2 Cybersecurity Interconnection Schedule

{For Government Reference Only: This subpart relates to CA-3(b), PL-8, SC-7(9), SC-7(11); CCI-000258, CCI-003072, CCI-003073, CCI-003075, CCI-002398, CCI-002399, CCI-002401, CCI-002402, CCI-002403. For MODERATE Impact systems, this subpart also relates to SC-7; CCI-001126, CCI-001109.}

Provide a completed Cybersecurity Interconnection Schedule documenting network connections between the installed system and other systems. Provide the following information for each device directly communicating between systems: Device Identifier, Device Manufacturer, Device Description, Transport layer Protocol, Network Address, Port (if applicable), MAC (Layer 2) address (if applicable), Media, Application Protocol, Service (if applicable), Descriptive Purpose of communication. For communication with other authorized systems also provide the Foreign Destination and POC for Destination. For MODERATE Impact Systems: Also describe the impact of loss of the connection on the control system. If other control system Sections used on this project include submittals documenting this information, provide copies of those submittals to meet this requirement.

In addition to the requirements of Section 01 33 00 SUBMITTAL PROCEDURES, provide the Cybersecurity Interconnection Schedule as an editable Microsoft Excel file (a template Cybersecurity Interconnection Schedule in Excel format is available at https://www.wbdg.org/dod/ufgs/ufgs-25-05-11.)

1.7.3 Network Communication, Ports, Protocols and Services Report

{For Government Reference Only: This subpart (and its subparts) relates to CA-9, PL-8; CCI-002102, CCI-002103, CCI-002104, CCI-002105, CCI-003072, CCI-003073, CCI-003075 and also the submittal requirements associated with CM-6, CM-7, including CM-7(3), CCI-000388.}

Provide a Network Communication, Ports, Protocols and Services Report. For each networked device, document device identifier and the communication characteristics of the device including communication

protocols, services used, encryption employed, and a general description of what information is communicated over the network. For each device using IP communication, document all TCP and UDP ports used. For each device using non-IP communication, document communication protocol and media used. If other control system Sections used on this project include submittals documenting this information, provide copies of those submittals to meet this requirement.

In addition to the requirements of Section 01 33 00 SUBMITTAL PROCEDURES, provide the Network Communication, Ports, Protocols and Services Report as an editable Microsoft Excel file.

1.7.4 Control System Inventory Reports

{For Government Reference Only: This subpart (and its subparts) relates to CM-8(a), SI-17, IA-3; CCI-000389, CCI-000392, CCI-000398, CCI-002773, CCI-002774, CCI-002775, CCI-000777, CCI-000778, CCI-001958.}

Provide a Pre-Construction Control System Inventory Report report and a Final Control System Inventory Report, using the Inventory Spreadsheet listed under this Section at https://www.wbdg.org/dod/ufgs/ufgs-25-05-11. In the Control System Inventory Reports, document all networked devices, including network infrastructure devices. For each device provide all applicable information for which there is a field on the spreadsheet in accordance with the instructions on the spreadsheet.

In addition to the requirements of Section 01 33 00 SUBMITTAL PROCEDURES, provide the Control System Inventory Reports as editable Microsoft Excel files. Provide the Pre-Construction Control System Inventory Report concurrently with the Proposed STIG and SRG Applicability Report.

1.7.5 Software and Configuration Backups

{For Government Reference Only: This subpart (and its subparts) relates to CP-10; CCI-000550, CCI-000551, CCI-000552.}

For all controllers, provide a backup of the controller configuration and the source code for all loaded application programs (all software that is not common to every controller of the same manufacturer and model).

If any or all of these are provided under another Section, provide documentation indicating this and referencing those submittals.

1.7.6 Cybersecurity Network (Riser) Diagram

{For Government Reference Only: This subpart (and its subparts) relates to PL-2(a), PL-8; CCI-003051, CCI-003053, CCI-003072, CCI-003073, CCI-003075.}

Provide a cybersecurity network (riser) diagram of the complete control system including all network and device hardware. For each device, include the device identifier, device type, and manufacturer. If the control system specifications require a riser diagram submittal, provide a copy of that submittal as the cybersecurity riser diagram. Otherwise, provide a riser diagram in one-line format.

1.7.7 Vendor Guide Compliance Result Report

For every component (device or software) with manufacturer provided

cybersecurity documentation, procedure, or method for secure configuration or installation, provide a report documenting how the component was configured and any deviation from the manufacturer instructions.

1.7.8 Control System Cybersecurity Documentation

{For Government Reference Only: This subpart (and its subparts) relates to SA-5(a),SA-5(b),SA-5(c), SA-22(b); CCIs: CCI-003124, CCI-003125, CCI-003126, CCI-003127, CCI-003128, CCI-003129, CCI-003130, CCI-003131, CCI-003374.}

Provide a Control System Cybersecurity Documentation submittal containing the indicated information for each device and software application.

1.8 SOFTWARE LICENSING

{For Government Reference Only: This subpart (and its subparts) relates to SI-2(a), SI-2(c), SI-7(14); CCI-001227, CCI-002605, CCI-002737.}

For all software provided that has not already been licensed to the Government or project site, provide a license to the for a period of no less than 5 years, and the license must also include the following software updates:

a. Security and bug-fix patches issued by the software manufacturer.

b. Security patches to address any vulnerability identified in the National Vulnerability Database at http://nvd.nist.gov with a Common Vulnerability Scoring System (CVSS) severity rating of MEDIUM or higher.

Provide a single Software Licenses submittal with documentation of the software licenses for all software provided.

1.9 CYBERSECURITY DURING CONSTRUCTION

{For Government Reference Only: This subpart (and its subparts) relates to AC-18, CA-3; CCI-000258.}

In addition to the control system cybersecurity requirements indicated in this section, meet following requirement throughout the construction process.

1.9.1 Contractor Computer Equipment

Contractor owned computers may be used for construction. Contractor computers connected to the control system, control system network, or a control system component at any point during construction must meet the following requirements:

1.9.1.1 Operating System

The operating system must be an operating system currently supported by the manufacturer of the operating system. The operating system must be current on security patches and operating system manufacturer required updates.

1.9.1.2 Anti-Malware Software

The computer must run anti-malware software from a reputable software manufacturer. Anti-malware software must be a version currently supported by the software manufacturer, must be current on all patches and updates, and must use the latest definitions file. Computers used on this project must perform a full antivirus scan at least once per day. Computers which have connected to any other network since the last full antivirus scan must perform a full antivirus scan prior to connection to the control system network or to the temporary contractor-installed IP network. Perform an antivirus scan on all removable media (e.g., external hard drives, CDs, DVDs, USB flash drives) prior to connecting to the control system environment.

1.9.1.3 Passwords and Passphrases

The passwords and passphrases for computers, applications, and web-based applications supporting passwords must be changed from their default values. Passwords must be a minimum of eight characters with a minimum of one uppercase letter, one lowercase letter, one number and one special character.

1.9.1.4 User-Based Authentication

Each user must have a unique account; sharing of a single account between multiple users is prohibited.

1.9.1.5 Demonstration of Compliance

The Government has the right to require demonstration of computer compliance with these requirements at any time during the project.

1.9.1.6 Contractor Computer Cybersecurity Compliance Statements

Provide a single submittal containing completed Contractor Computer Cybersecurity Compliance Statements for each company using contractor owned computers. Contractor Computer Cybersecurity Compliance Statements must use the template published at https://www.wbdg.org/dod/ufgs/ufgs-25-05-11. Each Statement must be signed by a cybersecurity representative for the relevant company.

1.9.2 Temporary IP Networks

Temporary contractor-installed IP networks may be used during construction. When used, temporary contractor-installed IP networks connected to the control system, control system network, or a control system component at any point during construction must meet the following requirements:

1.9.2.1 Network Boundaries and Connections

The network must not extend outside the project site and must not connect to any IP network other than those specifically provided or furnished for this project. Any and all access to the network from outside the project site is prohibited.

1.9.3 Government Access to Network

Government personnel must be allowed to have complete and immediate access

to the network at any time in order to verify compliance with this specification.

1.9.4 Temporary Wireless IP Networks

In addition to the other requirements on temporary IP networks, temporary wireless IP (WiFi) networks, when permitted, must not interfere with existing wireless networks, must use WPA2 security and must not broadcast the network name (SSID). Network names (SSID) for wireless networks must be changed from their default values.

1.9.5 Passwords and Passphrases

The passwords and passphrases for all network devices and network access must be changed from their default values. Passwords must be a minimum 8 characters with a minimum of one uppercase letter, one lowercase letter, one number and one special character.

1.9.6 Contractor Temporary Network Cybersecurity Compliance Statements

Provide a single submittal containing completed Contractor Temporary Network Cybersecurity Compliance Statements for each company implementing a temporary IP network. Contractor Temporary Network Cybersecurity Compliance Statements must use the template published at https://www.wbdg.org/dod/ufgs/ufgs-25-05-11. Each Statement must be signed by a cybersecurity representative for the relevant company. If no temporary IP networks will be used, provide a single copy of the Statement indicating this.

1.10 CYBERSECURITY DURING WARRANTY PERIOD

All work performed on the control system after acceptance must be performed using Government Furnished Equipment or equipment specifically and individually approved by the Government.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.1 CYBERSECURITY HARDENING AND CONFIGURATION GUIDES

Install, configure, and harden all hardware and software furnished on this project in accordance with manufacturer provided documentation, procedures, or methods for secure configuration or installation. Do not implement specific hardening actions if that action would conflict with required functionality or another requirement of this Section.

3.2 NETWORK REQUIREMENTS

3.2.1 Information Flow Enforcement In MODERATE Impact Systems

{For Government Reference Only: This subpart (and its subparts) relate to AC-4; CCI-001368, CCI-001414, CCI-001548, CCI-001549, CCI-001550, CCI-001551.}

3.2.2 Wireless and Wired Broadcast Communication for Fire Protection Systems

The use of wireless and wired broadcast communication for fire protection systems within a facility is prohibited. Wireless communication may be used to provide communication from the fire protection system in a facility to the central monitoring station.

3.2.3 Wireless and Wired Broadcast IP Communications

Unless specifically approved and installed in accordance with the project site requirements, do not install wireless or wired broadcast IP networks, including: Do not install a wireless access point; do not install or configure an ad-hoc wireless network; do not install or configure a WiFi Direct communication.

When explicitly authorized by the Government, wireless IP communication may be used to communicate with an existing wireless network.

3.2.4 Non-IP Wireless Communication

For MODERATE Impact Systems: When non-IP wireless communication is explicitly authorized by the Government, the radios must meet NIST FIPS 140-2 Level 2.

3.2.5 Non-IP Control Networks

When control system specifications require particular communication protocols, use only those communication protocols and only as specified. Do not implement any other communication protocol.

When control system specifications do not indicate requirements for communication protocols, use only those protocols required for operation of the system as specified.

3.2.6 IP Control Networks

{For Government Reference Only: This subpart relates to CM-6(a), CM-7(a), CM-7(b), CM-7(1)(b), SC-41; CCI-001588, CCI-000381, CCI-000380, CCI-000381, CCI-000382, CCI-001761, CCI-001762, CCI-002544, CCI-002545, CCI-002546. For Moderate Impact Systems, this subpart (and its subparts) also relates to SC-5(1), SC-5(2); CCI-001094 CCI-001095.}

For MODERATE Impact Systems, unless explicitly authorized, do not use IP networks if the same control functionality is available through the use of non-IP networks.

3.2.6.1 IP Network Routers

Do not install any device that performs IP routing.

3.2.6.2 IP Devices With Multiple Ethernet Connections

Except for Daisy Chain IP Controllers, devices must not have more than one Ethernet connection to IP networks unless doing so is required by the project specifications and the specific application is approved. If a device with Multiple Ethernet Connections to IP networks is required, provide a Multiple Ethernet Connection Device Request using the Multiple Ethernet Connection Device Request Template at

https://www.wbdg.org/dod/ufgs/ufgs-25-05-11 to request approval for each device. If a device with Multiple Ethernet Connections to IP networks is not required, instead provide a document stating that no approval is being requested.

3.3 ACCESS CONTROL REQUIREMENTS

3.3.1 User Accounts

{For Government Reference Only: This subpart (and its subparts) relate to AC-2(a), AC-3, AC-6(1), AC-6(10), AC-6(2), AC-6(9), CM-11(2), and IA-2; CCI-002110, CCI-000213, CCI-001558, CCI-002221, CCI-002222, CCI-002223, CCI-002235, CCI-000039, CCI-001419, CCI-002234, CCI-001812, and CCI-000764. For MODERATE Impact systems, this subpart (and its subparts) also relate to AC-2 (2), AC-2(3), AC-2(4), AC-6(1), and CM-5(1); CCI-001361, CCI-000017, CCI-000217, CCI-000018, CCI-001403, CCI-001404, CCI-001405, CCI-002130, CCI-001683, CCI-001684, CCI-001685, CCI-001686, CCI-002132, CCI-001558, CCI-002221, CCI-002222, CCI-002223, CCI-001813.}

Any user interface supporting user accounts (either FULLY or MINIMALLY) must limit access according to specified limitations for each account.

All user interfaces FULLY supporting accounts must implement user-based authentication where each account is uniquely assigned to a specific user. User interfaces FULLY supporting accounts must implement at least three (3) levels of user account privilege including: 1) An account with read-only permissions 2) an account with full permissions including account creation and modification and 3) an account with greater permissions than read-only but without account creation and modification. Disable any unnecessary or unused accounts. Disable any "guest-level" accounts that are created on the system by default.

3.3.1.1 Controllers

For user interfaces provided by controllers, provide access control in accordance with the User Interface Requirements table for the applicable control system and user interface type.

a. For table entries of "NA": NA means Not Applicable, there are no interfaces in this category.

b. For table entries of "None Required": The user interface is not required to support user accounts.

c. For table entries of "MINIMALLY": The user interface must at least MINIMALLY support user accounts.

d. For table entries of "FULLY": The user interface must at FULLY support user accounts.

e. For table entries of "KEY": The user interface must have physical security in the form of either a key lock on the interface itself or be furnished inside a lockable enclosure. Where this is required for a read only interface, the lockable enclosure must prevent viewing of data on the interface; for other interfaces, this lockable enclosure must prevent using the interface to alter data.

f. For table entries of "Physical Security": For Local FULL interfaces, the interface must be located inside mission space. For Local Limited

(not FULL) interfaces, the user interface must either a) be located within mission space or b) be protected by physical security at least as good as the control devices (and equipment controlled by the control devices) affected by the interface. For purposes of this requirement, 'affected' includes controllers with data that can be directly altered by the interface, as well as mechanical and/or electrical equipment directly controlled by those controllers, but does not include other interactions.

g. Entries of the form "X and Y" must meet both the requirement indicated for X and the requirement indicated for Y. For example, an entry of "MINIMALLY and Physical Security" indicates the user interface must both MINIMALLY support accounts and have physical security.

h. Entries of the form "X or Y" must meet either the requirement indicated for X or the requirement indicated for Y.

3.3.1.1.1 Fire Protection Systems

User Interface Requirements for MODERATE Impact Fire Protection Systems	
User Interface Type	**Access Control Requirement** (See note 2)
Local Read Only	None Required
Local Limited, Non-privileged	None Required
Local Limited, Privileged	KEY and Physical Security
Local Full	KEY
Remote Read Only	None Required
Remote Limited, Non-Privileged	FULLY
Remote Limited, Privileged AND Remote Full	FULLY
Notes: 1)Local Read Only User Interfaces are always Non-Privileged 2)Devices outside mission space require physical security protections as indicated (in "PHYSICAL SECURITY IN MODERATE IMPACT SYSTEMS")	

3.3.1.2 Additional User Account Expiration Requirements In MODERATE Impact Systems

In addition to other user account requirements, user account expiration and auditing must be configured as indicated.

3.3.2 Unsuccessful Logon Attempts

{For Government Reference Only: This subpart (and its subparts) relate to AC-7 (a), AC-7 (b); CCI-000043, CCI-000044, CCI-001423, CCI-002236, CCI-002237, CCI-002238.}

Except for high availability user interfaces indicated as exempt, devices

must meet the indicated requirements for handling unsuccessful logon attempts. If a device cannot meet these requirements, document device capabilities to protect from subsequent logon attempts and propose alternate protections in a Device Account Lock Exception Request submittal. Do not implement alternate protection measures in lieu of the indicated requirements without explicit permission from the Government. If no Device Account Lock Exceptions are requested, provide a document stating that no approval is being requested as the Device Account Lock Exception Request.

3.3.2.1 High Availability Interfaces Exempt from Unsuccessful Logon Attempts Requirements

There are no high availability interfaces which are exempt from unsuccessful logon attempts requirements.

3.3.3 System Use Notification

{For Government Reference Only: This subpart (and its subparts) relates to AC-8; CCI-000048, CCI-002247, CCI-002243, CCI-002244, CCI-002245, CCI-002246, CCI-000050, CCI-002248.}

3.3.3.1 System Use Notification for Remote User Interfaces

Remote user interfaces must display a warning banner meeting the requirements of DTM 08-060 on screen.

3.3.3.2 System Use Notification for Local User Interfaces

Devices which are connected to a network and have a local user interface must display a warning banner meeting the requirements of DTM 08-060 on the user interface screen if capable of doing so and must have a permanently affixed label with an approved banner from DTM 08-060 if unable to display the warning banner on the screen. Where it is impractical (perhaps due to device size) to affix the label to the device, affix the label to the device enclosure.

Labels must be machine printed or engraved, plastic or metal, designed for permanent installation, must use a font no smaller than 14 point, and must provide a high contrast between font and background colors.

3.3.4 Permitted Actions Without Identification or Authentication

{For Government Reference Only: This subpart (and its subparts) relates to AC-14; CCI-000061, CCI-000232.}

The control system must require identification and authentication before allowing any actions except read-only actions by a user acting from a user interface which MINIMALLY or FULLY supports accounts.

3.3.5 Physical Security in MODERATE Impact Systems

{For Government Reference Only: This subpart relates to PE-3(1), PE-4, PE-5, SC-7(a), SC-7(c), SC-8, SC-8(1); CCI-000928, CCI-002926, CCI-000936, CCI-002930, CCI-002931, CCI-000937, CCI-001097, CCI-001109, CCI-002418, CCI-002419, CCI-002421.}

3.3.5.1 Physical Security for Media

3.3.5.1.1 Physical Security for Media Inside Mission Space

Install all non-IP network media located inside of the mission space in conduit. Install all IP network media located inside of the mission space in intermediate metallic conduit.

3.3.5.1.2 Physical Security for Media Outside Mission Space

Install all network media (both IP and non-IP) located outside of the mission space in rigid metallic conduit.

3.3.5.1.3 Physical Security for Non-Network Media in Fire Protection Systems

For Fire Suppression Systems which can be inhibited or forced to activate by manipulation of non-network wiring, install all non-network media outside of mission space, including analog and binary instrumentation wiring and power wiring, in rigid metallic conduit.

3.3.5.2 Physical Security for Devices

Install all devices (controllers) which are located outside of mission space in lockable enclosures. (Recall that per definition of mission space, a room controlled by the mission is mission space regardless of whether it is contiguous with other mission space.)

Install all controllers connected to an IP network in lockable enclosures (both inside and outside of mission space).

3.3.5.2.1 Physical Security for Devices in Fire Protection Systems

For Fire Suppression systems with a release panel, install all components of the suppression system either inside mission space, or within locked enclosures. Components of these systems include: Release panel, any relay or interface panels, analog and binary inputs or outputs, control valves, manual valves.

3.3.5.3 Physical Security for User Interfaces

Physical security requirements for User Interfaces are specified in the preceding paragraphs of this Section.

3.3.6 Enclosures

Prior to final acceptance of the system, lock all lockable enclosures. Submit an Enclosure Keys submittal with all copies of keys for all enclosures and a key inventory list documenting all keys. Label each key with the matching enclosure identifier.

3.4 USER IDENTIFICATION AND AUTHENTICATION

{For Government Reference Only: This subpart (and its subparts) relates to IA-2, IA-2(1),IA-2(12), IA-5 IA-5(b), IA-5(c), IA-5(e), IA-5(g), IA-5(1), IA-5(11); CCI-000764, CCI-000765, CCI-001953, CCI-001954, CCI-001544, CCI-001989, CCI-000182, CCI-001610, CCI-000192, CCI-000193, CCI-000194, CCI-000205, CCI-001619, CCI-001611, CCI-001612, CCI-001613, CCI-001614, CCI-000195, CCI-001615, CCI-000196, CCI-000197, CCI-000199,

CCI-000198, CCI-001616, CCI-001617, CCI-000200, CCI-001618, CCI-002041, CCI-002002, CCI-002003. For MODERATE Impact systems, this subpart also relates to AC-6 (1), AC-6(10), AC-6(2), AC-6(9)IA-2(4), IA-5(13); CCI-001558, CCI-002221, CCI-002222, CCI-002223, CCI-002235, CCI-000039, CCI-001419, CCI-002234, CCI-000768, CCI-002007.}

This subpart indicates requirements for specific methods of identification and authentication for users and user accounts. Where these requirements conflict apply the following order of precedence: 1) If present, Device Specific Requirements take precedence over any other requirements; and then 2) multifactor authentication requirements take precedence over password requirements.

3.4.1 User Identification and Authentication for Specific System Types

System specific requirements are in addition to and supersede those indicated for all system types. When no additional requirements are indicated for a specific system type the requirements for all systems still apply to that system type.

3.4.2 User Identification and Authentication for Specific Devices

There are no additional device specific user interface requirements.

3.4.3 Implementation of Identification and Authorization Requirements

Identification and Authorization must be met by one of the following methods:

a. Direct implementation in the user interface.

3.4.4 Password-Based Authentication Requirements

3.4.4.1 Passwords for Controllers FULLY Supporting Accounts

All controllers FULLY supporting accounts and supporting password-based authentication must enforce the following requirements:

a. Minimum password length of 12 characters.

b. Password must contain at least one uppercase character.

c. Password must contain at least one lowercase character.

d. Password must contain at least one numeric character.

e. Password must contain at least one special character. The list of supported special characters must include at least 4 separate characters.

f. Password must have a maximum lifetime of sixty (60) days. When passwords expire, prompt users to change passwords. Do not lock accounts due to expired passwords.

g. Password must differ from previous five passwords, where differ is defined as changing at least 50 percent of the characters.

h. Passwords must be cryptographically protected during storage and transmission.

3.4.4.2 Passwords for Remote Interfaces

Passwords for connecting to a Remote User Interface supporting password-based authentication must enforce the following requirements:

a. Minimum password length of 12 characters.

b. Password must contain at least one uppercase character.

c. Password must contain at least one lowercase character.

d. Password must contain at least one numeric character.

e. Password must contain at least one special character. The list of supported special characters must include at least 4 separate characters.

f. Password must have a maximum lifetime of 60 days. When passwords expire, prompt users to change passwords. Do not lock accounts due to expired passwords.

g. Password must differ from previous five passwords, where differ is defined as changing at least 50 percent of the characters (where location is significant, a character may be reused if it is in a different position).

h. Passwords must be cryptographically protected during storage and transmission.

3.4.4.3 Passwords for Devices Minimally Supporting Accounts

Devices MINIMALLY supporting accounts must support passwords with a minimum length of four characters.

3.4.4.4 Password Configuration and Reporting

For all devices with a password, change the password from the default password. Coordinate selection of passwords with the Password Point of Contact. Do not use the same password for more than one device unless specifically instructed to do so.

Do not provide the Password Summary Report in electronic format. Provide two hardcopies of the Password Summary Report, each copy in its own sealed envelope.

For all devices with a password, coordinate the changing of passwords with the project site following testing of the system but prior to turnover to the Government. Coordinate with Password Point of Contact to determine appropriate project site personnel to complete password changes. Accompany identified personnel to each device with a password and instruct personnel on the process of changing password. Record the time, date and personnel present when each device's password is changed and submit a Password Change Summary Report documenting this information.

Provide the Password Summary Report electronically in both PDF and Microsoft Excel.

3.4.5 Authenticator Feedback

{For Government Reference Only: This subpart relates to IA-6; CCI-000206.}

Devices must never show authentication information, including passwords, on a display. Devices that momentarily display a character as it is entered, and then obscure the character, are acceptable.

3.5 CYBERSECURITY AUDITING

Where an auditing requirement exists for email notification, notify via email the application administrator and Information System Security Officer (ISSO) of the event. Coordinate with the Email Address Point of Contact for email addresses. If outgoing email is not available to the system, disable email notifications.

3.5.1 Audit Events, Content of Audit Records, and Audit Generation

{For Government Reference Only: This subpart (and its subparts) relates to AU-2(a), AU-2(c), AU-2(d), AU-3, AU-10, AU-12, AU-14(b), AU-14(1), AU-14(2), AU-14(3), CM-5(1), SC-7 (9); CCI-000123, CCI-001571, CCI-000125, CCI-001485, CCI-000130, CCI-000131, CCI-000132, CCI-001230, CCI-000133, CCI-000134, CCI-001487, CCI-000166, CCI-001899, CCI-000169, CCI-001459, CCI-000171, CCI-000172, CCI-001910, CCI-001914, CCI-001919, CCI-001464, CCI-001462, CCI-001920, CCI-001814, CCI-002400. For MODERATE Impact systems, this subpart (and its subparts) also relates to AU-3 (1); CCI-000135, CCI-001488.}

If auditing requirements can be met using existing control system alarm or event capabilities, those existing capabilities may be used to meet these requirements.

3.5.2 Audit Time Stamps

{For Government Reference Only: This subpart (and its subparts) relates to AU-8; CCI-000159, CCI-001889, CCI-001890. For MODERATE Impact systems, this subpart (and its subparts) also relates to AU-8 (1); CCI-001891, CCI-001892, CCI-002046.}

Any controller generating audit records must have an internal clock capable of providing time with a resolution of one second. Clocks must not drift more than 10 seconds per day. Configure the system so that each controller generating audit records maintains accurate time to within 1 second. Note that if the control system specifications include requirement for clocks, the most stringent requirement applies.

3.6 REQUIREMENTS FOR LEAST FUNCTIONALITY

{For Government Reference Only: This subpart (and its subparts), along with the Network Communication, Ports, Protocols and Services Report submittal specified elsewhere in this section, relates to CM-6(a), CM-6(c), CM-7, CM-7(1)(b), SC-41; CCI-000363, CCI-000364, CCI-000365, CCI-001588, CCI-001755, CCI-000381, CCI-000380, CCI-000382, CCI-001761, CCI-001762, CCI-002544, CCI-002545, CCI-002546. For MODERATE Impact systems, this subpart (and its subparts) also relates to CM-7(2), CM-7(5)(a), CM-7(5)(b); CCI-000381, CCI-000380, CCI-000382, CCI-001761, CCI-001762.}

3.6.1 Device Capabilities

Do not provide devices with remote user interfaces or full user interfaces where one was not required. Do not use a networked sensor or actuator where a non-networked sensor or actuator would suffice.

For all MODERATE Impact Systems: Unless specifically required by the Government, do not provide a capability to update device firmware over the network.

3.6.2 Software

Do not install software that is not specifically required to meet a contract requirement. Remove any previously installed that is not specifically required to meet a contract requirement. Do not implement functionality within software that is not specifically required to meet contract requirements.

3.7 SYSTEM AND COMMUNICATION PROTECTION

3.7.1 Collaborative Computing

{For Government Reference Only: This subpart relates to SC-15(a), SC-15(b); CCI-001150, CCI-001152.}

Without explicit approval from the project site, control systems must not use collaborative computing technologies.

3.7.2 Denial of Service Protection and Application Partitioning In MODERATE Impact Systems

{For Government Reference Only: This subpart relates to SC-5, SC-12, SC-7(a); CCI-001093, CCI-002385, CCI-002386, CCI-002430, CCI-001097. For MODERATE Impact systems, this subpart also relates to SC-2; CCI-001082.}

To the greatest extent practical, implement control logic without reliance on the network.

3.7.3 Protection of Information at Rest In MODERATE Impact Systems

{For Government Reference Only: This subpart relates to SC-28, SC-28(1); CCI-001199, CCI-002472, CCI-002475, CCI-002476.}

Any control system device storing personally identifiable information (PII), controlled unclassified information (CUI), or classified information must be protected by an Information At Rest encryption solution or by a physical security solution. Provide a Protection of Information At Rest Proposal indicating each device storing PII, CUI, or classified information and the encryption or physical security solution proposed for that device for Government approval. If no devices stores PII, CUI, or classified information, provide a document stating this as the Protection of Information At Rest Proposal submittal. Do proceed with device selection and installation until the Protection of Information At Rest Proposal is approved. Once approved, implement approved Information At Rest protections.

3.7.4 Process Isolation and Boundary Protection in Moderate Impact Fire Protection Systems

{For Government Reference Only: This subpart relates to SC-7(a), SC-7(c), SC-7(4)(a), SC-7(4)(c), SC-7(5), SC-7(7), SC-7(9)(a), SC-7(11), SC-7(13), SC-7(13), SC-7(18); CCI-001097, CCI-001098, CCI-001102, CCI-002396, CCI-001109, CCI-002397, CCI-002398, CCI-002399, CCI-002403, CCI-001120, CCI-001119, CCI-001126.}

3.7.4.1 Radio Interfaces for Fire Protection Systems

When radios interfacing a local fire protection system to a supervisory system are not NIST FIPS 140-2 validated, use a relay panel interface between the local fire protection system and the radio. Install and configure the relay panel to prohibit initiating any action within the local fire protection system other than causing the system to play a pre-recorded message or causing the system to play a live audio message. Install relays using the normally open contact such that they pass a signal when they close, and so that a relay that loses power or has a failed coil does not pass a signal.

3.7.4.2 Fire Suppression System Network Isolation

For fire suppression systems including a release panel, any network used in these systems must be dedicated to these systems and must be isolated from any other network, including other components of the Fire Alarm and Fire Suppression systems. Use only dry contacts and relays to transfer signals from these systems to any other systems. Install relays using the normally open contact such that they pass a signal when they close, and so that a relay that loses power or has a failed coil does not pass a signal.

3.8 SAFE MODE AND FAIL SAFE OPERATION

{For Government Reference Only: This subpart (and its subparts) relates to CP-12, SI-10(3), SI-17; CCI-002855, CCI-002856, CCI-002857, CCI-002754, CCI-002773, CCI-002774, CCI-002775.}

3.9 SYSTEM MAINTENANCE TOOL SOFTWARE

{For Government Reference Only: This subpart (and its subparts) relates to MA-3; CCI-000865.}

Submit and license to the Government all software required to operate, maintain and modify the control system such the Government or their agents are able to perform repair, replacement, upgrades, and expansions of the system without subsequent or future dependence on the Contractor, Vendor or Manufacturer. Submit hard copies of user manuals for each software with the software submittal. Provide any hardware keys or dongles, software keys, license numbers, and other information required to enable the Government to access or change the system.

For software provided and licensed to the Government under the requirements of another Section, submit a statement indicating the Section and Submittal under which the software was provided. For software provided to meet the requirements of this Section and not provided and licensed under another Section, submit software and software user manuals on DVD or CD as a Technical Data Package and submit one hard copy of the software user manual for each piece of software.

3.10 DEVICE POWER

{For Government Reference Only: This subpart (and its subparts) relates to PE-11, PE-11(1); CCI-002955, CCI-000961. For MODERATE Impact systems, this subpart (and its subparts) also relates to PE-9, PE-9(1); CCI-000952, CCI-002953, CCI-002954.}

For MODERATE Impact Systems: Provide control system with power supply meeting or exceeding the reliability of the controlled equipment. Powering control system devices using the same power source as the equipment controlled by the device is a permissible method of meeting this requirement. Without explicit approval from the Government, do not install local uninterruptible power supplies (UPSes) as a source of device power.

3.10.1 Device Behavior on Loss of Power In MODERATE Impact Systems

Application programs and configuration settings must be stored in devices in manner such that a loss of power does not result in a loss of the application program or configuration settings: Loss of power must never result in the loss of application programs, regardless of the length of time power is lost; and loss of power for less than 2,500 hours must not result in the loss of configured settings.

In the event of a loss of power, when power is restored, controllers executing control logic (and the underlying equipment) must recover and resume their normal sequences of operation. Note that the sequence of operation may require specific actions (e.g., startup sequences) upon recovery from loss of power.

3.11 VULNERABILITY SCANNING

{For Government Reference Only: This subpart (and its subparts) relates to RA-5 RA-5(a),RA-5(b),RA-5(c),RA-5(d); CCI-001054, CCI-001055, CCI-000156, CCI-001641, CCI-001643, CCI-001057, CCI-001058, CCI-001059. For MODERATE Impact systems, this subpart (and its subparts) also relates to RA-5(1), RA-5(5); CCI-001062, CCI-001067, CCI-001645, CCI-002906.}

All IP devices must be scannable, such that the device can be scanned by industry standard IP network scanning utilities without harm to the device, application, or functionality.

3.11.1 Controllers

Provide controllers that are scannable by standard control system discovery tools or control system browsers and return meaningful status information including the network inputs and outputs for the controller. This information must contain sufficient detail to detect vulnerabilities or exploits of the controller.

Provide all software needed to scan the control system as the Control System Scanning Tools submittal. If the software required to scan the system is already installed at the project site or is provided under a separate section instead provide a statement indicating this.

3.12 SYSTEM AND INTEGRATION INTEGRITY

3.12.1 Software, Firmware, and Information Integrity In MODERATE Impact Systems

{For Government Reference Only: This subpart relates to CM-5(3); CCI-001749, CCI-002704, CCI-002726.}

If there exists Integrity Verification Software that can check boot process, software, firmware, or information in the control system and verify its integrity, provide it. If no such software exists, provide a statement to this affect in lieu of the software.

3.13 CONTROL SYSTEM CYBERSECURITY TESTING

{For Government Reference Only: For MODERATE Impact systems, this subpart (and its subparts) relates to SA-11(a), SA-11(b), SA-11(c), SA-11(d), SA-11(e); CCI-003171, CCI-003172, CCI-003173, CCI-003174, CCI-003175, CCI-003176, CCI-003177, CCI-003178.}

3.13.1 Control System Cybersecurity Testing Procedures

Prepare and submit Control System Cybersecurity Testing Procedures explaining step-by-step, the actions and expected results that will demonstrate that the control system meets the requirements of this Section. The Control System Cybersecurity Testing Procedures may be submitted as a Technical Data Package.

3.13.2 Control System Cybersecurity Testing Execution

Using the Control System Cybersecurity Testing Procedures verify that the control system meets the requirements of this Section. UNLESS GOVERNMENT WITNESSING OF A TEST IS SPECIFICALLY WAIVED BY THE GOVERNMENT, PERFORM ALL TESTS WITH A GOVERNMENT WITNESS. If testing reveals deficiencies in the system, correct the deficiency and retest until successful.

3.13.3 Control System Cybersecurity Testing Report

Prepare and submit a Control System Cybersecurity Testing Report documenting all tests performed and their results. Include all tests in the Control System Cybersecurity Testing Procedures and any additional tests performed during testing. Document test failures and repairs conducted with the test results. The Control System Cybersecurity Testing Report may be submitted as a Technical Data Package.

3.14 FIELD QUALITY CONTROL, CYBERSECURITY VALIDATION SUPPORT

In addition to testing and testing support required by other Sections, provide a minimum of 16 hours of technical support for cybersecurity testing of control systems to support the DoD Risk Management Framework process Cybersecurity assessment of the control system. This support is independent of (and in addition to) the Control System Cybersecurity Testing specified in this section.

3.15 CYBERSECURITY TRAINING

Provide eight hours of classroom and hands-on training for six Government personnel on the cybersecurity operation and maintenance of the control system provided. This training is in addition to and must be coordinated

with control system training specified in other Sections.

The Government will provide the training location. Training must cover, at a minimum: (a) Applying software and firmware updates, (b) user account creation, modification and deletion, (c) audit log upload procedures and (d) identification of privileged user interfaces and system impact of those interfaces. Training session must include a question and answer period during which Government staff questions about cybersecurity aspects of the control system are answered.

-- End of Section --

SECTION 25 05 11.03

CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS - LOW ELEVATOR CONTROL SYSTEM

PART 1 GENERAL

Many subparts in this Section contain text in curly braces ("{" and "}") indicating which cybersecurity control and control correlation identifier (CCI) the requirements of the subpart relate to. The text inside these curly braces is for Government reference only and enables coordination of the requirements of this Section with the RMF process throughout the design and construction process. Text in curly braces are not contractor requirements.

This Section refers to Security Requirements Guide (SRGs) and Security Technical Implementation Guide (STIGs). STIGs and SRGs are available online at the Information Assurance Support Environment (IASE) website at https://public.cyber.mil/stigs/downloads/ and an SRG/STIG Applicability Guide and Collection Tool is available at https://public.cyber.mil/stigs/SCAP/. Not all control system components have applicable STIGs or SRGs. The "Control Systems SRG" does not apply to work performed under this Section; all requirements within this section to apply applicable SRGs DO NOT include the "Control Systems SRG".

1.1 CONTROL SYSTEM APPLICABILITY

There are multiple versions of this Section associated with this project. Different versions have requirements applicable to different control systems. This specific Section applies only to the following control systems: Elevator Control System.

1.2 RELATED REQUIREMENTS

This section does not contain sufficient requirements to procure a control system and must be used in conjunction with other Sections which specify control systems. This Section adds cybersecurity requirements to the control systems specified in other Sections, and as these requirements are conditioned on the control system being provided, there may be requirements in this Section that will not apply to this project. All Sections containing facility-related control systems or control system components are related to the requirements of this Section. Review all specification sections to determine related requirements.

In cases where a requirement is specified in both this Section and in another Section, the more stringent requirement must be met. In cases where a requirement in this Section conflicts with the requirements of another Section such that both requirements cannot be met at the same time, request direction from the Contracting Officer Representative to determine which requirement applies to the project.

1.3 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 802.1x	(2010) Local and Metropolitan Area Networks - Port Based Network Access Control

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST FIPS 201-2	(2013) Personal Identity Verification (PIV) of Federal Employees and Contractors

U.S. DEPARTMENT OF DEFENSE (DOD)

DTM 08-060	(2008) Policy on Use of Department of Defense (DoD) Information Systems - Standard Consent Banner and User Agreement

1.4 DEFINITIONS

1.4.1 Administrator Account

An administrator account is an account with full permissions to a device, application, or operating system, including the ability to create and modify other user accounts.

Note that the operating system Administrator Account may be different than Administrator Accounts for applications hosted on that operating system. Also, most controllers will not have any support for accounts and will therefore not have an 'Administrator Account'.

1.4.2 Computer

A computer is one of the following:

a. A device running a non-embedded desktop or server version of Microsoft Windows

b. A device running a non-embedded version of MacOS

c. A device running a non-embedded version of Linux

d. A device running a version or derivative of the Android Operating System, where Android is considered separate from Linux

e. A device running a version of Apple iOS

Unless otherwise indicated or clear from context use of the word "device" in this Section includes computers.

1.4.3 Controller

A device other than a computer or Ethernet switch.

1.4.4 Mission Space

Mission space is shown on the drawings.

1.4.5 Network

A network is a group of two or more devices that can communicate using a network protocol. Network protocols must provide a method for addressing devices on the network; a communication method that does not provide an addressing scheme is not a networked form of communication. Devices that communicate using a method of communication that does not support device addressing are not using a network.

1.4.6 Network Connected

A component is network connected (or "connected to a network") only when the device has a network transceiver which is directly connected to the network and implements the network protocol. A device lacking a network transceiver (and accompanying protocol implementation) can never be considered network connected. Note that (unlike many IT definitions of "Network Connected") a device connected to a non-IP network is still considered network connected (an IP connection or IP address is not required for a device to be network connected).

1.4.6.1 Wireless Network Connected

Any device that supports wireless network communication is network connected to a wireless network, regardless of whether the device is communicating using wireless. Unless physically disabled, devices with wireless transceivers support wireless, it is not sufficient to disable the wireless in software.

1.4.7 Network Media

The thing that provides the communication channel between the devices on a network. Typically wire, but might include wireless, fiber optic, or even power line (some network protocols allow sending network signals over power wiring).

1.4.8 User Account Support Levels

The support for user accounts is categorized in this Section as one of three levels:

1.4.8.1 FULLY Supported

Device supports configurable individual accounts. Accounts can be created, deleted, modified, etc. Privileges can be assigned to accounts. These devices support user-based (as opposed to role-based) authentication.

1.4.8.2 MINIMALLY Supported

Device supports a small, fixed number of accounts (perhaps only one). Accounts cannot be modified. A device with only a "User" and an "Administrator" account would fit this category. Similarly, a device with two PINs for logon - one for restricted and one for unrestricted rights would fit here (in other words, the accounts do not have to be the traditional "username and password" structure). These devices typically only support role-based authentication.

Examples of devices which MINIMALLY support accounts are a) a variable frequency drive with a single account which requires a PIN for access to configuration; and b) a room lighting control touchpad interface that has

a single account.

1.4.8.3 NOT Supported

Device does not support any Access Enforcement therefore the whole concept of "account" is meaningless.

1.4.9 Manual Local Input

Manual Local Inputs are system analog or binary inputs that are adjustable by a person but are, by intrinsic hardware design, very limited in potential capabilities. Manual Local Inputs do not have touch screens or full keyboards, but may have a few buttons or dials to allow input. Manual Local Inputs do not have full graphic screens or dot-matrix displays, but may have simple lights (LEDs) or 7-segment displays. Manual Local Inputs do not have any sort of menu structure, each button has a single well-defined function.

Examples of Manual Local Inputs are H-O-A switches, simple thermostats, and disconnect switches.

1.4.10 Card Reader

A card reader is an input/output device whose primary function is to assist in two-factor authentication. A card reader must have an interface to read data from a card and may be able to write data to a card. A card reader may have a means (such as buttons, keypad, touchscreen, etc.), for a user to input a PIN or password, as well as a limited display.

1.4.11 User Interface

A User Interface (UI) is something other than a Manual Local Input or Card Reader that allows a person to interact with the system or device. Note that while a Card Reader is not by itself a User Interface, a User Interface may contain a Card Reader in order for it to authenticate its user. Within control systems, there are a wide range of User Interfaces.

Two important distinctions are 1) whether the user interface is Local or Remote, and 2) the effective capabilities of the User Interface to alter data, which is the "privilege" of the user interface (where effective privilege available to a specific user at a specific user interface is the combination of the greatest privilege offered by the user interface and the specific account the user is logged into).

1.4.11.1 Local User Interface

A Local User Interface is a user interface where the physical hardware the user interacts with (keyboard, buttons, display, etc.), is physically part of the device being affected. All of the relevant characteristics of the user interface are embodied within a single device.

Note that a Local UI may be able to access data in a different device, Local versus Remote in this context refers to the user interface itself; the capability to access data in a different device is covered under "Full User Interface".

1.4.11.2 Remote User Interface

A Remote User Interface implements a Client/Server model where the

physical hardware the user interacts with (Client) is physically distinct from the device being affected (Server). Most or all of the security and functionality characteristics of the user interface are defined by the Server, not the Client. The Client and Server communicate via a network connection. A common example of a remote user interface is a web-based interface where the browser (client) is generally on different hardware than the web server (server). A Remote UI remains a Remote UI even if the user happens to be at a Client on the same hardware as the Server. What is important is that a) the Client may be on different hardware than the Server and b) the majority of the security and functional characteristics of the interface are defined at the Server.

Note that this definition of "remote" is consistent with that generally used in the control industry but is not aligned with the NIST 800-53 definition of "Remote", which refers to "outside the system". The term "Remote" here better aligns with the NIST 800-53 definition of "Network" (remote from within the system) Access.

1.4.11.3 Types of User Interface (by capability)

User interfaces are also categorized by their capabilities as being Read Only, Limited, or Full.

1.4.11.3.1 Read-Only User Interface

A Read Only User Interface (also referred to as a View-Only User Interface) is a user interface that only allows for reading data, it does not allow (have the capability to) modify data. A Read Only User Interface may be either Local or Remote. A User Interface that is configured to be Read Only (by some other means than the interface itself, such as using configuration software on a laptop) is a Read-Only Interface. Note a Read Only User Interface may have buttons (or touch screen, etc.), allowing the user to navigate through the presentation of data.

Examples of a Read Only User Interfaces are a) a publicly viewable "energy dashboard" showing weather data and energy usage within a building and b) digital wayfinding signage.

1.4.11.3.2 Limited User Interface

A Limited User Interface is a user interface that - by design - can only alter information local to the user interface. Note that the determination of "alter" includes only direct interactions, it explicitly excludes interactions that might occur as secondary effects. For example, an interface changing the flow setpoint in a pump controller is a direct interaction, the subsequent change in flow (as well as any subsequent downstream changes in valve position) are not direct interactions.

Two examples of LIMITED UIs are: a) a variable speed drive has a Limited Local User Interface which allows the user to change properties within the drive, but does not allow affecting things outside the drive; and b) a typical home WiFi Router has a Limited Remote User Interface which allows configuration of the Router, but does not allow direct interaction with other devices.

1.4.11.3.3 Full User Interface

A Full User Interface can alter information in devices outside the device

with the user interface. For example, a typical Local Display Panel is a Full Local User Interface while a browser-based front end is a Full Remote User Interface.

1.4.11.3.4 View-Only User Interface

See Read-Only User Interface

1.4.11.4 Other User Interface Terminology

In addition to defining whether a user interface is a Hardware Limited, Read-Only, Limited or Full, and whether it is Local or Remote, user interfaces are classified by whether they are writable or privileged.

1.4.11.4.1 Writable User Interface

Any User Interface that is not Read-Only is Writable. (Limited User Interfaces and Full User Interfaces are both writable user interfaces (as they are capable of changing a value)).

1.4.11.4.2 Privileged User Interface

A Privileged UI is a UI that has sufficient capabilities or functionality that it requires specific cybersecurity measures to be put in place to limit its unauthorized use. Ultimately, whether a specific user interface is considered a Privileged User Interface must be determined by usage. Unless otherwise specified, user interfaces can be determined to be privileged or not using the following:

a. Read-Only User Interfaces are not privileged user interfaces.

b. Full User Interfaces are privileged user interfaces.

c. User interfaces that allow for configuration of auditing or allows for modification or deletion of audit logs are privileged user interface.

d. User interfaces that allow for reprogramming a network connected device is a privileged user interface.

e. Except as specified above, a Limited User Interface must be determined to be privileged or not based on the specific capabilities and use case of the user interface. In general however, user interfaces that do not offer significant capabilities above and beyond those available at that location via other means (e.g., such as a disconnect switch, breaker, or hand-off-auto switch, or physical attack) are not privileged.

1.4.12 Wireless Network

Any network that communicates without using wires or fiber optics as the communication media. Wireless networks include: WiFi, Bluetooth, ZigBee, cellular, satellite, 900 MHz radio, 2.4 GHz, free space optical, point-to-point laser, and IR.

1.4.13 Wired Broadcast Network

Wired Broadcast Networks are any network, such as powerline carrier networks and modem (wired telephony), that use wire-based technologies where there is not a clearly defined boundary for signal propagation.

1.5 ADMINISTRATIVE REQUIREMENTS

1.5.1 Points of Contact

Coordinate with the following Points of Contact as indicated in this Section and as required. Not all projects will require coordination with all Points of Contact. When coordination is required and no Point of Contact is indicated, coordinate with The Contracting Office Representative (COR).

a. Government Computer Access Point of Contact: The Contracting Office Representative (COR)

b. HTTPS Certificate Point of Contact: The Contracting Office Representative (COR)

c. Email Address Point of Contact: The Contracting Office Representative (COR)

d. Password Point of Contact: The Contracting Office Representative (COR)

1.5.2 Coordination

Coordinate the execution of this Section with the execution of all other Sections related to control systems as indicated in the paragraph RELATED REQUIREMENTS. Items that must be considered when coordinating project efforts include but are not limited to:

a. If requesting permission for wireless or wired broadcast communication, the Wireless and Wired Broadcast Communication Request submittal must be approved prior to control system device selection and installation.

b. If requesting permission for alternate account lock permissions, the Device Account Lock Exception Request must be approved prior to control system device selection and installation.

c. If requesting permission for the use of a device with multiple physical connections to IP networks, the Multiple IP Connection Device Request must be approved prior to control system device selection and installation.

d. If the Device Audit Record Upload Software is to be installed on a computer not being provided as part of the control system, coordination is required to identify the computer on which to install the software.

e. The Cybersecurity Interconnection Schedule must be coordinated with other work that will be interconnected to, and interconnections must be approved by the Government before relying on them for system functionality.

f. Cybersecurity testing support must be coordinated across control systems and with the Government cybersecurity testing schedule.

g. Passwords must be coordinated with the indicated contact for the project site.

h. If applicable, HTTPS web server certificates must be obtained from the indicated HTTPS Certificate Point of Contact.

i. Contractor Computer Cybersecurity Compliance Statements must be provided for each contractor using contractor owned computers.

1.6 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Wireless and Wired Broadcast Communication Request; G

Device Account Lock Exception Request; G

Multiple Ethernet Connection Device Request; G

Contractor Computer Cybersecurity Compliance Statements; G

Contractor Temporary Network Cybersecurity Compliance Statements; G

Cybersecurity Interconnection Schedule; G

Proposed STIG and SRG Applicability Report; G

SD-02 Shop Drawings

Network Communication Report; G, AE

Cybersecurity Riser Diagram; G, AE

SD-03 Product Data

Control System Cybersecurity Documentation; G

SD-06 Test Reports

Control System Cybersecurity Testing Procedures; G

Control System Cybersecurity Testing Report; G

SD-07 Certificates

Software Licenses; G

SD-11 Closeout Submittals

Password Change Summary Report; G

Enclosure Keys; G

Software and Configuration Backups; G

Auditing Front End Software; G

Device Audit Record Upload Software; G

System Maintenance Tool Software; G

Control System Scanning Tools; G

STIG, SRG and Vendor Guide Compliance Result Report; G

Control System Inventory Report; G

1.7 QUALITY CONTROL

1.7.1 Certifications

For the Elevator Control System control system: Cybersecurity Subject Matter Expert:

This individual will oversee all work within this specification and is responsible for verifying all submittals of the integrator and overseeing any system hardening. Personnel performing this role must have current approved DoD IA baseline certifications in accordance with DoDI 8140 Cyberspace Workforce Improvement Program. Provide Contractor Personnel Certifications no later than 30 days following Notice To Proceed. Individuals for this position should have experience securing DoD Systems and with the Risk Management Framework (RMF). Control System experience is required.

See https://public.cyber.mil/wid/dod-cyber-workforce-framework/.

1.8 CYBERSECURITY DOCUMENTATION

{For Government Reference Only: This subpart (and its subparts) relates to PL-7; CCI-003071}

1.8.1 Proposed STIG and SRG Applicability Report

For each model of network connected or network infrastructure device, use the DISA SRG/STIG Applicability Guide and Collection Tool (available at https://public.cyber.mil/stigs/SCAP/to identify applicable STIGs or SRGs and provide a report indicating applicable STIGs and SRGs for each model.

1.8.2 Cybersecurity Interconnection Schedule

{For Government Reference Only: This subpart relates to CA-3(b), PL-8, SC-7(9), SC-7(11); CCI-000258, CCI-003072, CCI-003073, CCI-003075, CCI-002398, CCI-002399, CCI-002401, CCI-002402, CCI-002403.}

Provide a completed Cybersecurity Interconnection Schedule documenting network connections between the installed system and other systems. Provide the following information for each device directly communicating between systems: Device Identifier, Device Description, Transport layer Protocol, Network Address, Port (if applicable), MAC (Layer 2) address (if applicable), Media, Application Protocol, Service (if applicable), Descriptive Purpose of communication. For communication with other authorized systems also provide the Foreign Destination and POC for Destination. If other control system Sections used on this project include submittals documenting this information, provide copies of those

submittals to meet this requirement.

In addition to the requirements of Section 01 33 00 SUBMITTAL PROCEDURES, provide the Cybersecurity Interconnection Schedule as an editable Microsoft Excel file (a template Cybersecurity Interconnection Schedule in Excel format is available at https://www.wbdg.org/dod/ufgs/ufgs-25-05-11.)

1.8.3 Network Communication Report

{For Government Reference Only: This subpart (and its subparts) relates to CA-9, PL-8; CCI-002102, CCI-002103, CCI-002104, CCI-002105, CCI-003072, CCI-003073, CCI-003075 and also the submittal requirements associated with CM-6, CM-7, including CM-7(3), CCI-000388.}

Provide a network communication report. For each networked device, document the communication characteristics of the device including communication protocols, services used, encryption employed, and a general description of what information is communicated over the network. For each device using IP, document all TCP and UDP ports used. For non-IP communications, document communication protocol and media used. If other control system Sections used on this project include submittals documenting this information, provide copies of those submittals to meet this requirement.

In addition to the requirements of Section 01 33 00 SUBMITTAL PROCEDURES, provide the Network Communication Report as an editable Microsoft Excel file.

1.8.4 Control System Inventory Report

{For Government Reference Only: This subpart (and its subparts) relates to CM-8(a), SI-17, IA-3; CCI-000389, CCI-000392, CCI-000398, CCI-002773, CCI-002774, CCI-002775, CCI-000777, CCI-000778, CCI-001958}

Provide a Control System Inventory report using the Inventory Spreadsheet listed under this Section at https://www.wbdg.org/dod/ufgs/ufgs-25-05-11 documenting all devices, including networked devices, network infrastructure devices, non-networked devices, input devices (e.g., sensors) and output devices (e.g., actuators). For each device provide all applicable information for which there is a field on the spreadsheet in accordance with the instructions on the spreadsheet.

In addition to the requirements of Section 01 33 00 SUBMITTAL PROCEDURES, provide the Control System Inventory Report as an editable Microsoft Excel file.

1.8.5 Software and Configuration Backups

{For Government Reference Only: This subpart (and its subparts) relates to CP-10; CCI-000550, CCI-000551, CCI-000552}

For each computer on which software is installed under this project, provide a recovery image of the final as-built computer. This image must allow for bare-metal restore such that restoration of the image is sufficient to restore system operation to the imaged state without the need for re-installation of software. If additional user permissions are required to meet this requirement, coordinate the creation of the image with the identified Government Computer Access Point of Contact.

For all controllers, provide a backup of the controller configuration and the source code for all loaded application programs (all software that is not common to every controller of the same manufacturer and model).

If any or all of these are provided under another Section, provide documentation indicating this and referencing those submittals.

1.8.6 Cybersecurity Riser Diagram

{For Government Reference Only: This subpart (and its subparts) relates to PL-2(a), PL-8; CCI-003051, CCI-003053, CCI-003072, CCI-003073, CCI-003075}

Provide a cybersecurity riser diagram of the complete control system including all network and device hardware. If the control system specifications require a riser diagram submittal, provide a copy of that submittal as the cybersecurity riser diagram. Otherwise, provide a riser diagram in one-line format.

1.8.7 STIG, SRG and Vendor Guide Compliance Result Report

For every component (device or software) with an applicable STIG or SRG in the Proposed STIG and SRG Applicability Report, provide a result report documenting compliance with the STIG or SRG requirements. For components which are scannable by the SCAP (security content automation protocol) tool (available online at https://public.cyber.mil/stigs/scap), provide the SCAP report and raw scan results.

For every component (device or software) with manufacturer provided cybersecurity documentation, procedure, or method for secure configuration or installation, provide a report documenting how the component was configured and any deviation from the manufacturer instructions.

1.8.8 Control System Cybersecurity Documentation

{For Government Reference Only: This subpart (and its subparts) relates to SA-5(a),SA-5(b),SA-5(c), SA-22(b); CCIs: CCI-003124, CCI-003125, CCI-003126, CCI-003127, CCI-003128, CCI-003129, CCI-003130, CCI-003131, CCI-003374}

Provide a Control System Cybersecurity Documentation submittal containing the indicated information for each device and software application.

1.8.8.1 Elevator Control System Devices

For all Elevator Control System components, provide:

a. Documentation that describes the secure configuration of system components, including controllers, HMIs, and connected network devices. {For Government Reference Only: Relates to CCI-003124}.

b. Documentation that describes secure installation, commissioning, and hardening of all ECS hardware and software.

c. Documentation that specifies procedures for securely updating software and applying firmware patches, including validation processes.

d. Documentation that provides a System Security Plan (SSP) detailing

cybersecurity controls and configurations applied to the ECS.

e. Documentation that describes role-based access controls (RBAC) and user authentication methods, including multi-factor authentication (MFA).

f. Documentation of the incident response plan, including steps for identifying, reporting, and mitigating cybersecurity incidents.

g. Risk assessment documentation that identifies threats, vulnerabilities, and risk mitigation measures specific to ECS operations.

h. Documentation detailing logging and monitoring configurations, including log retention policies and anomaly detection procedures.

i. Documentation that includes as-built system configurations and final cybersecurity compliance certification.

1.8.8.2 Default Requirements for Control System Devices

For control system devices where Control System Cybersecurity Documentation requirements are not otherwise indicated in this Section, provide:

a. Documentation that describes secure configuration of the device {For Government Reference Only: Relates to CCI-003124}

b. Documentation that describes secure installation of the device {For Government Reference Only: Relates to CCI-003125}

c. Documentation that describes secure operation of the device {For Government Reference Only: Relates to CCI-003124}

d. Documentation that describes effective use and maintenance of security functions or mechanisms for the device {For Government Reference Only: Relates to CCI-003127}

e. Documentation that describes known vulnerabilities regarding configuration and use of administrative (i.e., privileged) functions for the device {For Government Reference Only: Relates to CCI-003128}

f. Documentation that describes user-accessible security functions or mechanisms in the device and how to effectively use those security functions or mechanisms {For Government Reference Only: Relates to CCI-003129}

g. Documentation that describes methods for user interaction which enables individuals to use the device in a more secure manner {For Government Reference Only: Relates to CCI-003130}

h. Documentation that describes user responsibilities in maintaining the security of the device {For Government Reference Only: Relates to CCI-003131}

i. Documentation of the published last date of support by the manufacturer or indication that a published date is not available. {For Government Reference Only: Relates to CCI-003374}

1.9 SOFTWARE LICENSING

{For Government Reference Only: This subpart (and its subparts) relates to SI-2(a), SI-2(c), SI-7(14); CCI-001227, CCI-002605, CCI-002737}

For all software provided that has not already been licensed to the government or project site, provide a license to the Government for a period of no less than 5 years, and the license must also include the following software updates:

a. Security and bug-fix patches issued by the software manufacturer.

b. Security patches to address any vulnerability identified in the National Vulnerability Database at http://nvd.nist.gov with a Common Vulnerability Scoring System (CVSS) severity rating of MEDIUM or higher.

Provide a single Software Licenses submittal with documentation of the software licenses for all software provided.

1.10 CYBERSECURITY DURING CONSTRUCTION

{For Government Reference Only: This subpart (and its subparts) relates to AC-18, CA-3; CCI-000258}

In addition to the control system cybersecurity requirements indicated in this section, meet following requirement throughout the construction process.

1.10.1 Contractor Computer Equipment

Contractor owned computers may be used for construction. Contractor computers connected to the control system, control system network, or a control system component at any point during construction must meet the following requirements:

1.10.1.1 Operating System

The operating system must be an operating system currently supported by the manufacturer of the operating system. The operating system must be current on security patches and operating system manufacturer required updates.

1.10.1.2 Anti-Malware Software

The computer must run anti-malware software from a reputable software manufacturer. Anti-malware software must be a version currently supported by the software manufacturer, must be current on all patches and updates, and must use the latest definitions file. Computers used on this project must be scanned using the installed software at least once per day.

1.10.1.3 Passwords and Passphrases

The passwords and passphrases for computers, applications, and web-based applications supporting passwords must be changed from their default values. Passwords must be a minimum of eight characters with a minimum of one uppercase letter, one lowercase letter, one number and one special character.

1.10.1.4 User-Based Authentication

Each user must have a unique account; sharing of a single account between multiple users is prohibited.

1.10.1.5 Demonstration of Compliance

The Government has the right to require demonstration of computer compliance with these requirements at any time during the project.

1.10.1.6 Contractor Computer Cybersecurity Compliance Statements

Provide a single submittal containing completed Contractor Computer Cybersecurity Compliance Statements for each company using contractor owned computers. Contractor Computer Cybersecurity Compliance Statements must use the template published at https://www.wbdg.org/dod/ufgs/ufgs-25-05-11. Each Statement must be signed by a cybersecurity representative for the relevant company.

1.10.2 Temporary IP Networks

Temporary contractor-installed IP networks may be used during construction. When used, temporary contractor-installed IP networks connected to the control system, control system network, or a control system component at any point during construction must meet the following requirements:

1.10.2.1 Network Boundaries and Connections

The network must not extend outside the project site and must not connect to any IP network other than those specifically provided or furnished for this project. Any and all access to the network from outside the project site is prohibited.

1.10.3 Government Access to Network

Government personnel must be allowed to have complete and immediate access to the network at any time in order to verify compliance with this specification.

1.10.4 Temporary Wireless IP Networks

In addition to the other requirements on temporary IP networks, temporary wireless IP (WiFi) networks, when permitted, must not interfere with existing wireless networks, must use WPA2 security and must not broadcast the network name (SSID). Network names (SSID) for wireless networks must be changed from their default values.

1.10.5 Passwords and Passphrases

The passwords and passphrases for all network devices and network access must be changed from their default values. Passwords must be a minimum 8 characters with a minimum of one uppercase letter, one lowercase letter, one number and one special character.

1.10.6 Contractor Temporary Network Cybersecurity Compliance Statements

Provide a single submittal containing completed Contractor Temporary Network Cybersecurity Compliance Statements for each company implementing

a temporary IP network. Contractor Temporary Network Cybersecurity Compliance Statements must use the template published at https://www.wbdg.org/dod/ufgs/ufgs-25-05-11. Each Statement must be signed by a cybersecurity representative for the relevant company. If no temporary IP networks will be used, provide a single copy of the Statement indicating this.

1.11 CYBERSECURITY DURING WARRANTY PERIOD

All work performed on the control system after acceptance must be performed using Government Furnished Equipment or equipment specifically and individually approved by the Government.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.1 CYBERSECURITY HARDENING AND CONFIGURATION GUIDES

Install, configure, and harden all hardware and software furnished on this project in accordance with manufacturer provided documentation, procedures, or methods for secure configuration or installation. Do not implement specific hardening actions if that action would conflict with required functionality or another requirement of this Section.

3.2 NETWORK REQUIREMENTS

3.2.1 Wireless and Wired Broadcast Communication

{For Government Reference Only: This subpart (and its subparts) relates to AC-18, AC-18(3); CCI-001438, CCI-001439, CCI-002323, CCI-001441, CCI-001449}

Do not use any wireless or wired broadcast communication.

3.2.1.1 Wireless and Wired Broadcast IP Communications

Do not install wireless or wired broadcast IP networks, including: Do not install a wireless access point; do not install or configure an ad-hoc wireless network; do not install or configure a WiFi Direct communication.

When explicitly authorized by the Government, wireless IP communication may be used to communicate with an existing wireless network.

3.2.1.2 Non-IP Wireless Communication

For LOW Impact Systems: When non-IP wireless communication is explicitly authorized by the Government, use the maximum level of encryption supported by the specific protocol employed and select signal strength and radiated power to the minimum necessary for reliable communication.

3.2.1.3 Wireless and Wired Broadcast Communication Request

If there is no proposed use of wireless or wired broadcast communication, provide a document indicating this instead of the Request Schedule.

3.2.2 Non-IP Control Networks

When control system specifications require particular communication protocols, use only those communication protocols and only as specified. Do not implement any other communication protocol.

When control system specifications do not indicate requirements for communication protocols, use only those protocols required for operation of the system as specified.

3.2.3 IP Control Networks

{For Government Reference Only: This subpart relates to CM-6(a), CM-7(a), CM-7(b), CM-7(1)(b), SC-41; CCI-001588, CCI-000381, CCI-000380, CCI-000381, CCI-000382, CCI-001761, CCI-001762, CCI-002544, CCI-002545, CCI-002546.}

3.2.3.1 IP Network Routers

Do not install any device that performs IP routing.

3.2.3.2 IP Devices With Multiple Ethernet Connection

Must not have more than one Ethernet connection to IP networks unless doing so is required by the project specifications and the specific application is approved. If a device with Multiple Ethernet Connections to IP networks is required, provide a Multiple Ethernet Connection Device Request using the Multiple Ethernet Connection Device Request Template at https://www.wbdg.org/dod/ufgs/ufgs-25-05-11 to request approval for each device. If a device with Multiple Ethernet Connections to IP networks is not required, instead provide a document stating that no approval is being requested.

3.2.4 Cryptographic Protection

{For Government Reference Only: This subpart relates to IA-2(9), IA-3(1), SC-8, SC-13, SC-23(1), SC-23(3); CCI-001942, CCI-001959, CCI-001967, CCI-002418, CCI-002449, CCI-002450, CCI-001185, CCI-001188, CCI-001664.}

All remote user interfaces must use HTTPS for all traffic between the user interface client and user interface server.

For devices that have STIG/SRGs related to cryptographic protection (CCI-002450), comply with the requirements of those STIG/SRGs. Ensure that all network traffic is encrypted using NSA-approved cryptography; provision of digital signatures and hashing, and FIPS-validated cryptography.

3.2.5 Device Identification and Authentication

{For Government Reference Only: This subpart (and its subparts) relates to IA-3; CCI-000777, CCI-000778, CCI-001958.}

All computers must support and implement IEEE 802.1x for device authentication to the network.

3.2.5.1 Default Requirements for Control System Devices

For control system devices where Device Identification and Authentication

requirements are not otherwise indicated in this Section: Devices using Ethernet must support IEEE 802.1x. Devices using HTTP as a control protocol must use HTTPS instead.

3.3 ACCESS CONTROL REQUIREMENTS

3.3.1 User Accounts

{For Government Reference Only: This subpart (and its subparts) relate to AC-2(a), AC-3, AC-6(1), AC-6(10), AC-6(2), AC-6(9), CM-11(2), and IA-2; CCI-002110, CCI-000213, CCI-001558, CCI-002221, CCI-002222, CCI-002223, CCI-002235, CCI-000039, CCI-001419, CCI-002234, CCI-001812, and CCI-000764. }

Any user interface supporting user accounts (either FULLY or MINIMALLY) must limit access according to specified limitations for each account. Install and configure any device having a STIG or SRG in accordance with that STIG or SRG.

All user interfaces FULLY supporting accounts must implement user-based authentication where each account is uniquely assigned to a specific user. User interfaces FULLY supporting accounts must implement at least three (3) levels of user account privilege including: 1) an account with read-only permissions 2) an account with full permissions including account creation and modification and 3) an account with greater permissions than read-only but without account creation and modification.

3.3.1.1 Computers

All computer operating systems must FULLY support user accounts and implement accounts for access. Each control system software application not supporting accounts and running on a computer must be installed such that use of the software is restricted by the computer operating system to specific users.

Applications running on computers must not require the user be logged in to a computer operating system administrator account for normal operation. It is permissible to require the computer operating system administrator account for initial application installation and configuration.

3.3.1.2 Controllers

For user interfaces provided by controllers, provide access control in accordance with the User Interface Requirements table for the applicable control system and user interface type.

a. For table entries of "NA": NA means Not Applicable, there are no interfaces in this category.

b. For table entries of "None Required": The user interface is not required to support user accounts.

c. For table entries of "MINIMALLY": The user interface must at least MINIMALLY support user accounts.

d. For table entries of "FULLY": The user interface must at FULLY support user accounts.

e. For table entries of "KEY": The user interface must have physical security in the form of either a key lock on the interface itself or be furnished inside a locked enclosure. Where this is required for a read only interface, this lock must prevent viewing of data on the interface; for other interfaces, this lock must prevent using the interface to alter data.

f. For table entries of "Physical Security": For Local FULL interfaces, the interface must be located inside mission space. For Local Limited (not FULL) interfaces, the user interface must either a) be located within mission space or b) be protected by physical security at least as good as the control devices (and equipment controlled by the control devices) affected by the interface. For purposes of this requirement, 'affected' includes controllers with data that can be directly altered by the interface, as well as mechanical and/or electrical equipment directly controlled by those controllers, but does not include other interactions.

g. Entries of the form "X and Y" must meet both the requirement indicated for X and the requirement indicated for Y. For example, an entry of "MINIMALLY and Physical Security" indicates the user interface must both MINIMALLY support accounts and have physical security.

h. Entries of the form "X or Y" must meet either the requirement indicated for X or the requirement indicated for Y.

3.3.1.2.1 Default Requirements for Other Control Systems

For control system devices where User Interface Requirements are not otherwise indicated in this Section, use the Default User Interface Requirements tables.

Default User Interface Requirements for LOW Impact Control Systems	
User Interface Type	**Access Control Requirement**
Local Read Only (see note 1)	MINIMALLY
Local Limited, Non-privileged	MINIMALLY
Local Limited, Privileged	Physical Security
Local Full	FULLY
Remote Read Only	MINIMALLY
Remote Limited, Non-Privileged	MINIMALLY
Remote Limited, Privileged AND Remote Full (see note 2)	FULLY

Default User Interface Requirements for LOW Impact Control Systems	
User Interface Type	**Access Control Requirement**
Notes: 1)Local Read Only User Interfaces are always Non-Privileged 2)Remote Full User Interfaces are always Privileged	

3.3.2 Unsuccessful Logon Attempts

{For Government Reference Only: This subpart (and its subparts) relate to AC-7 (a), AC-7 (b); CCI-000043, CCI-000044, CCI-001423, CCI-002236, CCI-002237, CCI-002238}

Except for high availability user interfaces indicated as exempt, devices must meet the indicated requirements for handling unsuccessful logon attempts. If a device cannot meet these requirements, document device capabilities to protect from subsequent logon attempts and propose alternate protections in a Device Account Lock Exception Request submittal. Do not implement alternate protection measures in lieu of the indicated requirements without explicit permission from the Government. If no Device Account Lock Exceptions are requested, provide a document stating that no approval is being requested as the Device Account Lock Exception Request.

3.3.2.1 Devices MINIMALLY Supporting Accounts

For LOW Impact Systems: Devices which MINIMALLY (but not FULLY) support accounts must lock the user account after five consecutive failed login attempts and must unlock the user account after 15 minutes have elapsed without an unsuccessful login attempt or by a successful login to a separate administrator account.

3.3.2.2 Devices FULLY Supporting Accounts

Devices which FULLY support accounts must meet the following requirements.

a. It must lock the user account when three unsuccessful logon attempts occur within a 15 minute interval.

b. Once an account is locked, the account must stay locked until unlocked by an administrator. If the account being locked is the sole administrator account on the device, the account must stay locked for 1 hour and then automatically unlock.

c. Once the indicated number of unsuccessful logon attempts occurs, delay further logon prompts by 5 seconds.

3.3.2.3 High Availability Interfaces Exempt from Unsuccessful Logon Attempts Requirements

There are no high availability interfaces which are exempt from unsuccessful logon attempts requirements.

3.3.3 System Use Notification

{For Government Reference Only: This subpart (and its subparts) relates to AC-8; CCI-000048, CCI-002247, CCI-002243, CCI-002244, CCI-002245, CCI-002246, CCI-000050, CCI-002248}

3.3.3.1 System Use Notification for Remote User Interfaces

Remote user interfaces must display a warning banner meeting the requirements of DTM 08-060 on screen.

3.3.3.2 System Use Notification for Local User Interfaces

Devices which are connected to a network and have a local user interface must display a warning banner meeting the requirements of DTM 08-060 on the user interface screen if capable of doing so and must have a permanently affixed label with an approved banner from DTM 08-060 if unable to display the warning banner on the screen. Where it is impractical (perhaps due to device size) to affix the label to the device, affix the label to the device enclosure.

Labels must be machine printed or engraved, plastic or metal, designed for permanent installation, must use a font no smaller than 14 point, and must provide a high contrast between font and background colors.

3.3.4 Permitted Actions Without Identification or Authentication

{For Government Reference Only: This subpart (and its subparts) relates to AC-14; CCI-000061, CCI-000232}

The control system must require identification and authentication before allowing any actions except read-only actions by a user acting from a user interface which MINIMALLY or FULLY supports accounts.

3.3.5 Enclosures

Prior to final acceptance of the system, lock all lockable enclosures. Submit an Enclosure Keys submittal with all copies of keys for all enclosures and a key inventory list documenting all keys. Label each key with the matching enclosure identifier.

3.4 USER IDENTIFICATION AND AUTHENTICATION

{For Government Reference Only: This subpart (and its subparts) relates to IA-2, IA-2(1),IA-2(12), IA-5 IA-5(b), IA-5(c), IA-5(e), IA-5(g), IA-5(1), IA-5(11); CCI-000764, CCI-000765, CCI-001953, CCI-001954, CCI-001544, CCI-001989, CCI-000182, CCI-001610, CCI-000192, CCI-000193, CCI-000194, CCI-000205, CCI-001619, CCI-001611, CCI-001612, CCI-001613, CCI-001614, CCI-000195, CCI-001615, CCI-000196, CCI-000197, CCI-000199, CCI-000198, CCI-001616, CCI-001617, CCI-000200, CCI-001618, CCI-002041, CCI-002002, CCI-002003.}

This subpart indicates requirements for specific methods of identification and authentication for users and user accounts. Where these requirements conflict apply the following order of precedence: 1) If present, Device Specific Requirements take precedence over any other requirements; and then 2) multifactor authentication requirements take precedence over password requirements.

3.4.1 User Identification and Authentication for All System Types

Unless otherwise indicated, all user interfaces supporting accounts (either FULLY or MINIMALLY) must implement Identification and Authorization via passwords.

3.4.2 User Identification and Authentication for Specific System Types

System specific requirements are in addition to and supersede those indicated for all system types. When no additional requirements are indicated for a specific system type the requirements for all systems still apply to that system type.

3.4.3 User Identification and Authentication for Specific Devices

There are no additional device specific user interface requirements.

3.4.4 Implementation of Identification and Authorization Requirements

Identification and Authorization must be met by one of the following methods:

a. Direct implementation in the user interface.

b. For user interfaces on a computer: Inheriting the Identification and Authorization from the computer operating system, either by the operating system limiting access to specific applications by user, or by the application itself having permissions based on the user logged into the computer.

c. For remote interfaces: An implementation shared between the remote user interface server and the remote user interface client. For example, a requirement for PIV authentication may be met on a remote user interface by a PIV reader on a web browser client which sends the authentication information via HTTPS to the remote server.

3.4.5 Password-Based Authentication Requirements

3.4.5.1 Passwords for Software and Applications Running on Computers

All software and applications running on computers supporting password-based authentication must enforce the following requirements:

a. Minimum password length of 12 characters.

b. Password must contain at least one uppercase character.

c. Password must contain at least one lowercase character.

d. Password must contain at least one numeric character.

e. Password must contain at least one special character. The list of supported special characters must include at least 4 separate characters.

f. Password must have a minimum lifetime of 24 hours.

g. Password must have a maximum lifetime of 60 days. When passwords expire, prompt users to change passwords. Do not lock accounts due to

expired passwords.

h. Password must differ from previous five passwords, where differ is defined as changing at least 50 percent of the characters (where location is significant, a character may be reused if it is in a different position).

i. Passwords must be cryptographically protected during storage and transmission.

3.4.5.2 Passwords for Controllers FULLY Supporting Accounts

All controllers FULLY supporting accounts and supporting password-based authentication must enforce the following requirements:

a. Minimum password length of twelve (12) characters.

b. Password must contain at least one uppercase character.

c. Password must contain at least one lowercase character.

d. Password must contain at least one numeric character.

e. Password must contain at least one special character. The list of supported special characters must include at least 4 separate characters.

f. Password must have a maximum lifetime of sixty (60) days. When passwords expire, prompt users to change passwords. Do not lock accounts due to expired passwords.

g. Password must differ from previous five (5) passwords, where differ is defined as changing at least fifty percent of the characters.

h. Passwords must be cryptographically protected during storage and transmission.

3.4.5.3 Passwords for Remote Interfaces

Passwords for connecting to a Remote User Interface supporting password-based authentication must enforce the following requirements:

a. Minimum password length of twelve (12) characters.

b. Password must contain at least one uppercase character.

c. Password must contain at least one lowercase character.

d. Password must contain at least one numeric character.

e. Password must contain at least one special character. The list of supported special characters must include at least 4 separate characters.

f. Password must have a maximum lifetime of 60 days. When passwords expire, prompt users to change passwords. Do not lock accounts due to expired passwords.

g. Password must differ from previous five passwords, where differ is

defined as changing at least 50 percent of the characters (where location is significant, a character may be reused if it is in a different position).

h. Passwords must be cryptographically protected during storage and transmission.

3.4.5.4 Passwords for Devices Minimally Supporting Accounts

Devices MINIMALLY supporting accounts must support passwords with a minimum length of four characters.

3.4.5.5 Password Configuration and Reporting

For all devices with a password, change the password from the default password. Coordinate selection of passwords with the Password Point of Contact. Do not use the same password for more than one device unless specifically instructed to do so.

Do not provide the Password Summary Report in electronic format. Provide two hardcopies of the Password Summary Report, each copy in its own sealed envelope.

For all devices with a password, coordinate the changing of passwords with the project site following testing of the system but prior to turnover to the Government. Coordinate with Password Point of Contact to determine appropriate project site personnel to complete password changes. Accompany identified personnel to each device with a password and instruct personnel on the process of changing password. Record the time, date and personnel present when each device's password is changed and submit a Password Change Summary Report documenting this information.

3.4.6 Authenticator Feedback

{For Government Reference Only: This subpart relates to IA-6; CCI-000206.}

Devices must never show authentication information, including passwords, on a display. Devices that momentarily display a character as it is entered, and then obscure the character, are acceptable. For devices that have STIGs or SRGs related to obscuring of authenticator feedback (CCI-000206), comply with the requirements of those STIGS/SRGs.

3.5 CYBERSECURITY AUDITING

Where an auditing requirement exists for email notification, notify via email the application administrator and Information System Security Officer (ISSO) of the event. Coordinate with the Email Address Point of Contact for email addresses. If outgoing email is not available to the system, configure the system for these notifications for future support of outgoing email.

3.5.1 Audit Events, Content of Audit Records, and Audit Generation

{For Government Reference Only: This subpart (and its subparts) relates to AU-2(a), AU-2(c), AU-2(d), AU-3, AU-10, AU-12, AU-14(b), AU-14(1), AU-14(2), AU-14(3), CM-5(1), SC-7 (9); CCI-000123, CCI-001571, CCI-000125, CCI-001485, CCI-000130, CCI-000131, CCI-000132, CCI-001230, CCI-000133, CCI-000134, CCI-001487, CCI-000166, CCI-001899, CCI-000169, CCI-001459, CCI-000171, CCI-000172, CCI-001910, CCI-001914, CCI-001919,

CCI-001464, CCI-001462, CCI-001920, CCI-001814, CCI-002400.}

For devices that have STIG/SRGs related to audit events, content of audit records or audit generation, comply with the requirements of those STIG/SRGs.

If auditing requirements can be met using existing control system alarm or event capabilities, those existing capabilities may be used to meet these requirements.

3.5.1.1 Default Requirements for Control System Controllers

For control system controllers where Audit Events, Content of Audit Records, and Audit Generation are not otherwise indicated in this Section:

3.5.1.1.1 Controllers Which FULLY Support Accounts

For each controller which FULLY supports accounts, provide the capability to select audited events and the content of audit logs. Configure controllers to audit the indicated events, and to record the indicated information for each auditable event.

3.5.1.1.1.1 Audited Events

Configure each controller to audit the following events:

a. Successful and unsuccessful attempts to access, modify, or delete privileges, security objects, security levels, or categories of information (e.g., classification levels).

b. Successful and unsuccessful logon attempts.

c. Successful logouts.

d. Concurrent logons from different workstations.

e. All account creations, modifications, disabling, and terminations.

f. All kernel module load, unload, and restart.

3.5.1.1.1.2 Audit Event Information To Record

Configure each controller to record, for each auditable event, the following information (where applicable to the event):

a. What type of event occurred.

b. When the event occurred.

c. Where the event occurred.

d. The source of the event.

e. The outcome of the event.

f. The identity of any individuals or subjects associated with the event.

3.5.1.1.2 Controllers Which Do Not FULLY Support Accounts

For each controller which does not FULLY support accounts configure the controller to audit all controller shutdown and startup events and to record for each event the type of event and when the event occurred.

3.5.2 Audit Time Stamps

{For Government Reference Only: This subpart (and its subparts) relates to AU-8; CCI-000159, CCI-001889, CCI-001890.}

Any device (computer or controller) generating audit records must have an internal clock capable of providing time with a resolution of one second. Clocks must not drift more than 10 seconds per day. Configure the system so that each device (computer or controller) generating audit records maintains accurate time to within 1 second. Note that if the control system specifications include requirement for clocks, the most stringent requirement applies.

3.5.3 Auditing Front End Software

If there is no existing auditing front end software or the software is not compatible with the provided control systems, provide Auditing Front End Software with audit log import and upload, export, notification, and analysis functionality. The Auditing Front End Software may be provided as a component of the control system front end or as a separate software package, and a single package may serve multiple control systems provided under the same projects if they are sharing a cybersecurity authorization.

When the Auditing Front End Software is neither existing nor installed under the requirements of another Section, furnish the Auditing Front End Software media and license for subsequent Government installation. Submit copies of Auditing Front End Software if this function is not part of the software provided with the control system to meet requirements of other Sections.

3.5.3.1 Import and Upload Requirements

Auditing Front End Software must be capable of importing audit logs from the Device Audit Record Upload Software and of uploading audit logs over the network from all control system devices supporting network upload of audit logs.

3.5.3.2 Export Requirements

Auditing Front End Software must be capable of exporting to a file format supported by Microsoft Excel.

3.5.4 Audit Storage Capacity and Audit Upload

{For Government Reference Only: This subpart (and its subparts) relates to AU-4; CCI-001848, CCI-001849.}

The creation of audit records must never interfere with normal device operation. Devices must cease collection of auditing information if required to maintain normal operation.

a. For devices that have STIG/SRGs related to audit storage capacity (CCI-001848 or CCI-001849) comply with the requirements of those

STIG/SRGs.

b. For controllers capable of generating audit records, provide 60 days worth of secure local storage, assuming 10 auditable events per day.

3.5.4.1 Device Audit Record Upload Software

For each device (computer or controller) required to audit events and for which audit logs cannot be uploaded over the network by the Auditing Front End Software, provide and license to the Government software implementing a secure mechanism of uploading audit records from the device and exporting them to the Auditing Front End Software. Where different devices use different software, provide software of each type required to upload audit logs from all devices.

When Device Audit Record Upload Software is capable of uploading audit logs over the network, install Device Audit Record Upload Software on the same computer as the Auditing Front End Software. Submit copies of device audit record upload software if this function is not part of the software provided with the control system to meet requirements of other Sections. If there are no devices requiring this software, provide a document stating this in lieu of this submittal.

3.5.5 Response to Audit Processing Failures

{For Government Reference Only: This subpart (and its subparts) relates to AU-5; CCI-000139, CCI-000140, CCI-001490.}

In the case of a failure in the auditing system, computers associated with auditing must provide email notification. In case of an audit failure, if possible, continue to collect audit records by overwriting existing audit records.

3.6 REQUIREMENTS FOR LEAST FUNCTIONALITY

{For Government Reference Only: This subpart (and its subparts), along with the network communication report submittal specified elsewhere in this section, relates to CM-6(a), CM-6(c), CM-7, CM-7(1)(b), SC-41; CCI-000363, CCI-000364, CCI-000365, CCI-001588, CCI-001755, CCI-000381, CCI-000380, CCI-000382, CCI-001761, CCI-001762, CCI-002544, CCI-002545, CCI-002546.}

For devices that have a STIG or SRG related to Requirements for Least Functionality (such as configuration settings and port and device I/O access for least functionality), install and configure the device in accordance with that STIG or SRGs.

3.6.1 Device Capabilities

For Other Control Systems: Do not provide devices with remote user interfaces or with full user interfaces where one was not required. Do not use a networked sensor or actuator where a non-networked sensor or actuator would suffice.

3.6.2 Software

For software that has a STIG or SRG related to Requirements for Least Functionality (such as configuration settings and port access for least functionality), install and configure the software in accordance with that

STIG or SRG.

3.7 SYSTEM AND COMMUNICATION PROTECTION

3.7.1 Collaborative Computing

{For Government Reference Only: This subpart relates to SC-15(a), SC-15(b); CCI-001150, CCI-001152.}

Control systems must not use collaborative computing technologies.

3.7.2 Denial of Service Protection

{For Government Reference Only: This subpart relates to SC-5, SC-12, SC-7(a); CCI-001093, CCI-002385, CCI-002386, CCI-002430, CCI-001097.}

To the greatest extent practical, implement control logic without reliance on the network. Except when required to meet the requirements of the control system Section (where the requirement can only be met using computer hardware), do not implement control logic in computers.

3.8 SAFE MODE AND FAIL SAFE OPERATION

{For Government Reference Only: This subpart (and its subparts) relates to CP-12, SI-10(3), SI-17; CCI-002855, CCI-002856, CCI-002857, CCI-002754, CCI-002773, CCI-002774, CCI-002775.}

For all control system components with an applicable STIG or SRG, configure the component in accordance with all applicable STIGs and SRGs.

3.9 SYSTEM MAINTENANCE TOOL SOFTWARE

{For Government Reference Only: This subpart (and its subparts) relates to MA-3; CCI-000865.}

Submit and license to the Government all software required to operate, maintain and modify the control system such the Government or their agents are able to perform repair, replacement, upgrades, and expansions of the system without subsequent or future dependence on the Contractor, Vendor or Manufacturer. Submit hard copies of user manuals for each software with the software submittal.

For software provided and licensed to the Government under the requirements of another Section, submit a statement indicating the Section and Submittal under which the software was provided. For software provided to meet the requirements of this Section and not provided and licensed under another Section, submit software and software user manuals on DVD or CD as a Technical Data Package and submit one hard copy of the software user manual for each piece of software.

3.10 DEVICE POWER

{For Government Reference Only: This subpart (and its subparts) relates to PE-11, PE-11(1); CCI-002955, CCI-000961.}

For LOW Impact Systems: Provide emergency power in accordance with the control system and equipment specification Sections.

3.11 VULNERABILITY SCANNING

{For Government Reference Only: This subpart (and its subparts) relates to RA-5 RA-5(a),RA-5(b),RA-5(c),RA-5(d); CCI-001054, CCI-001055, CCI-000156, CCI-001641, CCI-001643, CCI-001057, CCI-001058, CCI-001059.}

All IP devices must be scannable, such that the device can be scanned by industry standard IP network scanning utilities without harm to the device, application, or functionality.

3.11.1 Controllers

Provide controllers that are scannable by standard control system discovery tools or control system browsers and return meaningful status information including the network inputs and outputs for the controller. This information must contain sufficient detail to detect vulnerabilities or exploits of the controller.

Provide all software needed to scan the control system as the Control System Scanning Tools submittal. If the software required to scan the system is already installed at the project site or is provided under a separate section instead provide a statement indicating this.

3.12 FIPS 201-2 REQUIREMENT

{For Government Reference Only: This subpart (and its subparts) relates to SA-4 (10); CCI-003116}

Devices in the following systems which implement PIV must be on the NIST FIPS 201-2 approved product list (https://www.idmanagement.gov/approved-products-list/): Elevator Control System.

3.13 CONTROL SYSTEM CYBERSECURITY TESTING

3.13.1 Control System Cybersecurity Testing Procedures

Prepare Control System Cybersecurity Testing Procedures explaining step-by-step, the actions and expected results that will demonstrate that the control system meets the requirements of this Section.

Submit 4 copies of the Control System Cybersecurity Testing Procedures. The Control System Cybersecurity Testing Procedures may be submitted as a Technical Data Package.

3.13.2 Control System Cybersecurity Testing Execution

Using the Control System Cybersecurity Testing Procedures verify that the control system meets the requirements of this Section. UNLESS GOVERNMENT WITNESSING OF A TEST IS SPECIFICALLY WAIVED BY THE GOVERNMENT, PERFORM ALL TESTS WITH A GOVERNMENT WITNESS. If testing reveals deficiencies in the system, correct the deficiency and retest until successful.

3.13.3 Control System Cybersecurity Testing Report

Prepare and submit a Control System Cybersecurity Testing Report documenting all tests performed and their results. Include all tests in the Control System Cybersecurity Testing Procedures and any additional tests performed during testing. Document test failures and repairs

conducted with the test results.

Submit four copies of the Control System Cybersecurity Testing Report. The Control System Cybersecurity Testing Report may be submitted as a Technical Data Package.

3.14 FIELD QUALITY CONTROL, CYBERSECURITY VALIDATION SUPPORT

In addition to testing and testing support required by other Sections, provide a minimum of forty (40) hours of technical support for cybersecurity testing of control systems to support the DoD Risk Management Framework process Cybersecurity assessment of the control system. This support is independent of (and in addition to) the Control System Cybersecurity Testing specified in this section.

3.15 CYBERSECURITY TRAINING

Provide eight hours of classroom and hands-on training for six Government personnel on the cybersecurity operation and maintenance of the control system provided. This training is in addition to and must be coordinated with control system training specified in other Sections.

The Government will provide the training location. Training must cover, at a minimum: (a) applying software and firmware updates, (b) user account creation, modification and deletion, (c) audit log upload procedures and (d) identification of privileged user interfaces and system impact of those interfaces. Training session must include a question and answer period during which government staff questions about cybersecurity aspects of the control system are answered.

-- End of Section --

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SECTION 26 05 73

POWER SYSTEM STUDIES

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

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: Electrical switchboard, panel boards, lighting inverter, generator, automatic transfer switch, etc.

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. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. 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, AE

Fault Current Study; G, AE

System Coordination Study; G, AE

Arc Flash Hazard Study; G, AE

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.

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.

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 the utility service entrance of a building and extend down to load buses/panels where the fault current is 2,000 amperes or less (symmetrical) for distribution buses nominally operating at 208 volt AC and above.

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.

a. Utility

b. Generator

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 owner of the source bus. For multiple modes of operation, use the mode with available fault current that produces the greatest incident energies in the arc flash hazard study.

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 initial 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 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.

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 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. 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 3-560-01NFPA 70E. Obtain approval of arc flash label formats before printing.

a. Provide a 3.5 inch by 5 inch to 4 inch by 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 label for each compartment, cubicle, or section separated by barriers.

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 EasyPower(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

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

Contractor shall 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 entitled "Acceptance Tests and Inspections" herein. Organization shall be independent of the supplier, manufacturer, and installer of the equipment. The organization shall be a first tier subcontractor. No work required by this section of the specification shall be performed by a second tier subcontractor.

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

used shall 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 shall 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. Reports shall 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 shall perform acceptance tests and inspections. Test methods, procedures, and test values shall be performed and evaluated in accordance with NETA ATS, the manufacturer's recommendations, and paragraph entitled "Field Quality Control" of each applicable specification section. Tests identified as optional in NETA ATS are not required unless otherwise specified. Equipment shall be placed in service only after completion of required tests and evaluation of the test results have been completed. Contractor shall 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. Contracting Officer shall be notified 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 12 19.10 THREE-PHASE, LIQUID-FILLED PAD-MOUNTED TRANSFORMERS.

b. Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Medium voltage cables and grounding systems only.

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

d. Section 26 24 13 SWITCHBOARDS.

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 shall be present when equipment tested by the organization is initially energized and placed in service.

-- End of Section --

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SECTION 26 12 19.10

THREE-PHASE, LIQUID-FILLED PAD-MOUNTED TRANSFORMERS

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)

ANSI C12.1	(2014; Errata 2016) Electric Meters - Code for Electricity Metering

ASTM INTERNATIONAL (ASTM)

ASTM A240/A240M	(2023a) 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

FM GLOBAL (FM)

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

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	(2015) General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.12.28	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity

IEEE C57.12.34	(2015) 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	(2015; Corr 2017) 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	(2023) 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

UNDERWRITERS LABORATORIES (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, AE

SD-03 Product Data

Pad-mounted Transformers; G, AE

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

SD-10 Operation and Maintenance Data

Transformer(s), Data Package 5

1.4.1 Reduced Submittal Requirements

Transformers designed and manufactured by ABB 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 EasyPower 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 with terminals identified of watthour meter and current transformers.

d. One-line diagram, including switch(es), current transformers, meters, and fuses.

e. Manufacturer's published time-current curves in PDF format and in electronic format suitable for import or updating into the EasyPower computer program of the transformer high side fuses.

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 6,000 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. Information on watthour demand meter, CT's, and fuse block.

g. Actual nameplate diagram.

h. 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 with capacitance checkpoint, 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 with insulated standoff bushings, protective caps, 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. Bushing well inserts: IEEE 386, 200 amperes, 15 kV Class. Provide a bushing well insert for each bushing well unless indicated otherwise.

c. Load-break switch:

   Radial-feed two-position oil-immersed type 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 handle in the high-voltage compartment.

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 9 kV, fully shielded, dead-front, metal-oxide-varistor, elbow type with resistance-graded gap. Provide three arresters for radial feed circuits.

f. Parking stands: Provide a parking stand near each bushing. Provide insulated standoff bushings for parking of energized high-voltage connectors on parking stands.

g. Protective caps: IEEE 386, 200 amperes, 15 kV Class. Provide insulated protective caps (not shipping caps) for insulating and sealing out moisture from unused bushings.

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 gauge, pressure-vacuum gauge, and dial type thermometer with maximum temperature indicator.

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 as indicated.

c. Transformer voltage ratings: 12470 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:

2.50 for units rated 75kVA and below
2.87 for units rated 112.5kVA to 300kVA
4.03 for 500kVA rated units
5.32 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.

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 Brown, Robins AFB #48, with paint coating system complying with IEEE C57.12.28 regardless of base, cabinet, and tank material.

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.

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 CAST-IN-PLACE CONCRETE

Provide concrete associated with electrical work for other than encasement of underground ducts rated for 4,000 psi minimum 28-day compressive strength unless specified otherwise. Conform to the requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE.

2.7 SOURCE QUALITY CONTROL

2.7.1 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.

2.7.2 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 each of the specified transformer(s), 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.

2.7.3 Routine and Other Tests

IEEE C57.12.00. Routine and other tests: Performed in accordance with IEEE C57.12.90 by the manufacturer on each of the actual transformer(s) 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 4/0 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.

3.3.1 Meters and Current Transformers

ANSI C12.1.

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 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.

3.5.1 Cast-In-Place Concrete

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

3.5.2 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.

3.6 FIELD QUALITY CONTROL

3.6.1 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".

3.6.1.1 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. Proper voltages must be measured at the main switchboard.

(3) Perform insulation-resistance tests, winding-to-winding and each winding-to-ground. Calculate polarization index. Verify that the tap changer is set at the specified ratio.

(4) Perform turns-ratio tests at all tap positions.

(5) Perform insulation power-factor or dissipation-factor tests on all windings in accordance with test equipment manufacturer’s published data.

(6) Perform power-factor or dissipation-factor tests on each bushing equipped with a power-factor/capacitance tap. In the absence of a power-factor/capacitance tap, perform hot-collar tests.

(7) Measure the resistance of each high-voltage winding in each de-energized tap-changer position. Measure the resistance of each low-voltage winding in each de-energized tap-changer position, if applicable.

(8) Remove and test a sample of insulating liquid for the following: Dielectric breakdown voltage, Acid neutralization number, Specific gravity, Interfacial tension, Color, Visual Condition, Water in insulating liquids (required on 25 kV or higher voltages and on all silicone-filled units), and Power factor or dissipation factor.

(9) Perform dissolved-gas analysis (DGA) on a sample of insulating liquid.

3.6.1.2 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 wiring.

(5) Verify the unit is 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 that all required grounding and shorting connections provide good contact.

(8) Verify correct operation of transformer withdrawal mechanism and

grounding operation.

(9) Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

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.

3.6.1.3 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.

3.6.1.4 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.

3.6.2 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 --

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SECTION 26 20 00

INTERIOR DISTRIBUTION SYSTEM

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)

ANSI C12.1	(2014; Errata 2016) Electric Meters - Code for Electricity Metering

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

ASHRAE 90.1	(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

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 62053-21	(2020) Electricity Metering Equipment - Particular Requirements - Part 21: Static Meters for AC Active Energy (Classes 0,5, 1 and 2)

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 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms

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 C12.7	(2014) Requirements for Watthour Meter Sockets
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)
ANSI C80.5	(2020) American National Standard for Electrical Rigid Aluminum Conduit
NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
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	(2000; R 2015) 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 RN 1	(2005; R 2013) 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 TC 14	(2002) Standard for Reinforced Thermosetting Resin Conduit (RTRC) and Fittings
NEMA VE 1	(2017) Metal Cable Tray Systems
NEMA WD 1	(1999; R 2020) Standard for General Color Requirements for Wiring Devices
NEMA WD 6	(2016) Wiring Devices Dimensions Specifications
NEMA Z535.4	(2023) Product Safety Signs and Labels

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023) National Electrical Code
NFPA 70E	(2024) Standard for Electrical Safety in the Workplace
NFPA 780	(2020) Standard for the Installation of Lightning Protection Systems

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-568.1	(2020e) Commercial Building Telecommunications Infrastructure Standard
TIA-569	(2019e) 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

UNDERWRITERS LABORATORIES (UL)

UL 1	(2005; Reprint Jan 2020) UL Standard for Safety Flexible Metal Conduit

UL 6	(2022) UL Standard for Safety Electrical Rigid Metal Conduit-Steel
UL 6A	(2008; Reprint Mar 2021) UL Standard for Safety Electrical Rigid Metal Conduit - Aluminum, Red Brass, and Stainless Steel
UL 20	(2018; Reprint Jan 2021) 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 Jul 2020) UL Standard for Safety Panelboards
UL 83	(2017; Reprint Mar 2020) 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 360	(2013; Reprint Aug 2021) 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 May 2021) UL Standard for Safety Wire Connectors
UL 486C	(2018; Reprint May 2021) UL Standard for Safety Splicing Wire Connectors
UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 498	(2017; Reprint Feb 2021) UL Standard for Safety Attachment Plugs and Receptacles
UL 506	(2017) 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	(2013; Reprint Aug 2017) UL Standard for Safety Metallic Outlet Boxes
UL 514B	(2012; Reprint Mar 2024) 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 Mar 2021) UL Standard for Safety Electrical Metallic Tubing -- Steel
UL 817	(2015; Reprint Jul 2021) UL Standard for Safety Cord Sets and Power-Supply Cords
UL 854	(2020; Reprint Nov 2023) 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 943	(2016; Reprint Feb 2018) UL Standard for Safety Ground-Fault Circuit-Interrupters
UL 984	(1996; Reprint Sep 2005) Hermetic Refrigerant Motor-Compressors
UL 1063	(2017) UL Standard for Safety Machine-Tool Wires and Cables
UL 1242	(2006; Reprint Apr 2022) UL Standard for Safety Electrical Intermediate Metal Conduit -- Steel
UL 1449	(2021; Reprint Dec 2022) UL Standard for Safety Surge Protective Devices
UL 1561	(2011; Reprint Jun 2015) Dry-Type General Purpose and Power Transformers
UL 1660	(2019) Liquid-Tight Flexible Nonmetallic Conduit
UL 4248-1	(2017) UL Standard for Safety Fuseholders

	- Part 1: General Requirements
UL 4248-12	(2018) 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 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

Panelboards; G, AE

Transformers; G, AE

Busway; G, AE

Cable Trays; G, AE

Marking Strips Drawings; G, AE

SD-03 Product Data

Receptacles; G

Circuit Breakers; G

Switches; G

Transformers; G

Enclosed Circuit Breakers; G

Manual Motor Starters; G

Metering; G

Secondary Bonding Busbar; G

Surge Protective Devices; G

Cable Trays; 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

SD-10 Operation and Maintenance Data

Electrical Systems, Data Package 5; G

Metering, Data Package 5; G

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 6,000 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

1.5.1 Electrical Systems

Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and as specified herein. Submit operation and maintenance manuals for electrical systems that provide basic data relating to the design, operation, and maintenance of the electrical distribution system for the building. Include the following:

a. Single line diagram of the "as-built" building electrical system.

b. Schematic diagram of electrical control system (other than HVAC, covered elsewhere).

c. Manufacturers' operating and maintenance manuals on active electrical equipment.

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.

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.

2.2.1.2 Rigid Aluminum Conduit

ANSI C80.5, UL 6A.

2.2.2 Rigid Nonmetallic Conduit

PVC Type EPC-40, and EPC-80 in accordance with NEMA TC 2,UL 651, or fiberglass conduit, in accordance with NEMA TC 14.

2.2.3 Intermediate Metal Conduit (IMC)

UL 1242, zinc-coated steel only.

2.2.4 Electrical, Zinc-Coated Steel Metallic Tubing (EMT)

UL 797, ANSI C80.3.

2.2.5 Plastic-Coated Rigid Steel and IMC Conduit

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

2.2.6 Flexible Metal Conduit

UL 1, limited to 6 feet.

2.2.6.1 Liquid-Tight Flexible Metal Conduit, Steel

UL 360, limited to 6 feet.

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

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

2.2.7.1 Fittings for Rigid Metal Conduit and IMC

Threaded-type. Split couplings unacceptable.

2.2.7.2 Fittings for EMT

Steel compression type.

2.2.8 Fittings for Rigid Nonmetallic Conduit

NEMA TC 3 for PVC and NEMA TC 14 for fiberglass, and UL 514B.

2.2.9 Liquid-Tight Flexible Nonmetallic Conduit

UL 1660.

2.3 BUSWAY

NEMA BU 1.1, UL 857. Provide the following:

a. Buses: Copper.

b. Busways: Rated as indicated and include integral or internal ground bus.

c. Short circuit rating: As indicated.

d. Busway systems: Suitable for use indoors.

e. Enclosures: Steel.

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.

2.3.1 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. Busway: Capability to insert and remove plug-ins without de-energizing the bus.

2.4 CABLE TRAYS

NEMA VE 1. 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.

b. Cable trays: Constructed of steel that has been zinc-coated 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: Sizing as indicated.

2.4.1 Basket-Type Cable Trays

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

2.4.2 Ladder-Type Cable Trays

Provide size as indicated with maximum rung spacing of 9 inches. Cable tray must be suitable for use as an equipment grounding conductor.

2.5 OUTLET BOXES AND COVERS

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

2.5.1 Floor Outlet Boxes

Provide the following:

a. Boxes: Nonadjustable and concrete tight.

b. Each outlet: Consisting of nonmetallic or cast-metal body with threaded openings, for conduits, adjustable ring, and cover plate with 1-1/4 inch threaded plug.

c. Telecommunications outlets: Consisting of surface-mounted, horizontal or flush as indicated, aluminum or stainless steel housing with a receptacle as specified and 1-1/4 inch conduit routed to nearest accessible cable tray.

d. Receptacle outlets: Consisting of surface-mounted, horizontal or flush as indicated aluminum or stainless steel housing with duplex-type receptacle as specified herein.

e. Provide gaskets where necessary to ensure watertight installation.

2.5.2 Outlet Boxes for Telecommunications System

Provide the following:

a. Standard type 4-11/16 inches square by 2-1/8 inches deep.

2.6 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 3R.

2.7 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 12 months prior to date of delivery to site.

2.7.1 Conductors

Provide the following:

a. Conductor sizes and capacities shown are based on copper, unless indicated otherwise.

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.

e. All conductors: Copper.

2.7.1.1 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.

2.7.2 Color Coding

Provide color coding for service, feeder, branch, control, and signaling circuit conductors.

2.7.2.1 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.

2.7.2.2 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.

2.7.3 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 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.

2.7.4 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.

2.7.4.1 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.

2.7.4.2 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.

2.7.5 Service Entrance Cables

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

2.7.6 Cord Sets and Power-Supply Cords

UL 817.

2.8 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.

2.9 DEVICE PLATES

Provide the following:

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

b. For metal outlet boxes, plates on unfinished walls: Zinc-coated sheet steel or cast metal having round or beveled edges.

c. For nonmetallic boxes and fittings, other suitable plates may be provided.

d. 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.

e. Plates on finished walls: Satin finish stainless steel, minimum 0.03 inch thick.

f. Screws: Machine-type with countersunk heads in color to match finish of plate.

g. Sectional type device plates are not permitted.

h. Plates installed in wet locations: Gasketed and UL listed for "wet locations."

2.10 SWITCHES

2.10.1 Toggle Switches

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

a. Handles: Grey thermoplastic.

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.

2.10.2 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.

2.10.3 Breakers Used as Switches

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

2.10.4 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 1 enclosure per NEMA ICS 6 for interior locations. Provide NEMA 3R rated enclosure for

exterior locations.

2.11 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 or other circuit protective devices for proper operation. Submit coordination data for approval. Provide fuses with a voltage rating not less than circuit voltage.

2.11.1 Fuseholders

Provide in accordance with UL 4248-1.

2.11.2 Cartridge Fuses, Current Limiting Type (Class R)

UL 248-12, Class RK-5. Provide only Class R associated fuseholders in accordance with UL 4248-12.

2.11.3 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.

2.12 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: Grey as per NEMA WD 1.

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.

i. Controlled receptacles: As required per ASHRAE 90.1. Provide marking for controlled receptacle per NFPA 70.

2.12.1 Split Duplex Receptacles

Provide separate terminals for each ungrounded pole. One receptacle must be controlled separately.

2.12.2 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, polycarbonate, UV resistant/stabilized cover plate.

2.12.3 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.

2.12.4 Special Purpose Receptacles

Provide in ratings indicated.

2.13 PANELBOARDS

Provide panelboards in accordance with the following:

a. UL 67 and UL 50.

b. Panelboards for use as service disconnecting: Additionally conform to UL 869A.

c. Panelboards: Circuit breaker-equipped.

d. 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.

e. Where "space only" is indicated, make provisions for future installation of breaker sized as indicated.

f. Directories: Indicate load served by each circuit of panelboard.

g. Directories: Indicate source of service (e.g., upstream panel, switchboard) to panelboard.

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

i. Panelboard nameplates: Provided in accordance with paragraph FIELD FABRICATED NAMEPLATES.

2.13.1 Enclosure

Provide panelboard enclosure in accordance with the following:

a. UL 50.

b. Cabinets mounted outdoors or flush-mounted: Hot-dipped galvanized after fabrication.

c. Cabinets: Painted in accordance with paragraph 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.

2.13.2 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. In addition to equipment grounding bus, provide second "isolated" ground bus, where indicated.

2.13.2.1 Panelboard Neutrals for Non-Linear Loads

Provide in accordance with the following:

a. UL listed, with panelboard type specifically UL heat rise tested for use on non-linear loads.

b. Panelboard: Heat rise tested in accordance with UL 67, except with the neutral assembly installed and carrying 200 percent of the phase bus current during testing.

c. Verification of the testing procedure: Provided upon request.

d. Two neutral assemblies paralleled together with cable is not acceptable.

e. Nameplates for panelboard rated for use on non-linear loads: Marked "SUITABLE FOR NON-LINEAR LOADS" and in accordance with paragraph FIELD FABRICATED NAMEPLATES.

f. Provide a neutral label with instructions for wiring the neutral of panelboards rated for use on non-linear loads.

2.13.3 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.

2.13.3.1 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.

2.13.3.2 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.

2.13.4 Branch Circuit Monitoring Panelboards

Provide a microprocessor-based panelboard monitoring system having the following features:

a. ANSI C12.1 and IEC 62053-21 Class 1 energy revenue metering accuracy.

b. Direct reading metered or calculated values for up to forty-two branch circuits.

c. Monitored values at the branch circuit level for current (A), power (kW), and energy (kWh).

d. Four user-configurable alarm thresholds.

e. Communications with building automation system using Modbus RTU protocol via RS-485 cable connection.

2.13.5 Lighting Control Panelboards

Provided a lighting control panelboard having the following features:

a. Minimum sixteen schedules including a 7-day repeating schedule with sixteen daily on/off periods.

b. Minimum sixteen lighting zones grouping branch breakers that are controlled by schedules, manual inputs, or override commands.

c. Electronic clock including real-time, astronomical clock, and leap year and daylight savings time adjustments.

d. Burn-hour tracking.

e. Remote circuit breaker operation.

f. Communications with building automation system using Modbus RTU protocol via RS-485 cable connection.

2.14 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.

2.15 TRANSFORMERS

Provide transformers in accordance with the following:

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

b. Copper windings.

c. Provide transformers in NEMA 1 enclosure. Transformers located outside must be NEMA 3R enclosure.

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

e. Transformer insulation system:

(1) 220 degrees C insulation system for transformers 15 kVA and greater, with temperature rise not exceeding 115 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.

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

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

h. Transformer of 80 degrees C temperature rise: Capable of carrying continuously 130 percent of nameplate kVA without exceeding insulation rating.

2.15.1 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.

2.15.2 Transformers With Non-Linear Loads

Provide 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.

2.16 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 or available short-circuit current is greater than 10,000 amps at rated voltage at the switch terminals, provide fused switches in lieu of non-fused switches indicated.

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

2.16.1 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.

2.16.2 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.

2.16.3 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.

2.16.4 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, 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.

2.17 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 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, thermostat, 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.

2.17.1 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.

2.17.2 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.

2.17.2.1 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.

2.17.3 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.

2.17.4 Enclosures for Motor Controllers

NEMA ICS 6.

2.17.5 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.

2.17.6 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.

2.17.7 Pilot and Indicating Lights

Provide transformer, resistor, or diode type.

2.18 MANUAL MOTOR STARTERS (MOTOR RATED SWITCHES)

Single, double, or three pole as indicated designed for surface mounting with overload protection and pilot lights.

2.18.1 Pilot Lights

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

2.19 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, "Mechanical" for mechanical isolation of machines and other equipment.

2.20 TELECOMMUNICATIONS SYSTEM

Provide system of telecommunications wire-supporting structures (pathway), including: Outlet boxes, conduits with pull wires, 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.

2.21 GROUNDING AND BONDING EQUIPMENT

2.21.1 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.

2.21.2 Ground Bus

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

2.21.3 Secondary Bonding Busbar

Provide corrosion-resistant grounding busbar suitable for indoor installation in accordance with TIA-607. Busbars: Plated for reduced contact resistance. If not plated, clean the busbar prior to fastening the conductors to the busbar and apply an anti-oxidant to the contact area to control corrosion and reduce contact resistance. Provide a Primary bonding busbar (PBB) in the telecommunications entrance facility and a Secondary bonding busbar (SBB) in all other telecommunications rooms and equipment rooms. The Primary bonding busbar (PBB) and the Secondary bonding busbar (SBB): Sized in accordance with the immediate application

requirements and with consideration of future growth. Provide Secondary bonding busbars with the following:

a. Predrilled copper busbar provided with holes for use with standard sized lugs;

b. Minimum dimensions of 0.25 in thick by 4 in wide for the PBB and 2 in wide for SBBs with length as indicated;

c. Listed by a nationally recognized testing laboratory.

2.22 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.

2.23 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.

2.24 WARNING SIGNS

Provide warning signs for flash protection in accordance with NFPA 70E and NEMA Z535.4 for switchboards, panelboards, and industrial control panels 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.

2.25 FIRESTOPPING MATERIALS

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

2.26 METERING

ANSI C12.1. Provide a self-contained, socket-mounted, electronic programmable outdoor watthour meter. Meter: Either programmed at the factory or programmed in the field. Turn field programming device over to the Contracting Officer at completion of project. Coordinate meter to system requirements. Coordinate meter, system components, and meter location to be compatible with the Activity's central advanced metering system. Provide the meter indicated in drawings.

a. Socket: ANSI C12.7. Provide NEMA Type 3R, box-mounted socket, ringless, having jaws compatible with requirements of the meter. Provide Brown, Robins AFB #48 enclosure color.

2.27 SURGE PROTECTIVE DEVICES

Provide parallel type surge protective devices (SPD) which comply with UL 1449 at the service entrance, panelboards, and switchgears. Provide surge protectors in a NEMA 1 enclosure per NEMA ICS 6. 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)

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) and downstream SPDs rated 40,000 amperes for L-L mode minimum and 20,000 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:

1,000V for 120/240V, single phase system
600V for 208Y/120V, three phase system
1,200V for 480Y/277V, three phase system

Maximum L-G Protection Rating:

1,000V for 120/240V, single phase system
700V for 208Y/120V, three phase system
1,200V for 480Y/277V, three phase system

Maximum L-L Voltage Protection Rating:

1,200V for 208Y/120V, three phase system
1,800V for 480Y/277V, three phase system

2.28 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: Brown, Robins AFB No. 48.

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

2.29 SOURCE QUALITY CONTROL

2.29.1 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.

2.30 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 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: 3/4 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.

3.1.3.2 Metal-Clad Cable

Install in accordance with NFPA 70, Type MC cable for uses permitted in NFPA 70 section 330.10 and limited to 6 foot fixture whips.

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 Aluminum Conduit

a. Do not install underground or encase in concrete or masonry.

b. Do not use brass or bronze fittings.

c. 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 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 outdoors.

3.1.4.3 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 40 and 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 penetrating fire-rated walls or partitions, or fire-rated floors.

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3.1.4.4 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).

3.1.4.5 Underground Conduit

Plastic-coated rigid steel; plastic-coated steel IMC; PVC, Type EPC-40. Plastic coating: Extend minimum 6 inches above floor.

3.1.4.6 Conduit for Circuits Rated Greater Than 600 Volts

Rigid metal conduit or IMC only.

3.1.4.7 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.

3.1.4.8 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.

3.1.4.9 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.

3.1.4.10 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. 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 watertight 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.

3.1.4.11 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.

3.1.4.12 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.

3.1.4.13 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 nonmetallic conduit in wet and damp locations and in fire pump rooms 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.

3.1.4.14 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 and cable trays 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 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 Cable Tray Installation

Install and ground in accordance with NFPA 70. In addition, install and ground telecommunications cable tray in accordance with TIA-569, and TIA-607. Install cable trays parallel with or at right angles to ceilings, walls, and structural members. Cable tray and tray supports must not partially nor completely obstruct access to the room. Support in accordance with manufacturer recommendations but at not more than 6 foot intervals. Coat contact surfaces of connections with an antioxidant compound prior to assembly. Adjacent cable tray sections: Bonded together by connector plates of an identical type as the cable tray sections. For grounding of cable tray system provide No. 2 AWG bare copper wire throughout cable tray system, and bond to each section, except

use No. 1/0 aluminum wire if cable tray is aluminum. Terminate cable trays 10 inches from both sides of smoke and fire partitions. Install conductors run through smoke and fire partitions in 4 inch rigid steel conduits with grounding bushings, extending 12 inches beyond each side of partitions. Seal conduit on both ends to maintain smoke and fire ratings of partitions. Firestop penetrations in accordance with Section 07 84 00 FIRESTOPPING. 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.

3.1.7 Telecommunications Cable Support Installation

Install open top 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.

3.1.8 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, 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.

3.1.8.1 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. Telecommunications outlets: A minimum of 4-11/16 inches square by 2-1/8 inches deep. Mount outlet boxes flush in finished walls.

3.1.8.2 Pull Boxes

Construct of at least minimum size required by NFPA 70 of code-gauge aluminum or galvanized sheet steel, and compatible with nonmetallic raceway systems, 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.

3.1.8.3 Extension Rings

Extension rings are not permitted for new construction.

3.1.9 Mounting Heights

Mount panelboards, motor controller 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 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 48 inches above finished floor. Mount other devices as indicated. Measure mounting heights of wiring devices and outlets to center of device or outlet.

3.1.10 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, 23 09 13 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC, and 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS. Provide telecommunications system conductor identification as specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEMS.

3.1.10.1 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.

3.1.11 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.

3.1.12 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.

3.1.13 Electrical Penetrations

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

3.1.14 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, grounding conductor of nonmetallic sheathed cables, 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.

3.1.14.1 Ground Rods

Provide ground rods and measure the resistance to ground using the fall-of-potential method described in IEEE 81. Do not exceed 25 ohms under normally dry conditions for the maximum resistance of a driven ground. If this resistance cannot be obtained with a single rod, add additional rods, spaced on center. Spacing for additional rods must be a minimum of 10 feet. If the resultant resistance exceeds 25 ohms measured not less than 48 hours after rainfall, notify the Contracting Officer who will decide on the number of ground rods to add.

3.1.14.2 Grounding Connections

Make grounding connections which are buried or otherwise normally inaccessible, excepting specifically those connections for which access for periodic testing is required, 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.

3.1.14.3 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.

3.1.14.4 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.

3.1.14.5 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. Provide a Secondary bonding busbar (SBB) in all other telecommunications rooms and telecommunications equipment rooms. Install the SBB as close to the telecommunications room panelboard as practicable, when equipped. Where a panelboard for telecommunications equipment is not installed in the telecommunications room, locate the SBB near the backbone cabling and associated terminations. In addition, locate the SBB to provide for the shortest and straightest routing of the grounding conductors. Where a panelboard for telecommunications equipment is located within the same room or space as a SBB, bond that panelboard's alternating current equipment ground (ACEG) bus (when equipped) or the panelboard enclosure to the SBB. 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. Provide a telecommunications bonding backbone (TBB) that originates at the PBB extends throughout the building using the telecommunications backbone pathways, and connects to the SBBs in all telecommunications rooms and equipment rooms. Install the TBB conductors such that they are protected from physical and mechanical damage. The TBB conductors should be installed without splices and routed in the shortest possible straight-line path. Make the bonding conductor between a TBB and a SBB continuous. Where splices are necessary, the number of splices should be a minimum. Make the splices accessible and located in telecommunications spaces. Connect joined segments of a TBB using exothermic welding, irreversible compression-type connectors, or equivalent. Install all joints to be adequately supported and protected from damage. Whenever two or more TBBs are used within a multistory building, bond the TBBs together with a grounding equalizer (GE) at the top floor and at a minimum of every third floor in between. Do not connect the TBB and GE to the pathway ground, except at the PBB or the SBB.

c. Telecommunications Grounding Connections: Telecommunications grounding connections to the PBB or SBB: Utilize listed compression two-hole lugs, exothermic welding, 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 or SBB to the PBB or SBB respectively. In a metal frame (structural steel) building, where the steel framework is readily accessible within the room; bond each PBB and SBB 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.

3.1.15 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.

3.1.16 Elevator

Provide circuit to line terminals of elevator controller, and disconnect switch on line side of controller, outlet for control power, outlet receptacle and work light at midheight of elevator shaft, and work light and outlet receptacle in elevator pit.

3.1.17 Repair of Existing Work

Perform repair of existing work, demolition, and modification of existing electrical distribution systems as follows:

3.1.17.1 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.

3.1.17.2 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.

3.1.17.3 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.

3.1.17.4 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.

3.1.18 Watthour Meters

ANSI C12.1.

3.1.19 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.

3.2 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.

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. Painting: Asspecified in Section 09 90 00 PAINTS AND COATINGS.

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 Watthour Meter

a. Visual and mechanical inspection:

(1) Examine for broken parts, shipping damage, and tightness of connections.

(2) Verify that meter type, scales, and connections are in accordance with approved shop drawings.

b. Electrical tests:

(1) Determine accuracy of meter.

(2) Calibrate watthour meters to one-half percent.

(3) Verify that correct multiplier has been placed on face of meter, where applicable.

3.5.7 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.

-- End of Section --

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SECTION 26 24 13

SWITCHBOARDS

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)

ANSI C12.1	(2014; Errata 2016) Electric Meters - Code for Electricity Metering

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 A780/A780M	(2020) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials
ASTM D1535	(2014; R 2018) Standard Practice for Specifying Color by the Munsell System

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 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C2	(2023) National Electrical Safety Code
IEEE C37.90.1	(2013) Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus

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/NEMA PB 2.1	(2013) General Instructions for Proper Handling, Installation, Operation and Maintenance of Deadfront Distribution Switchboards Rated 600 V or Less
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA PB 2	(2011) Deadfront Distribution Switchboards

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment
UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 891	(2005; Reprint Oct 2012) Switchboards

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 100.

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

Switchboard Drawings; G, AE

SD-03 Product Data

Switchboard; G, AE

SD-06 Test Reports

Switchboard Design Tests; G

Switchboard Production Tests; G

Acceptance Checks and Tests; G

SD-07 Certificates

Cybersecurity Installation Certification; G

Submit certification indicating conformance with the paragraph CYBERSECURITY INSTALLATION CERTIFICATION.

SD-10 Operation and Maintenance Data

Switchboard Operation and Maintenance, Data Package 5; G

SD-11 Closeout Submittals

Assembled Operation and Maintenance Manuals; G

Equipment Test Schedule; G

Required Settings; G

Service Entrance Available Fault Current Label; G

1.5 QUALITY ASSURANCE

1.5.1 Product Data

Include manufacturer's information on each submittal for each component, device and accessory provided with the switchboard including:

a. Circuit breaker type, interrupting rating, and trip devices, including available settings.

b. Manufacturer's instruction manuals and published time-current curves (in electronic format) of the main secondary breaker and largest secondary feeder device.

1.5.2 Switchboard 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. Identify circuit terminals on wiring diagrams and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Indicate on the drawings adequate clearance for operation, maintenance, and replacement of operating equipment devices. Include the nameplate data, size, and capacity on submittal. Also include applicable federal, military, industry, and technical society publication references on submittals. Include the following:

a. One-line diagram including breakers, current transformers, and meters.

b. Outline drawings including front elevation, section views, footprint, and overall dimensions.

c. Bus configuration including dimensions and ampere ratings of bus bars.

d. Markings and NEMA nameplate data.

e. Circuit breaker type, interrupting rating, and trip devices, including available settings.

f. Wiring diagrams and elementary diagrams with terminals identified, and indicating prewired interconnections between items of equipment and the interconnection between the items.

g. Manufacturer's instruction manuals and published time-current curves (in electronic format) of the main secondary breaker and largest secondary feeder device. Use this information to provide breaker settings that ensures protection and coordination are achieved.

1.5.3 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" or "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.

1.5.4 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.

1.5.4.1 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 furnished.

1.5.4.2 Material and Equipment Manufacturing Date

Products manufactured more than one year prior to date of delivery to site are not acceptable.

1.6 MAINTENANCE

1.6.1 Switchboard Operation and Maintenance Data

Submit Operation and Maintenance Manuals in accordance with Section

01 78 23 OPERATION AND MAINTENANCE DATA.

1.6.2 Assembled Operation and Maintenance Manuals

Assemble and securely bind manuals in durable, hard covered, water resistant binders. Assemble and index the manuals in the following order with a table of contents:

a. Manufacturer's O&M information required by the paragraph SD-10, OPERATION AND MAINTENANCE DATA.

b. Catalog data required by the paragraph SD-03, PRODUCT DATA.

c. Drawings required by the paragraph SD-02, SHOP DRAWINGS.

d. Prices for spare parts and supply list.

e. Information on metering.

f. Design test reports.

g. Production test reports.

1.7 WARRANTY

Provide equipment items that are supported by service organizations 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 PRODUCT COORDINATION

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

2.2 SWITCHBOARD

NEMA PB 2 and UL 891.

2.2.1 Ratings

Provide equipment with the following ratings:

a. Voltage rating: 480Y/277 volts AC, three-phase, 4-wire.

b. Continuous current rating of the main bus: As indicated.

c. Short-circuit current rating: As indicated.

d. UL listed and labeled as service entrance equipment.

2.2.2 Construction

Provide the following:

a. Switchboard: Consisting of one or more vertical sections bolted

together to form a rigid assembly and rear aligned.

b. All circuit breakers: Front accessible.

c. Rear aligned switchboards: Front accessible load connections.

d. Where indicated, "space for future" or "space" means to include a vertical bus provided behind a blank front cover. Where indicated, "provision for future" means full hardware provided to mount a breaker suitable for the location.

e. Completely factory engineered and assembled, including protective devices and equipment indicated with necessary interconnections, instrumentation, and control wiring.

2.2.2.1 Enclosure

Provide the following:

a. Enclosure: NEMA ICS 6 Type 1.

b. Enclosure: Bolted together with removable bolt-on side and rear covers.

c. Base: Includes any part of enclosure that is within 3 inches of concrete pad.

d. Paint color: ASTM D1535 light gray No. 61 or No. 49 over rust inhibitor.

2.2.2.2 Bus Bars

Provide the following:

a. Bus bars: Copper with silver-plated contact surfaces.

(1) Phase bus bars: Uninsulated.

(2) Neutral bus: Rated 100 percent of the main bus continuous current rating.

b. Make bus connections and joints with hardened steel bolts.

c. Main-bus (through bus): Rated at the full ampacity of the main throughout the switchboard.

d. Minimum one-quarter by 2 inch copper ground bus secured to each vertical section along the entire length of the switchboard.

2.2.2.3 Main Section

Provide the main section consisting ofa combination section with an individually mounted drawout insulated-case circuit breaker.

2.2.2.4 Distribution Sections

Provide the distribution sections consisting of individually mounted, insulated-case circuit breakers or group mounted molded-case circuit breakers.

2.2.3 Protective Device

Provide main and branch protective devices as indicated.

2.2.3.1 Insulated-Case Breaker

Provide the following:

a. UL 489. UL listed and labeled, 100 percent rated main breaker, manually operated, low voltage, insulated-case circuit breaker, with a short-circuit current rating as indicated at 480 volts.

b. Breaker frame size: As indicated.

c. Series rated circuit breakers are unacceptable.

d. Maintenance switch for arc-flash reduction per NEC 240.87 as indicated.

2.2.3.2 Molded-Case Circuit Breaker

Provide the following:

a. UL 489. UL listed and labeled, 100 percent rated main breaker, manually operated, low voltage molded-case circuit breaker, with a short-circuit current rating as indicated at 480 volts.

b. Breaker frame size: As indicated or required for indicated breaker rating.

c. Series rated circuit breakers are unacceptable.

2.2.4 Drawout Breakers

Provide drawout breakers as indicated. Equip drawout breakers with disconnecting contacts, wheels, and interlocks for drawout application. Provide main, auxiliary, and control disconnecting contacts with silver-plated, multifinger, positive pressure, self-aligning type. Provide each drawout breaker with four-position operation with each position clearly identified by an indicator on the circuit breaker front panel as follows.

a. Connected Position: Primary and secondary contacts are fully engaged. Breaker must be tripped before racking into or out of position.

b. Test Position: Primary contacts are disconnected but secondary contacts remain fully engaged. This position allows complete test and operation of the breaker without energizing the primary circuit.

c. Disconnected Position: Primary and secondary contacts are disconnected.

d. Withdrawn (Removed) Position: Places breaker completely out of compartment, ready for removal. Removal of the breaker actuates assembly that isolates the primary stabs.

2.2.5 Electronic Trip Units

Equip main and distribution breakers as indicated with a solid-state

tripping system consisting of three current sensors and a microprocessor-based trip unit that provides true rms sensing adjustable time-current circuit protection. Include the following:

a. Current sensors ampere rating: As indicated.

b. Trip unit ampere rating: As indicated.

c. Ground fault protection: As indicated.

d. Electronic trip units: Provide additional features as indicated:

(1) Breakers: Include long delay pick-up and time settings, and LED indication of cause of circuit breaker trip.

(2) Main breakers: Include short delay pick-up and time settings and, instantaneous settings and ground fault settings.

(3) Distribution breakers: Include short delay pick-up and time settings, instantaneous settings, and ground fault settings as indicated.

(4) Main Breakers: Include a digital display for phase and ground current.

(5) Main Breakers: Include a digital display for watts, vars, VA, kWh, kvarh, and kVAh.

(6) Main Breakers: Include a digital display for phase voltage, and percent THD voltage and current.

(7) For electronic trip units that are rated for or can be adjusted to 1,200 amperes or higher, provide arc energy reduction capability with an energy-reducing maintenance switch with local status indicator.

2.2.6 Thermal Magnetic 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.

2.2.7 Metering

2.2.7.1 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.

a. Display capability:

(1) 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.

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

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

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

e. Provide digital communications protocol as required for monitoring by the UMCS.

f. 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.

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

h. 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.

2.2.7.2 Submetering

ASHRAE 90.1 - IP. Provide submetering for receptacle loads, interior lighting, exterior lighting, and HVAC. Loads must be aggregated so a total can be analyzed for each load type and overall load.

2.2.8 Terminal Boards

Provide with engraved plastic terminal strips and screw type terminals for external wiring between components and for internal wiring between removable assemblies. Provide short-circuiting type terminal boards associated with current transformer. Terminate conductors for current transformers with ring-tongue lugs. Provide terminal board identification that is identical in similar units. Provide color coded external wiring that is color coded consistently for similar terminal boards.

2.2.9 Wire Marking

Mark control and metering conductors at each end. Provide factory installed, white, plastic tubing, heat stamped with black block type letters on factory-installed wiring. On field-installed wiring, provide white, preprinted, polyvinyl chloride (PVC) sleeves, heat stamped with black block type letters. Provide a single letter or number on each sleeve, elliptically shaped to securely grip the wire, and keyed in such a manner to ensure alignment with adjacent sleeves. Provide specific wire markings using the appropriate combination of individual sleeves. Indicate on each wire marker the device or equipment, including specific

terminal number to which the remote end of the wire is attached.

2.3 MANUFACTURER'S NAMEPLATE

Provide a nameplate on 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 is not acceptable. This nameplate and method of attachment may be the manufacturer's standard if it contains the required information.

2.4 FIELD FABRICATED NAMEPLATES

ASTM D709. Provide laminated plastic nameplates for each switchboard, equipment enclosure, relay, switch, and device; as specified in this section or as indicated on the drawings. Identify on each nameplate inscription the function and, when applicable, the position. Provide nameplates of melamine plastic, 0.125 inch thick, white with black center core. Provide red laminated plastic label with white center core where indicated. Provide matte finish surface. Provide square corners. Accurately align lettering and engrave into the core. Provide nameplates with minimum size of one by 2.5 inches. Provide lettering that is a minimum of 0.25 inch high normal block style.

2.5 SOURCE QUALITY CONTROL

2.5.1 Equipment Test Schedule

The Government reserves the right to witness tests. Provide equipment test schedules 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.

Provide the following as part of test equipment calibration:

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

b. Accuracy: Traceable to the National Institute of Standards and Technology.

c. Instrument calibration frequency schedule: Less than or equal to 12 months for both test floor instruments and leased specialty equipment.

d. Dated calibration labels: Visible on all test equipment.

e. Calibrating standard: Higher accuracy than that of the instrument tested.

f. 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:

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

(2) Identify the third party/laboratory calibrated instrument to

verify that calibrating standard is met.

2.5.2 Switchboard Design Tests

NEMA PB 2 and UL 891.

2.5.2.1 Design Tests

Furnish documentation showing the results of design tests on a product of the same series and rating as that provided by this specification.

a. Short-circuit current test.

b. Enclosure tests.

c. Dielectric test.

2.5.2.2 Additional Design Tests

In addition to normal design tests, perform the following tests on the actual equipment. Furnish reports which include results of design tests performed on the actual equipment.

a. Temperature rise tests.

b. Continuous current.

2.5.3 Switchboard Production Tests

NEMA PB 2 and UL 891. Furnish reports which include results of production tests performed on the actual equipment for this project. These tests include:

a. 60-hertz dielectric tests.

b. Mechanical operation tests.

c. Electrical operation and control wiring tests.

d. Ground fault sensing equipment test.

2.6 COORDINATED POWER SYSTEM PROTECTION

Provide a power system study as specified in Section 26 05 73 POWER SYSTEM STUDIES.

2.7 ARC FLASH WARNING LABEL

Provide warning label for switchboards. Locate this self-adhesive warning label on the outside of the enclosure warning of potential electrical arc flash hazards and appropriate PPE required. Provide label format as indicated.

2.8 SERVICE ENTRANCE AVAILABLE FAULT CURRENT LABEL

Provide label on exterior of switchboards used as service equipment listing the maximum available fault current at that location. Include on the label the date that the fault calculation was performed and the contact information for the organization that completed the calculation.

Locate this self-adhesive warning label on the outside of the switchboard. Provide label format as indicated.

2.9 MIMIC BUS LABELING

Provide a mimic bus on the front of the equipment to diagrammatically show the internal bus structure of the lineup.

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 that grounds and 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 the ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors.

3.2.2 Equipment Grounding

Provide bare copper cable not smaller than No. 4/0 AWG not less than 24 inches below grade connecting to the indicated ground rods. When work in addition to that indicated or specified is directed 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 equipment furnished under this section as indicated on project drawings, the approved shop drawings, and as specified herein.

3.3.1 Switchboard

ANSI/NEMA PB 2.1.

3.3.2 Meters and Instrument Transformers

ANSI C12.1.

3.3.3 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.

3.3.4 Galvanizing Repair

Repair damage to galvanized coatings using ASTM A780/A780M, zinc rich paint, for galvanizing damaged by handling, transporting, cutting, welding, or bolting. Do not heat surfaces that repair paint has been applied to.

3.3.5 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 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES

3.4.1 Interior Location

Mount switchboard on concrete slab as follows:

a. Unless otherwise indicated, provide the slab with dimensions at least 4 inches thick.

b. Install slab such that the top of the concrete slab is approximately 4 inches above the finished grade.

c. Provide edges above grade 1/2 inch chamfer.

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

e. Provide conduit turnups and cable entrance space required by the equipment to be mounted.

f. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant.

g. Cut off and bush conduits 3 inches above slab surface.

h. Provide concrete work as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.5 FIELD QUALITY CONTROL

Submit Required Settings of breakers to the Contracting Officer after approval of switchboard and at least 30 days in advance of their requirement.

3.5.1 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.

3.5.1.1 Switchboard Assemblies

a. Visual and Mechanical Inspection:

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

(2) Inspect physical, electrical, and mechanical condition.

(3) Verify appropriate anchorage, required area clearances, and correct alignment.

(4) Clean switchboard and verify shipping bracing, loose parts, and documentation shipped inside cubicles have been removed.

(5) Inspect all doors, panels, and sections for paint, dents, scratches, fit, and missing hardware.

(6) Verify that circuit breaker sizes and types correspond to approved shop drawings as well as to the circuit breaker’s address for microprocessor-communication packages.

(7) Verify that current transformer ratios correspond to approved shop drawings.

(8) 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.

(9) Confirm correct operation and sequencing of electrical and mechanical interlock systems.

(10) Confirm correct application of manufacturer's recommended lubricants.

(11) Inspect insulators for evidence of physical damage or contaminated surfaces.

(12) Verify correct barrier installation and operation.

(13) Exercise all active components.

(14) Inspect all mechanical indicating devices for correct operation.

(15) Verify that filters are in place and vents are clear.

(16) Test operation, alignment, and penetration of instrument transformer withdrawal disconnects.

(17) Inspect control power transformers.

b. Electrical Tests:

(1) Perform insulation-resistance tests on each bus section.

(2) Perform dielectric withstand voltage tests.

(3) Perform insulation-resistance test on control wiring; do not perform this test on wiring connected to solid-state components.

(4) Perform control wiring performance test.

(5) Perform primary current injection tests on the entire current circuit in each section of assembly.

(6) Perform phasing check on double-ended switchboard to ensure correct bus phasing from each source.

3.5.1.2 Circuit Breakers

Low Voltage - Insulated-Case, Thermal Magnetic, and Low Voltage Molded Case with Solid State Trips

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

(6) Inspect mechanism contacts and arc chutes in unsealed units.

b. Electrical Tests:

(1) Perform contact-resistance tests.

(2) Perform insulation-resistance tests.

(3) Perform Breaker adjustments for final settings in accordance with Government provided settings.

(4) Perform long-time delay time-current characteristic tests

(5) Determine short-time pickup and delay by primary current injection.

(6) Determine ground-fault pickup and time delay by primary current injection.

(7) Determine instantaneous pickup current by primary injection.

(8) Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and anti-pump function.

3.5.1.3 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) 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 all 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 tests.

(3) Perform polarity tests.

(4) Perform ratio-verification tests.

3.5.1.4 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 watthour meters according to manufacturer's published data.

(3) Verify all instrument multipliers.

(4) Electrically confirm that current transformer and voltage transformer secondary circuits are intact.

3.5.1.5 Grounding System

a. Visual and Mechanical Inspection:

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

b. Electrical Tests:

(1) IEEE 81. 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.

3.5.1.6 Cybersecurity Installation Certification

Furnish a certification that control systems are installed in accordance with DoD Instruction 8500.01, DoD Instruction 8510.01, and as required by individual Service Implementation Policy.

3.5.2 Follow-Up Verification

Upon completion of acceptance checks, settings, and tests, show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. Trip circuit breakers by operation of each protective device. Test each item to perform its function not less than three times. As an exception to requirements stated elsewhere in the contract, provide the Contracting Officer five working days advance notice of the dates and times for checks, settings, and tests.

-- End of Section --

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SECTION 26 29 23

ADJUSTABLE SPEED DRIVE (ASD) SYSTEMS UNDER 600 VOLTS

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	(2014) Recommended Practices and Requirements 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	(2000; R 2015) 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 ICS 61800-2	(2005) Adjustable Speed Electrical Power Drive Systems Part 2: General Requirements - Rating Specifications for Low Voltage Adjustable Frequency A.C. Power Drive Systems
NEMA MG 1	(2021) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023) National Electrical Code

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

47 CFR 15	Radio Frequency Devices

UNDERWRITERS LABORATORIES (UL)

UL 489	(2016; Rev 2019) 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, IEEE C62.41.2, IEEE 519, and 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, AE

Interconnecting Diagrams; G, AE

Installation Drawings; G, AE

As-Built Drawings; G, AE

SD-03 Product Data

Adjustable Speed Drives; G

Wires and Cables

Equipment Schedule; G

SD-06 Test Reports

ASD Test

Performance Verification Tests

Endurance Test

SD-07 Certificates

Testing Agency's Field Supervisor NETA Certificate; G

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.

Provide one spare ASD of each model provided for HVAC equipment, fully programmed and ready for back-up operation when connected.

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 600 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 external dynamic braking resistor designed to meet NEMA ICS 61800-2 to be capable of decelerating six times the motor inertia with no more than 150 percent of rated current with the motor at its base speed. 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 have Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing, Class II ground-fault protection, with start and run delays to prevent nuisance trip on staring, analog communication module, NO isolated overload alarm contact, external overload, reset push button.

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 and for safety transfers motor between power converter output and bypass circuit using a field-selectable automatic and manual bypass mode. 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.

i. The ASD must be capable of automatic control by a remote 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, and 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 engaging a qualified testing agency's field supervisor currently certified by NETA to supervise on-site testing.

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 procedur.s

g. Troubleshooting and repair.

h. Maintenance and calibration.

i. System programming and configuration.

-- End of Section --

SECTION 26 36 23

AUTOMATIC TRANSFER SWITCHES AND BY-PASS/ISOLATION SWITCH

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

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	(2023) National Electrical Code
NFPA 110	(2022) Standard for Emergency and Standby Power Systems

UNDERWRITERS LABORATORIES (UL)

UL 508	(2018; Reprint Jul 2021) UL Standard for Safety Industrial Control Equipment
UL 1008	(2014) Transfer Switch Equipment
UL 1066	(2012; Reprint Mar 2017) UL Standard for

Safety Low-Voltage AC and DC Power Circuit Breakers Used in Enclosures

1.2 RELATED REQUIREMENTS

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, and Section 26 08 00 APPARATUS INSPECTION AND TESTING, applies to this section, with the 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-02 Shop Drawings

Automatic Transfer Switch Drawings; G, AE

SD-03 Product Data

Automatic Transfer Switches; G

By-Pass/Isolation Switch (BP/IS); G

Remote Annunciator and Control System Panel; 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

1.4 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".

1.4.1 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.

1.4.2 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.

1.5 QUALITY ASSURANCE

1.5.1 Proof of Listing

Submit proof of listing by UL 1008.

1.5.2 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.

1.5.3 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word "shall" or "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.

1.5.4 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.

1.5.4.1 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.

1.5.4.2 Material and Equipment Manufacturing Date

Products manufactured more than 1 years prior to date of delivery to site are not acceptable.

1.6 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.

1.7 ENVIRONMENTAL CONDITIONS

Provide an ATS that is suitable for prolonged performance under following service conditions:

a. Operating altitude: Sea level to 3,300 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.

1.8 SEISMIC REQUIREMENTS

Provide seismic details as indicated.

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: 480/277 volts ac.

b. Amperage: Amps ac as indicated. 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 18 cycle close and withstand ratings. Minimum UL listed close and withstand ratings at 480 VAC shall be as indicated.

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 200 percent the current rating of the phase contacts.

j. Configuration. Provide an ATS for use in emergency systems described in NFPA 70. Provide an ATS that is listed for emergency use.

k. ATS Configuration. Provide an open transition ATS. Phase contacts are to break and make, but the neutral is to make before break (overlap).

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.

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/Emergency 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/Emergency 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 1 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 0.5 seconds. Time delay occurs for both transfer directions. Manufacturer is to provide recommendations for establishing the length of the time delay.

2.1.10 Make Before Break Neutral

Provide the ATS with a make before break neutral. Phase contacts are to break before make. The neutrals are to make for 50 ms.

2.1.11 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 240 volts.

Provide contacts for used by the elevator controller. Provide two time delay contacts that open simultaneously at 10 seconds (adjustable 0 - 10 seconds) prior to transfer when transferring between two live sources. These contacts must close after a time delay upon transfer and be programmable for 0 to 9,999 seconds after transfer.

2.1.12 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 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.

2.1.13 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. Provide automatic shutters that closed to isolate the bus.

j. Provide a means to ensure the switch is transferred to the alternate or emergency 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 1, 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 top and 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.

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 REMOTE ANNUNCIATOR AND CONTROL SYSTEM PANEL

Provide a remote annunciator and control system that utilizes a touchscreen human machine interface (HMI) with the ability to remotely monitor and control multiple transfer switches from a single panel. Minimum screen size is 7 inches. Provide password protection and date/time stamped alarm history. The controller is to have internal battery backup. In the event of a communication link failure, the system is to automatically revert to stand-alone, self-contained operation. Automatic transfer switch sensing, controlling or operating function is not to depend on remote panel for proper operation. Provide a surface mounted cabinet. Communication is to be by a Modbus RS-485 connection. The annunciator controller is to be configured to monitor and control 2 transfer switches.

2.4.1 Monitor

Monitor the following:

a. Sources available.

b. Switch position.

c. Switch in test mode.

d. Overvoltage.

e. Failure of communication link.

f. Engine test or exercise.

2.4.2 Alarm Screen

Alarm for the following conditions:

a. Alternate source closed.

b. Undervoltage.

c. Lockout.

2.4.3 Control Functions

Provide a means to perform the following functions from the controller: An alarm silence button in addition to monitoring the following items:

a. Control of switch-test initiation.

b. Control of switch operation in either direction.

c. Control of time-delay bypass for transfer to normal source.

d. Control to perform an engine test.

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 3 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

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 emergency/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 --

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SECTION 26 51 00

INTERIOR LIGHTING

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	(2018) Standard Specification for Stainless Steel Wire
ASTM A641/A641M	(2019) Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire
ASTM A653/A653M	(2023) 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	(2019) Technical Memorandum: Projecting Long-Term Lumen, 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)

ANSI C78.54	(2019) Specification Sheet for Tubular Fluorescent Replacement and Retrofit LED Lamps
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	(2017) 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) Occupancy Motion Sensors Standard

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023) National Electrical Code
NFPA 101	(2024) Life Safety Code
NFPA 111	(2025) Standard on Stored Electrical Energy Emergency and Standby Power Systems

U.S. DEPARTMENT OF ENERGY (DOE)

Energy Star	(1992; R 2006) Energy Star Energy Efficiency Labeling System (FEMP)

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

47 CFR 15	Radio Frequency Devices

UNDERWRITERS LABORATORIES (UL)

UL 20	(2018; Reprint Jan 2021) 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 844	(2012; Reprint Jul 2020) UL Standard for Safety Luminaires for Use in Hazardous (Classified) Locations
UL 916	(2015; Reprint Oct 2021) UL Standard for Safety Energy Management Equipment
UL 917	(2006; Reprint Aug 2013) UL Standard for Safety Clock-Operated Switches
UL 924	(2016; Reprint May 2020) UL Standard for Safety Emergency Lighting and Power Equipment
UL 1472	(2015) UL Standard for Safety Solid-State Dimming Controls

UL 1598	(2021; Reprint Jun 2021) Luminaires
UL 1598C	(2014) Standard for Light-Emitting Diode (LED) Retrofit Luminaire Conversion Kits
UL 1993	(2017) Self-Ballasted Lamps and Lamp Adapters
UL 2043	(2023) Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces
UL 8750	(2015; Reprint Jul 2021) 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. Commissioning requirements for Army and Air Force projects 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, AE

Occupancy/Vacancy Sensor Coverage Layout; G, AE; S

Lighting Control System One-Line Diagram; G, AE

Sequence of Operation for Lighting Control System; G, AE

SD-03 Product Data

Luminaires; G

Light Sources; G

LED Drivers; G

Luminaire Warranty; G

Lighting Controls Warranty; G

Local Area Controller; G

Lighting Relay Panel; G

Lighting Control Panel; G

Gateway; G

Lighting Contactor; G

Switches; G

Digital Switch Timers; G

Wall Box Dimmers; G

Scene Wallstations; G

Occupancy/Vacancy Sensors; G

Photosensors; G

Time Clocks; G

Power Packs; G

Exit Signs; G

Emergency Drivers; G

Energy Star Label; G, S

Linear LED Lamps; G

SD-05 Design Data

Luminaire Design Data; G, AE

Photometric Plan; G, AE

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

End-User Training Plan

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, aiming diagram, 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 Photometric Plan

1.5.8.1 Computer-generated Photometric Plans

Computer-generated photometric plans for each space are required to verify proposed luminaires and locations meet the required performance criteria of the design using the applicable light loss factor (LLF).

Target illumination levels are provided for each Interior Application. Depending on the application and the recommendations provided by the IES, values are given as one of the following:

a. Minimum: No values anywhere on the calculation grid may be less than this value, within a 10 percent margin of error.

b. Minimum Average: An average, taken over the entire task area for the application, may not be less than this value, within a 10 percent margin of error.

c. Maximum: No values anywhere on the calculation grid may be greater than this value, within a 10 percent margin of error.

d. Maximum Average: An average, taken over the entire task area for the application, may not be greater than this value, within a 10 percent margin of error.

e. Uniformity: Unless otherwise noted, uniformity is calculated as a ratio of the average calculated illuminance over the minimum calculated illuminance of the calculation grid.

1.5.8.2 Schematic Photometric Plan Calculations

Schematic photometric plan calculations must include:

a. Horizontal illuminance measurements at workplane or other designated height above finished floor, taken at a maximum of every one foot across the task area.

b. Average maintained illuminance level.

c. Minimum and maximum maintained illuminance levels.

d. Lighting power density (Watts per square foot).

e. LLF. Recommended LLF is 0.81 for LED luminaires but LLF varies based on environment and application.

1.5.8.3 Final Photometric Plan Calculations

Final photometric plan calculations must include:

a. Horizontal illuminance measurements at workplane or other designated height above finished floor, taken at a maximum of every one foot across the task area.

b. Where applicable, vertical illuminance measurements at designated surface, taken at a maximum of every one foot across task area.

c. Minimum and maximum maintained illuminance levels.

d. Average maintained illuminance level.

e. Average to minimum and maximum to minimum ratios for horizontal illuminance.

f. Lighting power density (Watts per square foot).

g. LLF. Recommended LLF is 0.81 for LED luminaires but LLF varies based on environment and application.

1.5.9 Occupancy/Vacancy Sensor Coverage Layout

Provide floor plans showing coverage layouts of all devices using manufacturer's product information.

1.5.10 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.

1.5.11 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.

1.5.12 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.

1.5.12.1 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 6,000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.12.2 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.

Provide luminaire with Energy Star Label for downlights, linear accent lights, exterior wall scones, and steplight in accordance with Energy Star.

2.2.1 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	120 LPW
Recessed 2 by 2	123 LPW
Recessed 2 by 4	140 LPW
Recessed Downlight (fixed, adjustable, wallwash)	80 LPW
Linear, Accent (undercabinet, cove)	45 LPW
Linear, Ambient (indirect wall mount, linear pendent)	131 LPW
High Bay	175 LPW
Low Bay	143 LPW
Industrial	100 LPW
Exterior Wall Sconce	50 LPW
Steplight	30 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
Steplight	Above 4 feet AFF	B1-U1-G2
Steplight	Below or at 4 feet AFF	B4-U1-G4

2.2.1.1 Luminaire Conversion Kits

Provide luminaire conversion kits that meet UL 1598C Standard for Light-Emitting Diode (LED) Retrofit Luminaire Conversion Kits.

2.2.2 Luminaires for Hazardous Locations

In addition to requirements stated herein, provide LED luminaires for hazardous locations which conform to UL 844 or which have Factory Mutual certification for the class and division indicated.

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.

2.3.1.1 Linear LED Lamps

Provide linear LED Lamps that are compatible with existing instant-start or programmed-start ballasts, and meet the following additional requirements:

a. UL 1993 UL Type A linear LED lamp.

b. Power Factor greater than or equal to 0.90 at full input power and across specified dimming range.

c. Maximum Total Harmonic Distortion (THD) less than or equal to 20 percent at full input power and across specified dimming range.

d. Lumen per watt efficacy no less than 120.

e. Minimum beam angle of 270 degrees.

f. Lamp datasheet complies with ANSI C78.54. Manufacturer must provide list of all ballasts that are compatible for use with lamp.

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 1 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 1 relay rated 20 amps with one manual switch 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. Capable of 0-10V dimming.

g. AV interface via ethernet and CAT5.

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 Relay Panel

UL 924. Enclose panel hardware in a surface-mounted, NEMA 1, painted, steel enclosure with lockable access door and ventilation openings. Internal low-voltage compartment must be separated from line-voltage compartment of enclosure with only low-voltage compartment accessible upon opening of door. Provide additional remote cabinets that communicate back to main control panel as required. Provide Lighting Control Panels that meet the following criteria:

a. Input voltage of 120-277 at 50/60 Hz, with internal low voltage power

supply as required.

b. 32 single-pole latching relays rated at 20 amps, 120-277 volts. Provide provision for relays to close upon power failure. Provide relays designed for 10 years of use at full rated load.

c. Relay control module operates at 24 VDC and is rated to control a minimum of 32 relays.

d. Capable of 0-10V dimming.

2.5.1.2.2 Lighting Control Panel

UL 916, 47 CFR 15. Provide an electronic, programmable lighting control panel complete with microprocessor, capable of providing lighting control with input from internal programming, digital switches, time clocks, and other control devices.

Enclose panel hardware in a surface-mounted, NEMA 1, painted, steel enclosure with lockable access door and ventilation openings. Internal low-voltage compartment must be separated from line-voltage compartment of enclosure with only low-voltage compartment accessible upon opening of door. Provide additional remote cabinets that communicate back to main control panel as required. Provide Lighting Control Panels that meet the following criteria:

a. Input voltage of 120-277 at 50/60 Hz, with internal low-voltage VDC power supply as required.

b. Solid-state, microprocessor-based, internal astronomical time clock. Microprocessor must have nonvolatile memory and must reset automatically after power interruptions of up to 90 days.

c. Interface for providing local programming and control capability, with physical key-locked cover or programmed security access code to prevent unauthorized use.

d. Dimming modules capable of 0-10V dimming.

e. Modules and control panels include multichannel output with 8 channels, with multiple inputs for manual control, photosensors, and occupancy/vacancy sensors.

f. Outputs that require line-voltage switching are provided by relays which are designed for 10 years of use at full rated load.

g. Control processor indicates failure of normal power and which circuits are supplied by alternative power source if connected to emergency lighting units.

h. Provide building automation system write access points to lighting control system for manual override.

2.5.1.2.3 Gateway

Provide hardware and software to enable the BAS to monitor, control, display, and record data for use in processing reports. Provide BACnet communication interface that enables remote control and monitoring of lighting from a workstation according to read access points and write

access points listed in this section. Control features and monitoring points displayed locally at lighting panel must be available through the Gateway. Provide Gateway that meets the following requirements:

a. Microprocessor-based communications device that perform bi-directional protocol translation.

b. Support full bi-directional communication and translation.

c. Contain its own microprocessor, RAM, battery, communication ports, and power supply.

d. Support an additional 5 percent points for future expansion.

2.5.1.2.4 Lighting Contactor

NEMA ICS 2, NEMA ICS 6. Provide an electrically-held lighting contactor housed in a NEMA 1 enclosure. Provide contactor with one normally-open(NO), single pole contacts, rated 600 volts, 30 amps. Provide coil operating voltage of 277 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 Digital Switch Timers

Provide line-voltage toggle switches that allow manual control to ON and automatically switches lighting load to OFF. Device operates with the use of paddle, button, or toggle, and operates at 120-277 volts. Device allows for programming of auto off timer from 2 minutes to 12 hours.

2.5.2.3 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.

2.5.2.4 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.

2.5.2.5 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 manufacturer shop drawings. 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 ceiling or wall-mounted occupancy/vacancy sensors that meet the following requirements:

a. Operating voltage of 120-277 volts.

b. Time delay of 30 seconds to 30 minutes with at least four intermediate time delay settings.

c. Sensors are ceiling mounted.

d. No minimum load requirement and be capable of switching from zero to 800 W at 120 VAC, 50/60 Hz and from zero to 1200 W at 277 VAC, 50/60 Hz.

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.

2.5.2.5.1 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.

2.5.2.5.2 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.

2.5.2.5.3 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.

2.5.2.5.4 High Bay Sensors

Provide occupancy/vacancy sensors specifically designed for high-bay mounting applications for all ceiling-mounted sensors mounted above 35 feet using PIR technology. Provide high-bay sensors with interchangeable lenses for 360 degree open area coverage or narrow rectangular warehouse aisle coverage.

2.5.2.5.5 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.

2.5.2.6 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 wall-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.

2.5.2.7 Time Clocks

UL 917, NEMA ICS 6. House time clock in a surface-mounted, lockable, NEMA 1 enclosure constructed of painted steel or plastic polymer. Provide electronic type time clock that meets the following criteria:

a. 24 hour programming function, providing a total of 56 on/off set points.

b. 24 hour type digital clock display format.

c. Power outage back-up for time clock utilizing alkaline batteries which provides coverage for a minimum of seven days.

d. Capable of controlling a minimum of 1 channels or loads.

e. Contacts are rated for 30 amps at 120-277 VAC resistive load in a SPST normally open (NO) configuration.

f. Contains manual bypass or remote override control.

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 constructed of UV-stable, thermo-plastic.

b. UL listed for damp location.

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. In lieu of battery, can use a nonradioactive photoluminescent plate.

2.6.1.2 Remote-Powered Exit Signs

Provide exit sign that contains provision for 120-277 VAC input from remote source.

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.

2.6.4 Central Emergency Lighting System

UL 924, NFPA 101, NFPA 111 level 1, NFPA 70. Provide a central power system providing emergency power at 277 volts, 60 hertz, for a minimum period of 90 minutes. Design the system to handle surges during loss and recovery of the voltage, and to deliver its full rated output to the designated lamp load. Provide batteries for power.

2.6.4.1 Operation

Provide system such that when the lighting system loses normal supply voltage, it automatically disengages itself from the normal input line, and switches to a self-contained inverter with built-in protection when the output is shorted or overloaded. Ensure that, when normal line voltage resumes, the emergency system automatically switches back to normal operation. Size the transfer switch for this function to handle 125 percent of full load. Provide the battery system with self-contained inverters with overload protection.

2.6.4.2 Charger

Provide a completely automatic battery charger that maintains the batteries in a fully charged condition and recharges the batteries to full capacity within 24 hours after full discharge in accordance with UL 924.

2.6.4.3 Batteries

Provide sealed lead-acid batteries, maintenance-free for a period of not less than 10 years under normal operating conditions.

2.6.4.4 Accessories

Provide visual indicators to indicate normal power, inverter power, and battery-charger operation. Provide a low-voltage test switch to simulate power failure by interrupting the input line, voltage meter, electrolyte level detector to automatically disable the charging circuit in the event of a fault, and low-voltage cutoff to prevent extreme battery power dissipation. Provide annunciation compliant with NFPA 111.

2.6.4.5 Enclosure

Provide a free-standing cabinet with floor stand and constructed of 2.7 millimeter 12-gauge sheet steel with baked-on enamel finish and a locking latch.

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. 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.

3.1.3 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.

Connect exit signs on separate circuits and serve from an emergency panel. Provide only one source of control, which would be the circuit breaker in the emergency panel. Paint source of control red and provide lockout capability.

3.1.5 Lighting Controls

3.1.5.1 Scene Wallstations

Submit labeling templates for all scene wallstations, ganged faceplates and other manual control cover plates. Label each scene control button with approved scene description.

3.1.5.2 Occupancy/Vacancy Sensors

a. Provide quantity of sensor units indicated as a minimum. Provide additional units to give full coverage over controlled area. Full coverage must provide hand and arm motion detection for office and administration type areas and walking motion for industrial areas, warehouses, storage rooms and hallways.

b. Locate ceiling-mounted sensors no closer than 6 feet from the nearest HVAC supply or return diffuser.

c. Locate the sensor(s) as indicated and in accordance with the manufacturer's recommendations.

3.1.5.3 Photosensors

Locate and aim sensor as indicated and in accordance with the manufacturer's recommendations. Adjust sensor set-point in accordance with the manufacturer's recommendations and for the indicated light level of the area of coverage, measured at the work plane.

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 --

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SECTION 27 10 00

BUILDING TELECOMMUNICATIONS CABLING SYSTEM

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	(2023) 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-568.0	(2020e) Generic Telecommunications Cabling for Customer Premises
TIA-568.1	(2020e) Commercial Building Telecommunications Infrastructure Standard
TIA-568.2	(2018d) Balanced Twisted-Pair Telecommunications Cabling and Components Standards
TIA-568.3	(2022e) Optical Fiber Cabling Components Standard
TIA-569	(2019e) Telecommunications Pathways and Spaces
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

U.S. FEDERAL COMMUNICATIONS COMMISSION (FCC)

FCC Part 68	Connection of Terminal Equipment to the Telephone Network (47 CFR 68)

UNDERWRITERS LABORATORIES (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 Office Furnishing Systems
UL 1363	(1996) Relocatable Power Taps
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 applies 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, 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 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. Provide telecommunications pathway systems referenced herein as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

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, AE

Telecommunications Space Drawings; G, AE

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

Ceiling Services Panel; G

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

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 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, BD'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 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 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 except as indicated below. Provide system furniture pathways in accordance with UL 1286.

2.2.1 Cable Runway

Cable runway shall be constructed of rectangular steel tubing with cross members welded at 12-inch intervals, black in color. When supported at a maximum of 8 feet between supports runway can support 232 lb/ft with minimal deflection. Runway shall be UL Classified for suitability as an equipment grounding conductor. Runway shall be provided for vertical and horizontal cable support within Telecommunications Rooms (TR). Coordinate required runway accessories such as grounding clamps, cable dropouts, radius bends, wall supports, etc., as required for proper installation and cable support.

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 unshielded twisted pair (UTP) 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 Copper

Copper backbone cable shall be solid conductor, 24 AWG, 100 ohm, 100 -pair, Category 3, UTP, in accordance with ICEA S-90-661, TIA-568.1, TIA-568.2 and UL 444, formed into 25 pair binder groups covered with a gray thermoplastic jacket. Cable shall be imprinted with manufacturers name or identifier, flammability rating, gauge of conductor, transmission performance rating (category designation) at regular length marking intervals in accordance with ICEA S-90-661 . Provide plenum (CMP), riser (CMR), or general purpose (CM or CMG)communications rated cabling in accordance with NFPA 70. Substitution of a higher rated cable shall be permitted in accordance with NFPA 70.

2.3.1.2 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 (OS2), tight buffered fiber optic cable.

Provide plenum (OFNP) riser (OFNR), or general purpose (OFN or OFNG) rated non-conductive, fiber optic cable in accordance with NFPA 70. The cable cordage jacket, fiber, unit, and group color shall be in accordance with TIA/EIA-598. Cables installed in conduit within and under slabs shall be UL listed and labeled for wet locations in accordance with NFPA.

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, UTP, 100 ohm in accordance with TIA-568.2, UL 444, ANSI/NEMA WC 66, and ICEA S-90-661. Provide four each individually twisted pair, minimum size 24 AWG conductors, Category 6A, with a blue thermoplastic jacket. For wireless access points, provide Category 6A cabling with the same cabling requirements listed previously. Jacket color as indicated on plans. 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), riser (CMR), or general purpose (CM or CMG) 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.

2.4 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 as indicated. 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. Racks, floor mounted modular type, 16 gauge steel construction, minimum, treated to resist corrosion. Provide rack with vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug and a surge protected power strip with 6 duplex 20 amp receptacles. Rack shall be compatible with 19 inches panel mounting.

2.4.2.1 Equipment Rack Accessories

a. Grounding Kit: Provide a telecommunications rack grounding kit that includes the following for each telecommunications rack provided in the Project:

(1) Paint piercing grounding washer, provides a bond between frame members, serrations eliminate the need for scraping paint.

(2) Electrostatic discharge port kit, bonding lug with 45-degree bend to hold ESD wrist strap, two required per row, front and back.

(3) Grounding strip kit, thread-forming screws provide a bond between grounding strip and frames.

(4) Equipment jumper kit, bonds network equipment to the cabinet grounding strip or busbar.

(5) Common bonding network jumper kit, connects cabinet grounding strip or grounding busbar to main grounding busbar. Provide with Telecommunications grounding and bonding conductor label kit.

(6) Electrostatic Discharge (ESD) wrist strap: Provide one (1) ESD wrist strap with 6-foot telescoping cable per telecommunications room (TR) and (5) per Equipment Room.

b. Vertical Cable Management:

(1) Composite plastic, UL 94V-0 flame retardant with integral cable routing fingers at 1-RU intervals, black in color, 6 inches wide, 7 feet high, or size as indicated, double-sided (front/back) with covers on both sides, with integral wire retaining fingers.

c. Horizontal Cable Management:

(1) Composite plastic, UL 94V-0 flame retardant with integral cable

routing fingers top and bottom, black in color, 2-RU in height, 19 inches wide, 3 inches deep front, 4 inches deep rear with covers front and back. Provide where indicated.

d. Power Strips (Cabinet PDUs):

(1) Comply with UL 1363.

(2) Rack mounting, horizontal, 19 inches wide, with integral amperage meter display.

(3) Output receptacles shall have distinct colors by phase.

(4) LED indicator lights for power and surge protection status.

(5) Circuit Breaker circuit protection.

2.4.3 Connector Blocks

Provide insulation displacement connector (IDC) Type 110 for Category 6 and 6A 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 racks and telecommunications backboards. Cable guides of ring or bracket type devices mounted on rack for horizontal cable management and individually mounted for vertical cable management. Mount cable guides with screws, and/or nuts and 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 copper patch cords for patch panels. Provide patch cords, as complete assemblies, with matching connectors as specified. 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 TIA Category 6 and 6A requirements. Panel shall be constructed of 0.09 inches minimum aluminum and shall be rack mounted and compatible with an ECIA EIA/ECA 310-E 19 inches equipment rack. Panel shall provide 48 non-keyed, 8-pin modular ports, wired to T568B. 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 rack mounted and compatible with a ECIA EIA/ECA 310-E 19 inches equipment

rack. Each panel shall be provided adapters as duplex SC in accordance with TIA/EIA-604-3 with zirconia ceramic alignment sleeves. Total quantity of required duplex ports and associated panel rack unit height as indicated on drawings. 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.

2.5 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. UTP 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 and shall comply with TIA-568.2 Category 6 and 6A requirements. 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 T568B. UTP outlet/connectors shall comply with TIA-568.2 for 200 mating cycles. UTP outlet/connectors installed in outdoor or marine environments shall be jell-filled type containing an anti-corrosive, memory retaining compound.

2.5.2 Optical Fiber Adapters(Couplers)

Provide optical fiber adapters suitable for duplex SC in Accordance with TIA/EIA-604-3 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 SC in accordance with TIA/EIA-604-3 with zirconia ceramic alignment sleeves, compatible with 8/125 single-mode fiber. The connectors shall provide a maximum attenuation of 0.3 dB at 1300 and 1550 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, TIA-568.1, and TIA-568.2; flush design constructed of to 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.

2.6 CEILING SERVICES PANEL

Construct with minimum 18 gauge steel and nominal size of 24 by 24 inch. Provide with white powdered coat finishes. Design and equip with suitable framing and fastenings for removal and replacement without damage. Panel shall be recessed and flushed with adjacent ceiling tiles. Provide knock-outs as indicated.

2.7 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.

2.8 FIRESTOPPING MATERIAL

Provide as specified in Section 07 84 00 FIRESTOPPING.

2.9 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.

2.10 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.

2.11 FIELD-FABRICATED CABLE IDENTIFICATION

Provide heat-shrink preprinted tubes of flame-retardant polyolefin with machine-printed identification label. Install labels at each end of backbone and horizontal cabling (within 6 inches of termination) and where indicated in TIA-606. Label background field colors shall match cable jacket colors; all label text shall be black in color.

2.12 TESTS, INSPECTIONS, AND VERIFICATIONS

2.12.1 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, and TIA-526-7 for single mode 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 UTP and optical fiber telecommunications cabling system as detailed in TIA-568.1, TIA-568.2, and TIA-568.3. 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 UTP 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 in cable trays. 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 a minimum of 8 inches above ceilings by cable supports no greater than 60 inches apart. 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. Plenum cables shall comply with flammability plenum requirements of NFPA 70.

3.1.1.2 Backbone Cable

a. Copper Backbone Cable. Install intrabuilding backbone copper cable, in indicated pathways, between the campus distributor, located in the telecommunications entrance facility or room, the building distributors and the floor distributors located in telecommunications rooms and telecommunications equipment rooms as indicated on drawings.

b. 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 and 6A UTP 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 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.

3.1.3.1 Cable Tray Installation Drawings

No later than 30 calendar days before shipment, submit installation drawings to the Contracting Officer for approval. Coordinate drawings with those being used for all other work in the immediate area to ensure that this other work does not conflict with the installation. Include the layout of the cable tray work and details on both horizontal and vertical supports as specified in the paragraph Cable Tray Supports.

3.1.4 Work Area Outlets

3.1.4.1 Terminations

Terminate UTP 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.

3.1.4.2 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.

3.1.4.3 Cables

Unshielded 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.

3.1.4.4 Pull Cords

Pull cords shall be installed in conduit serving telecommunications outlets that do not have cable installed.

3.1.5 Telecommunications Space Termination

Install termination hardware required for Category 6, 6A, and optical fiber system. An insulation displacement tool shall be used for terminating copper cable to insulation displacement connectors.

3.1.5.1 Patch Panels

Patch panels shall be mounted in equipment racks 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 with hook and loop ties 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.

3.1.5.2 Equipment Support Frames

Install in accordance with TIA-569:

a. Racks, floor mounted modular type. Permanently anchor rack to the floor in accordance with manufacturer's recommendations.

3.1.6 Electrical Penetrations

Seal openings around electrical penetrations through fire resistance-rated wall, partitions, floors, or ceilings as specified in Section 07 84 00 FIRESTOPPING.

3.1.7 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.

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, and 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 UTP 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, and TIA-568.3. Visually confirm Category 6 and 6A, marking of outlets, cover plates, outlet/connectors, and patch panels.

3.5.1.2 Verification Tests

UTP backbone copper cabling shall be tested for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors, and between conductors and shield, if cable has overall shield. Test operation of shorting bars in connection blocks. Test cables after termination but prior to being cross-connected.

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 and MUTOA as follows:

a. Perform Category 6 and 6A 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 UTP 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 --

SECTION 27 41 00

AUDIO-VISUAL SYSTEMS

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.

AUDIOVISUAL AND INTEGRATED EXPERIENCE ASSOCIATION (AVIXA)

ANSI/AVIXA D401.01	(2023) Standard Guide for Audiovisual Design and Coordination Processes
ANSI/INFOCOMM 10	(2013) Audiovisual Systems Performance Verification
ANSI/INFOCOMM A102.01	(2017) Audio Coverage Uniformity in Listener Areas
AVIXA F502.01	(2018) Rack Building for Audiovisual Systems
AVIXA F502.02	(2020) Rack Design for Audiovisual Systems
INFOCOMM F501.01	(2015) Cable Labeling for Audiovisual Systems

BICSI International Standards Program (BICSI)

ANSI/BICSI 001	(2017) Information and Communication Technology Systems Design and Implementation Best Practices for Educational Institutions and Facilities
ANSI/BICSI N1	(2019) Installation Practices for Telecommunications and ICT Cabling and Related Cabling Infrastructure
ANSI/BICSI N3	(2020) Planning and Installation Methods for the Bonding and Grounding of Telecommunication and ICT Systems and Infrastructure

ELECTRONIC COMPONENTS INDUSTRY ASSOCIATION (ECIA)

ECIA EIA/ECA 310-E	(2005) Cabinets, Racks, Panels, and Associated Equipment

EXTRON ELECTRONICS (EE)

EE GUI Design Guide	(2020; 4th Edition) Graphical User Interface Design Guide

MIDDLE ATLANTIC PRODUCTS (MA)

MA Whitepaper (2018) Controlling the Temperature Inside Equipment Enclosures

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2023) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-568.0 (2020e) Generic Telecommunications Cabling for Customer Premises

TIA-568.1 (2020e) Commercial Building Telecommunications Infrastructure Standard

TIA-568.2 (2018d) Balanced Twisted-Pair Telecommunications Cabling and Components Standards

TIA-568.3 (2022e) Optical Fiber Cabling Components Standard

TIA-568.4 (2022e) Broadband Coaxial Cabling and Components Standard

TIA-569 (2019e) Telecommunications Pathways and Spaces

TIA-606 (2021d) Administration Standard for Telecommunications Infrastructure

TIA-607 (2019d) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises

U.S. Code (USC)

19 USC 13 Trade Agreements Act of 1979

41 USC 83 Buy American Act

U.S. DEPARTMENT OF DEFENSE (DOD)

DODI 8100.04 (2010) DOD Unified Capabilities (UC)

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

36 CFR 1191 Americans with Disabilities Act (ADA) Accessibility Guidelines for Buildings and Facilities; Architectural Barriers Act (ABA) Accessibility Guidelines

UNDERWRITERS LABORATORIES (UL)

UL 2043 (2023) Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in

Air-Handling Spaces

UL 62368-1	(2019) UL Standard for Audio/Video, Information, and Communication Technology Equipment - Part 1: Safety Requirements

1.2 RELATED DOCUMENTS

a. Drawings and general provisions of the Contract including General and Supplementary Conditions and UFGS Division 01 Specification Sections.

b. UFGS Division 26 Specification for Communications cabling, cabling pathways, termination and physical mounting of cable hangers and cable trays.

c. UFGS Division 26 Specification Sections for room lighting fixtures, dimmers, power receptacle outlets, and interconnecting wiring for these circuits.

d. UFGS Division 27 Specification Sections for all telecommunications requirements - including LAN connections, analog and digital telephone lines, digital data circuits, high speed internet access and building horizontal cabling.

e. UFGS Division 25 Specification Sections for CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS.

f. UFGS Division 23 Specification Sections for Heating, Ventilation and Air Conditioning.

g. Audiovisual drawings and equipment lists.

h. If system design services are required, provide designs in accordance with ANSI/AVIXA D401.01 and ANSI/BICSI 001.

1.3 SCOPE OF WORK

This Specification Section outlines the minimum requirements and installation methods for the integrated audiovisual System, hardware, software, cables, accessories, and acceptance testing. System refers to the complete and functional assemblage of equipment required to achieve the specified functionality, performance, and design intent. The work must be in accordance with this specification and in conformity with the designs, layouts, and descriptions shown on the drawings. This includes but is not limited to:

a. Audio equipment: Speakers, mixers, amplifiers, microphones, signal processing equipment, and source equipment.

b. Video equipment: Displays, signal routing and processing equipment, and source equipment.

c. Video projection screens.

d. Remote control equipment including touch panels, control processors, software, and programming.

e. Equipment racks and associated hardware such as rack screws, power distribution products, cooling products, and blank panels.

f. Cables, snakes, connectors, plates, and wiring.

g. Other similar parts that may be required for normal operation such as projector bulbs and lenses.

h. Mounts, rigging, and required hardware such as all-thread, unistrut, chains, and cables.

i. AV lecterns and credenzas.

j. System commissioning.

k. Training.

l. Documentation.

m. Communication and coordination with all team members and trades to fulfill the requirements of this Specification.

n. It is the intention of these specifications to provide complete and properly operating audio-visual systems. The major items of equipment must be provided in the quantity indicated by the audio-visual system diagrams on the drawings or in the quantity as specified herein. However, any minor item of equipment or hardware that may not be specifically shown on the drawings or specified herein but required for proper audio-visual system operation or installation must be provided by the Contractor.

1.4 EXCLUDED SCOPE OF WORK

a. Cutting and patching.

b. Painting, refinishing and finishes.

c. Wire raceway, junction boxes, and conduit.

d. AC Power circuits.

e. Floor boxes.

f. AV lecterns and credenzas.

g. Work specified in other UFGS Specification Sections.

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 information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Qualifications; G

Bid Pricing; G

SD-02 Shop Drawings

Floor Plans; G, AE

System Wiring Diagrams; G, AE

Rack Elevations; G, AE

Plate and Panel Drawings; G, AE

Riser Diagrams; G, AE

Control System Graphical User Interfaces; G, AE

Patch Panel and Network Switch Layouts; G, AE

Equipment List; G, AE

Field Condition Changes; G, AE

Shop Drawings; G, AE

SD-06 Test Reports

System Testing and Adjustment; G

SD-09 Manufacturer's Field Reports

Status Reports and Meeting Minutes

SD-10 Operation and Maintenance Data

Record Drawings; G

Operation and Maintenance (O&M) Manuals, G

1.6 CYBERSECURITY

Coordinate any network security requirements related to this Specification in accordance with UFGS Division 25 Specification Sections for CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS.

1.7 QUALIFICATIONS

1.7.1 General

a. Comply with all UFGS Division 1 (General Requirements) standards to include Section 01 14 00 WORK RESTRICTIONS.

b. The Government reserves the right to accept or reject the System Contractor or Manufacturer based upon qualifications and ability to conform to specified technical or licensing requirements of this Section. System Contractors, Installers and Manufacturers that do not have the specified qualifications will not be acceptable and will not be allowed to perform the work of this Section.

c. The Government will determine the acceptability of any proposed System Contractor, Installer and Manufacturer based on submitted and verified

documentation that substantiates that the proposed System Contractor, Installer and Manufacturer have the qualifications specified in this Section.

d. Submit documented verification of the specified qualifications as part of the Data Qualifications submittal. The Government maintains the right to request, inspect and verify references and resumes of all technical and managerial personnel assigned to the project.

1.7.2 System Contractor Qualifications

The System Contractor must:

a. Be licensed in the project jurisdiction as required to perform the work included in this Specification.

b. Be regularly engaged in the system application design, documentation, installation, testing, training, and maintenance of the type of system specified in this Section.

c. Have a minimum of five years of experience providing these services for systems having the same level of features and functions as the system being provided.

d. Submit three references with contact names and valid telephone numbers regarding similar projects successfully completed within the last five years.

e. Be capable of providing manufacturer-specified installation, programming, training, maintenance, and repair for all equipment provided.

f. Be able to respond to on-site maintenance service requests within 24 hours during the warranty period described in System Warranty and Maintenance section of these specifications.

g. Be a suitably staffed and equipped service organization and must regularly offer maintenance services for systems of this type and size.

h. Be responsible for any required low voltage permits.

i. Use a Project Manager with a CTS-I certification.

j. Use a Lead Installer with a CTS-I certification.

k. Use a Control System and Digital Signal Processor (DSP) Programmer certified by the manufacturer(s) of the product(s) used in the project.

l. Submit names and resumes of key personnel that will be assigned to the project. As a minimum, these personnel must include the Project Salesman, Project Manager, Lead Installer, Control System Programmer, and Digital Signal Processor Programmer. The same person may be utilized for multiple project responsibilities. Once approved, these personnel are expected to work on the project through the duration. Any replacement personnel must be approved by the Contracting Officer. The approved Lead Installer, Control System Programmer, and Digital Signal Processor Programmer must be present during system commissioning.

1.7.3 Manufacturer Qualifications

Each product manufacturer must:

a. Have a minimum of five years' experience in producing the products and type of system included in this Specification Section.

b. Guarantee the availability of the replacement parts for the designed system for a minimum of three years from the date of final acceptance of the system by the Contracting Officer.

1.8 BID PRICING

Submit the following in conjunction with the System Contractor Qualifications information:

a. Complete and accurate listing of all equipment to be used in assembling the system(s).

b. Itemized pricing for all equipment. Include sales tax where applicable.

c. Itemized costs for all pertinent labor/installation categories.

d. Itemized costs for any optional items such as Add/Deduct Alternates and Extended Warranties.

1.9 SHOP DRAWINGS

Submit the following prior to the purchase, assembly, or installation of any equipment:

a. Drawing Index and Title Page.

b. Symbols Legend showing all devices, cable types, labeling scheme and any other information required to decipher symbols in the submittal package.

c. Floor Plans, Reflected Ceiling Plans, and Sectional View drawings as required to completely document all devices, dimensional locations, and infrastructure requirements.

d. System wiring diagrams showing make and model of equipment, logical wire traces, cable types, and any other identifying labels for wiring or ancillary devices.

e. Rack Elevations showing rack identifiers, equipment location within each rack, per-outlet AC power distribution details, AC power sequencing, and any rack accessories.

f. Plate and Panel drawings showing connections, size, finish, color, engraving, and any other information required to document fit and finish of wall plates or floor boxes.

g. Riser diagrams showing cable routing between wall plates, floor boxes, ceiling devices, racks, and any other devices as required.

h. Mounting details for loudspeakers, flat panel displays, video projectors, projection screen, and any other devices mounted from the

building structure.

i. Control system graphical user interfaces.

j. Additional drawings as required -including but not limited to custom furniture and millwork, custom display details and equipment mounting.

k. Patch Panel and Network Switch Layouts that show port numbering schemes and IP information as required.

l. A equipment list for all equipment and cabling to be used on the project, including quantities and product data sheets, organized logically by system type and indexed for reference. Any parts used but not approved may be rejected at any time.

m. Material samples as required.

n. Field condition changes that affect the system design and/or location of equipment.

o. Project schedule including key milestones including but not limited to submittal packages, material procurement, rack fabrication and shop testing, installation milestones as applicable, acceptance testing, and completion.

p. Images of proposed touch panel layouts, with functional descriptions of buttons and pages. The Contractor will make up to two iterative edits based on comments from the Contracting Officer at no additional cost.

1.10 STATUS REPORTS AND MEETING MINUTES

a. Provide weekly status reports outlining progress on the project to the Contracting Officer. These reports must include information on the work completed during the week, the work to be completed during the upcoming week and any potential scheduling issues.

b. Provide minutes for any meetings directly related to this project. Minutes are to be completed within one week of the meeting.

1.11 DELIVERY, STORAGE, AND HANDLING

a. All costs for shipping to the site, and of any unusual storage requirements, are to be a part of this Specification.

b. Make appropriate arrangements, and coordinate with authorized personnel at the site, for the proper acceptance, handling, protection, and storage of equipment so delivered.

c. Until site conditions are ready for installation of the AV equipment, some AV equipment must be received and stored offsite in suitable environmental conditions for sensitive electronic equipment. This equipment must be made available to the Government for inspection as required.

PART 2 PRODUCTS

2.1 GENERAL

a. All materials must be new, free from defects and not less than the quality specified. Materials must be designed to ensure satisfactory operation and operational life in the environmental conditions which will prevail where they are being installed.

b. At the time of submittal, supply the latest model for each piece of equipment.

c. All products used must be manufactured no more than one year prior to installation.

d. All products must be provided with the latest version of all software/firmware.

e. Where the specifications list several manufacturers for a particular major item of equipment such as power amplifiers or loudspeakers, the Contractor must supply all of that item of equipment from one manufacturer.

f. All equipment must be UL 62368-1 or equivalent listed or industry standard and comply with the NEC NFPA 70.

g. Equipment installed in air handling spaces must be UL 2043 listed.

h. Where indicated as relevant to this project, all equipment must be 19 USC 13 compliant, 41 USC 83 compliant, and approved prior to purchase.

i. Where indicated as relevant to this project, all equipment must be DISA compliant and on the DODI 8100.04 DoDIN Approved Products List.

j. No Substitutions or Variances are allowed without the written consent of the Contracting Officer or their approved representative.

k. Substitute equipment must meet or exceed the performance specifications of the basis of design equipment and be at no additional cost.

l. Substitute equipment must not impact the existing architectural, mechanical or electrical designs.

m. Submit equipment pricing based on the specified equipment herein. Any substitute equipment or new proposed equipment necessary to fulfill the design intent, must be clearly categorized and priced individually on a separate page as an alternate to the specified equipment. Pricing for the original specified equipment must still be provided.

2.2 SUBSTITUTIONS

a. No Substitutions or Variances are allowed without the written consent of the Contracting Officer or their approved representative.

b. Substitute equipment must meet or exceed the performance specifications of the basis of design equipment and be at no additional cost.

c. Substitute equipment must not impact the existing architectural, mechanical or electrical designs.

d. Substitute equipment must be specifically noted in submittals as "substitution" with a footnote stating the reason for the substitution.

e. The Contractor must furnish all descriptive material to the Contracting Officer or their approved representative necessary to demonstrate the acceptability of such product. This process may include evaluation and testing of the proposed substitute product at the discretion of the Contracting Officer or their approved representative.

f. Submit equipment pricing based on the specified equipment herein. Any substitute equipment or new proposed equipment necessary to fulfill the design intent, must be clearly categorized and priced individually on a separate page as an alternate to the specified equipment. Pricing for the original specified equipment must still be provided.

2.3 SYSTEM DESCRIPTION

2.3.1 Commander’s Conference Room 104

a. Three (3) 75 inch diagonal UHD resolution flat panel displays, one wall-mounted at the front of the room and one mounted on each side wall of the room.

b. USB connections between the conference table and credenza for a keyboard and mouse (GFGI) connection to computer (GFGI).

c. HDMI inputs and audio/video USB connections at the credenza (1) and conference table (2) for connection to output of the computer (GFGI).

d. Medium AV credenza installed in room to house AV equipment and with rack shelves for computer(s) (GFGI).

e. PTZ video camera below display at the front of the room.

f. Two (2) array microphones flush mounted in ceiling.

g. Flush mounted ceiling loudspeakers for audio playback.

h. Integrated control system for display power on/off and volume control.

i. Control touchpanel at the conference table.

2.3.2 Conference Room 147

a. One (1) 75 inch diagonal UHD resolution flat panel display, wall-mounted at the front of the room.

b. USB connection between the conference table and credenza for a keyboard and mouse (GFGI) connection to computer (GFGI).

c. HDMI inputs and audio/video USB connections at the credenza (1) and conference table (1) for connection to computers (GFGI).

d. Medium AV credenza installed in room to house AV equipment and with

rack shelves for one (1) computer (GFGI).

e. One (1) USB video camera installed above the display.

f. One (1) array microphone flush mounted in ceiling.

g. Flush mounted ceiling loudspeakers for audio playback.

h. Integrated control system for display power on/off and volume control.

i. Control touchpanel at the conference table.

2.3.3 Commander’s Large Conference Room 201

a. Four (4) 98 inch diagonal UHD resolution flat panel displays, two (2) wall-mounted at the front of the room and one mounted on each side wall of the room.

b. USB connection between the conference table and equipment rack for a keyboard and mouse (GFGI) connection to Secure KVM Switch (GFGI).

c. Floorstanding equipment rack installed in adjacent Support/AV room to house AV equipment and with rack shelves for one (1) computer (GFGI).

d. HDMI inputs and audio/video USB connections at the equipment rack (2) and conference table (6) for connection to computer(GFGI).

e. Three (3) PTZ video cameras installed around the room.

f. Four (4) array microphones flush mounted in ceiling.

g. Flush mounted ceiling loudspeakers for audio playback.

h. Integrated control system for display power on/off and loudspeaker volume control.

i. Control touchpanel at the conference table.

2.4 AUDIO EQUIPMENT

2.4.1 Microphones

Ceiling Array Microphone; beamforming digital array, with network connection and digital audio output, with mounting accessories for flush mounting in 2’x2’ ceiling grid or hung from exposed ceiling as noted on the drawings, with power supply as required.

2.4.2 Audio Mixers and Processors

a. Digital Audio Processor (DAP); multiple balanced switchable mic/line level inputs and outputs as shown on the drawings, with acoustic-echo canceling (AEC) on at least 4 channels per Ceiling Array Microphone, with drag-and-drop type software, configurable processing enabling parametric broadband and narrowband filters, audio delays, gain control, and mixing of audio signals, with multiple configurable logic inputs and outputs, SIP phone connectivity and setup for Voice-over-IP integration, with integral USB camera video extension, DANTE digital audio interface, expandable architecture, ability to store program on DSP and connected computer, ability to download stored and current

programming from DAP, all components from the same manufacturer, with power supply and rack mount kit as required.

b. USB Bridge; audio and video connection via IP stream on gigabit Ethernet network, USB output, Power-over-Ethernet, compatible with Digital Audio Processor above, with surface mounting hardware as required.

2.4.3 Amplifiers

a. Ceiling Loudspeaker Assembly; flush mounted in ceiling, two-way design with nominal 6-inch woofer and separate tweeter with high power crossover, with low-profile integral or pre-install metal back can, ceiling mounting hardware, and baffle, with internal transformer and front mounted tap selector, low impedance rating, and minimum 88 dB sensitivity, minimum frequency response of 95-16k Hz +/- 3dB, with manufacturer’s tile bridge or support rails where installed in T-bar ceilings.

b. All loudspeakers and loudspeaker enclosures shall be supported from the building structure as designed by the Contractor's structural engineer and as indicated on loudspeaker suspension shop drawings submitted to Government. Such devices installed into a T-bar/channel style ceiling shall have a load support tie-off to the building structure above and not rely on the ceiling support system for structural integrity.

2.5 VIDEO EQUIPMENT

2.5.1 Cameras

PTZ Camera, motorized pan-tilt-zoom operation, USB video output over IP-based stream on gigabit Ethernet network connection; compatible with Audio Processor above, Power-over-Ethernet compatible, with Camera Mount as listed below.

2.5.2 Video Distribution Equipment

a. Video Encoder, surface mount form factor, HDMI input, PoE, low-latency, IP-based video stream output over gigabit LAN output, 4K/UHD compliant (3840x2160 @60Hz), compatible with Video Decoder and Control System.

b. Video Decoder, surface mount form factor, HDMI output, analog audio output, Dante audio output, PoE, low-latency, IP-based video stream input over gigabit LAN output, selectable source routing, 4K/UHD compliant (3840x2160 @60Hz), compatible with Video Encoder and Control System.

2.5.3 Flat Panel Displays

a. Flat Panel (FP) Display; LCD type; 16:9 aspect ratio; native UHD (3840x2160) resolution; 500 nits brightness or better; HDCP compliant; with built in loudspeakers where shown; with multiple computer, HDMI, DisplayPort, with no wireless functions, and audio inputs; 16/7 rated or better, RS232 and TCP/IP remote controllable, with infrared handheld remote where control system is not included.

(1) FP55: nominal 55 inches diagonal.

(2) FP65; nominal 65 inches diagonal.

(3) FP75; nominal 75 inches diagonal.

(4) FP86; nominal 86 inches diagonal.

(5) FP98; nominal 98 inches diagonal.

2.5.4 Video Accessories

a. Camera Mount, in-wall camera mount, ADA compliant, compatible with USB Camera, color as selected by Government.

b. Flat Panel (FP) Display Mount, wall mount, with tilt adjustment and lateral positioning, with open design for junction box access, less than 1 inch deep, for use with all flat panel displays unless otherwise noted.

c. USB Extender Transmitter/Receiver (Tx/Rx); two (2) or more USB peripheral inputs, USB Host output, IP-based extension over Ethernet network connection, selectable routing between multiple Tx or Rx endpoints, compatible with USB 2.0, surface mounted form factor, with mounting hardware and power supply as required.

d. Portable HDMI Video Cable, factory-made, male to male HDMI molded connectors, thin flexible cable.

(1) Type 1: 6-feet long.

(2) Type 2: 12-feet long.

2.6 ETHERNET NETWORK EQUIPMENT

2.6.1 Switches and Accessories

a. Ethernet Switch, managed 10/100/1000Base-T switch, with DSCP QoS support with four queues with strict priority queuing, with multicast filtering, with POE+ as required, number of ports as required.

b. Patch Panels, modular ports, fiber optic or category cable as indicated on the drawings, rack mounted.

(1) Refer to Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM for exact model numbers.

c. All fiber optic and copper twisted pair field circuits shall terminate to appropriately labeled terminations (patch panels or biscuit jacks) installed in the equipment racks. Use factory fabricated patch cables between all terminations and the switches.

2.7 CONTROL EQUIPMENT

2.7.1 Touchpanels and Remote Control

Control Touchpanel, nominal 7 inch diagonal touchscreen, PoE compatible, motion sensing wakeup mode, compatible with Control System specified below, with no wireless functions; tabletop mounted enclosure color as selected by Government.

2.7.2 Control Processors

a. Control System, programmable appliance with configurable architecture, with multiple RS232, relay, and TCP/IP control ports on device or available through port expanders, with no wireless functionality, with rack mount kit, with power supply as required.

   Control system may be integral to Digital Audio Processor above.

b. The Contractor must provide custom system programming incorporating all the below functions with input from the Government. The Contractor must provide to the Government a copy of the final system configuration files (including all source codes), the latest version of system programming software, and any required computer connection cables, for the Government’s use.

c. The Contractor must have a manufacturer-certified programmer, one familiar with the details of the project, on site during the commissioning of the system to implement any required programming corrections and revisions.

d. Where rooms are indicated to include the addition of future/optional equipment, the control system programming must include all hardware and software required to control this future/optional equipment. Pages, sub-pages, and buttons for future/optional equipment shall be hidden and disabled so that they can easily be activated once the equipment has been installed.

e. Control system layout and custom graphical user interfaces must be submitted for approval to the Government. User interfaces must be designed using the latest graphics standards and templates from the manufacturer. The functions that must be included in each system type are as listed below, and as applicable based on the one-line diagrams for each individual space. Refer to Section 3.7 REMOTE CONTROL SYSTEM PROGRAMMING below for additional requirements.

2.8 EQUIPMENT RACKS, CABINETS, AND ACCESSORIES

2.8.1 Equipment Racks

a. AV Credenza, 2-bays, nominal 32-inches high, nominal 32-inches deep, with integral exhaust fans and vent openings, with 14 RU front and rear rack rails, with locking front and rear doors, with hidden casters, and with finish and exterior wood style as selected by Government.

b. AV Equipment Rack, with fixed base and swingout rack enclosure, nominal 27 inches deep, 40 RU, front and rear rack rails, locking vented front door, with exhaust fan top.

c. Any rack front panel details shown on the drawings are for concept only. Shop drawings are required indicating the exact equipment to be furnished. The exact size (larger or taller racks) and quantity of equipment racks is to be determined by the Audio-Visual Contractor based upon the exact equipment to be furnished. Verify all audio equipment room dimensions and conditions.

d. Except as noted on the drawings, allow 1-3/4 inch blank panel space at

the top of each rack, minimum 3-1/2 inch vent panel space at the bottom of each rack, and ventilation space (vent panels) between all equipment. Fill any empty rack space that is not near equipment with blank panels. Except as noted on the drawings or for mounting switches or LED indicators, blank panels shall not be used between equipment.

e. Where applicable, install a brush grommet panel directly above equipment such as an Ethernet Switch to allow cables to pass from the back of the equipment rack to the front panel of equipment.

f. Where applicable, mount small components behind vent panels on sub-chassis shelves or component panels (BUD CB series chassis or similar). Mount components with connections visible from rear of equipment rack using barrier strip terminal blocks for connections.

g. The following guidelines concerning equipment rack layouts shall be followed. Submit shop drawings illustrating proposed equipment rack layouts, indicating equipment labels.

Equipment Rack Layouts shall be according to function and follow applicable equipment security separation requirements.

Equipment that requires operator interface (e.g. audio-visual system AC power pushbuttons, audio-visual system mode select switches, power amplifier monitor/test system, monitor loudspeaker, computer monitor and keyboard, patch panels, audio mixers, program source and/or audio-visual equipment) shall be installed at heights that permit ease of operation and viewing.

2.9 AC POWER EQUIPMENT

2.9.1 AC Power in Equipment Racks

a. The Audio-Visual Contractor shall be responsible for providing distribution and connection of AC power circuits within the audio-visual equipment racks and credenzas. The audio-visual system AC power service will be provided to the equipment rack/credenza location by the project electrical contractor as noted on the electrical drawings.

b. Power distribution details shown on the drawings are for concept only. Shop drawings for AC power low voltage control switching and sequencing are required indicating the exact equipment to be furnished by the Contractor.

c. Rear Rack Light, LED, gooseneck, built-in 120V power supply.

Provide one (1) Rear Rack Light for each AV Credenza.

d. Power Module, for use in AV credenzas, 2-stage surge suppression, a minimum of six sequenced outlets, rack mounted, with contact closure control input.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with the details of the work and working

conditions, verify dimensions and equipment locations in the field, and advise the Contracting Officer of any discrepancies before performing the work.

3.2 GENERAL INSTALLATION STANDARDS

a. Coordinate the installation of all equipment, wiring, and associated hardware to be compatible with the work of other trades and with the overall construction completion schedule. Coordinate all access and work with the Government in advance.

b. Protect all finishes, furniture, and equipment, and maintain a clean work environment while working and when finished each day.

c. Perform installation in strict accordance with AVIXA standards and best practices, general industry standards and best practices, the National Electrical Code, and any other governing codes.

d. Keep a complete and accurate set of installation drawings and specifications at the job site. Note any changes made during installation on the drawings. Include a final set of as-built drawings with the Operation and Maintenance manuals.

e. Install all equipment following the manufacturers' recommendations and broadcast standards. Adjust and test to assure that all components are functioning properly by themselves and in conjunction with their associated components.

f. Install all equipment in appropriate cabinets or consoles at the locations designated in this document or on the associated contract drawings.

g. Apply no advertising to racks, equipment, and accessories. Where possible, and requested by the Contracting Officer, remove all visible manufacturer name badges from equipment mounted in public areas.

h. Cleanup and dispose of all waste materials daily. Wherever possible, materials must be properly recycled.

3.3 MOUNTING, RIGGING AND SEISMIC RESTRAINT

a. Design and build equipment racks in accordance with AVIXA F502.01, AVIXA F502.02, and ECIA EIA/ECA 310-E.

b. Mount equipment in accordance with 36 CFR 1191.

c. Securely fasten all equipment in place unless requirements of portability dictate otherwise. Fastenings and supports must be adequate to support their loads with a safety factor of at least five.

d. Provide seismic protection, including supports and hangers, as required by applicable code.

e. Install all boxes and equipment plumb and square per the manufacturer's recommended mounting practice.

f. All adjacent equipment racks must be ganged together if applicable.

g. Securely fasten and support all equipment without hindering equipment

operation. Rear rack rails must be installed as required to support heavy or deep equipment. Lacing bars must be installed to assist in organizing cable. Lacing bars must not interfere with access to any terminations or connectors.

h. Provide shaft locks or security covers on all non-user-operated equipment having front panel controls.

i. Any and all structural, mounting, or rigging details on the drawings are shown for concept only. It is the responsibility of the Contractor to employ the services of a qualified Structural Engineer to be responsible for the design of the details to be employed.

j. Provide structural/rigging calculations and details for mounting equipment. Stamped shop drawings must be submitted for review by the Contracting Officer and/or the project's Structural Engineer.

k. Equipment racks will be designed to ensure proper thermal management. Maximum constant operating temperature of equipment should not exceed 85 degrees Fahrenheit. Where cooling fans are provided in racks located in sensitive areas, select fans to minimize the noise impact in the area. Refer to MA Whitepaper.

3.4 GROUNDING AND SHIELDING

a. Install grounding in accordance with NFPA 70, TIA-607, ANSI/BICSI N3 and all Division 26 Specification Sections.

b. As a minimum, provide individual equipment racks with a rack grounding stud or bus bar and a #12 stranded (minimum) bonding jumper connected to the grounding and bonding stud on the primary power distribution unit that is plugged into the power receptacle serving the rack. Isolate the rack from the floor with plastic or rubber wheels/leveling feet.

c. Verify the integrity of grounding systems prior to connection of equipment.

3.5 GENERAL WIRING STANDARDS

a. Provide, install, terminate, and test all cabling in accordance with TIA-568.0, TIA-568.1, TIA-568.2, TIA-568.3, TIA-568.4, TIA-569, ANSI/BICSI N1, AVIXA F502.01, AVIXA F502.02 and other industry best practices.

b. All wiring runs must be unspliced where possible. Splices are not permitted in conduit, outside of listed splice boxes.

c. Cable routed in conduits or equipment racks to have non-plenum (PVC) rated jacket. All other cables to have a plenum rated jacket.

d. Cables routed above ceilings must be suspended above the ceiling tiles in J-hooks or cable tray.

e. Cable within equipment racks must be separated and routed in groups according to function: Microphone circuits, intercom circuits, line level audio circuits, loudspeaker circuits, video circuits, control circuits, and 120 volt AC power circuits. Cable must be neatly arranged, but tight bundling which makes modifications difficult shall

be avoided. Plastic or hook-and-loop cable ties must be used for grouping of circuits. Unless otherwise noted on the drawings, all cables must enter the equipment racks in one of the following manners:

(1) Through conduit landed directly to the equipment rack.

(2) Through rack knock-outs on the top or back of the equipment rack with plastic or rubber grommets.

(3) Directly into the back of wall mounted equipment racks. The rack must be installed over flush mounted junction boxes allowing all cables to pass directly from the junction box into the back of the rack.

(4) Directly into an open side of floor standing equipment racks without side panels.

(5) Directly into the bottom of floor standing equipment racks through access floor holes or conduit in the floor. The rack must be installed above the conduit stub or hole allowing all cables to pass directly into the bottom of the rack. All conduit stubs or access floor holes must also have a plastic or rubber bushing to protect the cables.

f. All cabling to/from the unclassified computers and equipment (except fiber optic cables) may be bundled together but must be separated by a minimum of 5 cm from any other cables.

g. Any grouping of cables left exposed in a room, such as those associated with a movable equipment rack, must be bundled together into a single bunch using black, flexible and expandable sleeving.

h. Provide outdoor-rated, direct burial, or other similar specialty rated cable types where required based on installation conditions and applicable codes.

i. The following denotes the most common cabling types and the minimum performance requirements. The Contractor is required to verify all cabling specifications based on the actual equipment provided.

(1) Microphone and Line Audio Cable:

(a) 22 AWG (7x30) stranded twisted shielded pair with overall shield.

(b) Nominal Capacitance (Conductor to Conductor): less than or equal to 35 pF/ft.

(c) Nominal Capacitance (Conductor to Conductor and Shield): less than or equal to 67 pF/ft.

(2) Low Impedance Loudspeaker Cable:

(a) 14 AWG (19x27) stranded twisted pair.

(b) Nominal Capacitance (Conductor to Conductor): less than or equal to 36 pF/ft.

(3) Low Impedance Loudspeaker Cable:

(a) 12 AWG (19x25) stranded twisted pair.

(b) Nominal Capacitance (Conductor to Conductor): less than or equal to 36 pF/ft.

(4) Low or High Impedance Loudspeaker Cable:

(a) 16 AWG (19x29) stranded pair.

(b) Nominal Capacitance (Conductor to Conductor): less than or equal to 36.5 pF/ft.

(5) Data Tie Line Cable:

(a) Refer to telecommunications specifications for project-standard data cabling information.

(6) RS-232 Control Cable:

(a) 22 AWG (7X30) Two pair twisted, individually shielded with drain wire.

(b) Nominal Capacitance (Conductor to Conductor): less than or equal to 17 pF/ft.

(7) Specialty Control Cable - as required for select manufacturer equipment:

(a) 22 AWG (7X30) shielded twisted pair with drain wire and 18 AWG unshielded pair in single jacket.

(b) Nominal Capacitance (Conductor to Conductor): less than or equal to 14 pF/ft.

(8) HDMI Video Cable:

(a) Factory-made.

(b) Molded connectors.

(c) HDMI 2.0 or better.

(9) Multimode Optical Fiber:

(a) 50/125 micron as required per transmission equipment manufacturer recommendation. If transmission equipment does not support 50/125 micron, 62.5/125 micron shall be permitted.

(b) Strand count per functional drawings; minimum of two strands for each run outside the main equipment cabinet.

(c) Shall support 10Gbps transmission speed for length of run.

(d) Each optical fiber strand shall be sufficiently free of surface imperfections and inclusions to meet the optical, mechanical, and environmental requirements of this specification and all TIA-568.3 performance parameters.

(10) Unshielded Ethernet:

(a) 4Px24 AWG UTP.

(b) Cat6 with a minimum TIA-568.2 standard rating.

(11) Shielded Ethernet or Video Extension:

(a) 4Px24 AWG STP.

(b) Cat6 with a minimum TIA-568.2 standard rating.

j. Use digital video cable as specified by the product manufacturer to obtain a signal at the maximum capable system resolution (minimum 3840x2160, 30Hz) that is free from all artifacts at each display from each source location. Use shielded cabling and connectors as required. Where multiple cabling options are provided by a manufacturer, use the option resulting in the greatest performance.

k. All Category cabling and connectors are to be rated at CAT6 or greater with a minimum TIA-568.2 standard rating.

l. All Category cabling and connectors to be terminated to the T568A standard unless otherwise required.

m. Use color-coded ruggedized and lockable shielded panel connectors and shielded inline connectors for all Contractor provided signal distribution equipment that requires RJ-45 style connectors at wall panel or floor box panel connections, except for those connecting a piece of AV equipment to the LAN. Maintain all cable shielding as required.

n. Use color-coded ruggedized and lockable panel connectors and inline connectors for all Contractor provided signal distribution equipment that requires fiber optic connectors at wall panel or floor box panel connections.

o. Each digital AV over RJ-45 or optical receptacle, permanently installed cable, equipment cord, and patch panel will be of a color or have markings that are non-standard with the voice/data system, and be plainly and permanently labeled "AV Only".

p. Arrange, route, and isolate wiring in equipment racks and within conduit according to signal level to minimize crosstalk, hum, or spurious signals. Wiring categories must consist of: microphone level and network (minus 80 dBm to minus 20 dBm), line level (minus 20 dBm to plus 30 dBm), loudspeaker level (plus 30 dBm and above), AC power, and DC control or emergency power.

q. Select cable color according to signal type. Submit color scheme to Contracting Officer for approval as a part of the Shop Drawing submission package.

r. Install all cabling in an orderly and professional manner. Provide service loops to allow access to the rear of equipment.

3.6 LABELING AND NAMEPLATES

a. Label all cables and equipment in accordance with TIA-606 and INFOCOMM F501.01.

b. Use white labeling with black text unless requested otherwise by the Contracting Officer.

c. Provide the wire run list as software spreadsheet and include as a part of the Operation and Maintenance Manuals.

d. Clearly and logically label external devices such as audio mixers, wireless microphones, belt packs, and assistive listening receivers.

e. Label relevant inputs and outputs on switchers, matrices, and mixers. This includes digital/virtual labeling of audio channels and video inputs and outputs.

f. Label telephone numbers, ISDN numbers and IP addresses of pertinent devices.

g. Label cabling wherever it is exposed in junction or pull boxes.

h. All control panels, all patch panels, and all controls, jacks, microphone receptacles, switches, etc. (except for controls, etc., on audio equipment which are properly identified by the manufacturer) must be suitably identified by engraved panels or engraved plates. Engraved panels or plates must be filled with a suitable contrasting color as approved on shop drawings.

i. Room numbers shown on drawings and indicated on control panel details, patch panels, etc., are architectural room numbers for identification only during the construction phase. Fabricated labels must reflect the room numbers to be later assigned by the Owner and/or as designated by the Contracting Officer.

j. All digital audio processors, power amplifiers, and other electronic equipment must be identified on front and rear panels by nameplates.

k. Except as noted, all standard gang wall plates must be stainless steel wall plates factory finished to match electrical device covers on the same surfaces, or color as selected by the Contracting Officer, with all lettering engraved and filled directly on the wall plate. All floor box covers shall be engraved and filled directly on the cover.

l. Unless noted otherwise, NEMA size connection panels must be clear anodized brushed aluminum, or color as selected by Contracting Officer.

(1) 12-inches or smaller: 1/8-inch thick.

(2) Larger than 12-inches: 3/16-inch thick.

(3) Field-verify mounting conditions for each box. Flush mounted plates shall have a minimum 1/2-inch flange on all sides.

m. All connection panels must have countersunk screw holes and crosshead countersunk or oval-head screws finished to match the panel. All lettering must be engraved and filled directly on the panel. Regardless of panel color, all panel mounted connectors must match the

finish color of the panel wherever possible.

n. All standard sized rack panels used to mount controls or connectors must have formed edges, with all lettering engraved and filled directly on the panel.

3.7 REMOTE CONTROL SYSTEM PROGRAMMING

a. Design graphical user interfaces in accordance with industry standards such as noted in EE GUI Design Guide.

b. As a minimum, the remote-control systems (where provided) will be programmed for the following general functionality as appropriate for each room:

(1) Power sequencer: Rack power on/off.

(2) Displays: Power on/off, input source select, video mute. Automatic power on when a source is selected for display.

(3) Video matrices: Source routing.

(4) Video cameras: Pan/tilt/zoom, preset store and select.

(5) Audio Processor: Dialing, privacy, local and remote volume up/down/mute, pick up/hang up.

c. Where all room video sources are portable, use video sync sensing to automatically power on the room display system upon connection of a video source and automatically power off the display upon disconnection of a video source.

d. Provide separate Program and Microphone audio level controls with mute function. Include a technician's page with access to individual microphone level controls. Include a preset button to recall default levels.

e. Lighting system: Preset 1-4 recall, all lights on, all lights off, individual lighting zone raise/lower, all lights raise/lower.

f. In the absence of pre-defined touch panel templates, propose draft touch panel pages for review and approval by the Government prior to programming. A minimum of one meeting must be provided to present these pages. Provide modifications as necessary based on comments resulting from the meeting.

g. Where applicable, provide web browser-based control of each room in addition to the room touch panels.

h. Coordinate all required control system LAN settings with the Contracting Officer.

i. Include twelve hours of additional programming time as a part of this Specification for any requested control system modifications after initial system acceptance but prior to the expiration of the warranty period.

3.8 SYSTEM TESTING AND ADJUSTMENT

a. Perform in accordance with ANSI/INFOCOMM 10.

b. Demonstrate that all audio system coverage is in accordance with ANSI/INFOCOMM A102.01.

c. Demonstrate that the entire scope of work defined is complete and fully functional per the scope of this specification and drawings, as well as any additional approved modifications and revisions.

d. Prior to conducting Commissioning with the Government, complete an internal quality review including a minimum of the following:

(1) Verify that all equipment has been delivered and installed per specifications. Provide a detailed equipment list sorted by room number and rack complete with make, model and serial number.

(2) Verify that all other trades have completed the work associated with the functioning of the audiovisual systems and that any installed third-party devices such as screens, shades, and lights work properly with the AV systems.

(3) Power on all equipment and verify the intended functions.

(4) Verify signal paths and cable continuity/integrity for all field terminated wiring, including Qualification of all Category-type field cabling.

(5) Measure each loudspeaker line impedance to verify that no short/open circuits exist (including shorts to conduit/ground) and proper/expected loads are connected.

(6) Test each loudspeaker to ascertain that none of the units "squawk" or "rattle" when energized with one-third octave bands of pink noise at a nominal input power of two watts.

(7) Adjust and align all displays for color, contrast, and geometry.

(8) Verify all communications services such as POTS, ISDN, and Ethernet. Setup of all dedicated networks, including assignment of appropriate IP addresses for all equipment, setup of any DHCP servers, and switch configuration.

(9) Configure and test the functionality of all audio and video conferencing systems.

(10) Load and test all DSP and control system software and provide button by button testing of all control system touch panels.

(11) Installation of the latest product firmware and software.

e. Provide documentation to the Contracting Officer that the systems are substantially complete at least one week in advance of Commissioning and Proof of Performance with the Government.

3.9 TEST EQUIPMENT

Provide all test equipment and test materials relative to the scope of the

project to include legal copies of all source media in all appropriate formats and blank recordable media in all appropriate formats.

3.10 COMMISSIONING

a. After the audio-visual systems have received their preliminary testing, and are found to be operating properly, the systems can be tuned and adjusted for optimal performance. This process of “system commissioning” is accomplished after the completion of the systems installation, but prior to any use of the audio-visual systems.

b. All commissioning tasks must be performed to ensure a complete and functioning system. Individual tasks that must be performed will include but not be limited to the following:

c. Sound Systems:

(1) To achieve proper acoustic levels and aiming, select loudspeaker transformers may require re-tapping and select loudspeakers or loudspeaker clusters may require reorientation.

(2) Adjust all gain controls to proper levels.

(3) Equalize the loudspeaker systems using broadband graphic or parametric equalizers, delays, and compressors/limiters.

(4) Equalize each installed microphone using broadband graphic or parametric equalizers and any applicable dynamics.

(5) Setup of any narrowband filters to prevent feedback.

(6) Setup of any acoustic echo cancellation processing.

d. Audio-Visual Systems:

(1) Configure all EDID and HDCP settings for each source and display.

(2) Setup of all video scalers.

(3) Setup of each display for color and brightness.

(4) Adjust camera image settings and configuration of any pan/tilt/zoom presets.

(5) Assist with configuration of videoconferencing systems provided and installed by the Government.

e. Networking and Control Systems:

(1) Verify all specified control operations.

(2) Verify and adjust all user control interfaces for proper operation, with input from the Government for custom interfaces.

(3) Verify all control software installations.

(4) Verify a proper Ethernet network configuration.

3.11 PROOF OF PERFORMANCE

a. Perform in accordance with ANSI/INFOCOMM 10.

b. After Commissioning, conduct a Proof of Performance Test with representatives from the Government present.

c. Schedule testing to ensure the availability of all required personnel and rooms.

d. During the proof of performance, demonstrate the operation of each individual piece of equipment in the system, and the system as a whole. Also demonstrate that equipment functions according to manufacturer's specifications, industry standards, and as stated in this Specification.

e. This demonstration must include a minimum of the following:

(1) A physical inventory of all equipment.

(2) An evaluation of general workmanship and construction quality.

(3) A mechanical check of all system components.

(4) The physical operation of all system equipment (audio, video, control, and network) including button-by-button control system testing.

(5) The placement of audio and video test calls.

3.12 SYSTEM TRAINING AND OPERATION ASSISTANCE

a. Conduct a training program for staff members as designated by the Contracting Officer to instruct on overall system and individual equipment operation, basic preventative maintenance, and basic system troubleshooting. Provide a minimum of three training sessions which may be scheduled at the Government's request at any time up to one year following system acceptance.

b. The training program will include a minimum of two video recorded sessions. The first session must occur immediately after the acceptance of the systems and cover the basic operation of each system. Provide the second training session within four weeks from the first session. The operation and maintenance manuals for the equipment must be completed and presented at this time. This training session will be used to train additional people and/or to answer questions/resolve issues developed within the first weeks of system use.

c. Coordinate scheduling of each session with the Contracting Officer.

3.13 RECORD DRAWINGS

a. Submit as-built documentation upon completion, including but not limited to, the following:

(1) All information contained in the Shop Drawings submittal package as detailed above and edited to reflect final conditions.

(2) Documentation of equipment serial numbers and network/phone/ISDN addressing scheme.

(3) Software files for touch panel interfaces, source code, DSP, and equipment settings, both compiled and un-compiled code for future system modification.

(4) Manufacturer product guides and instruction manuals.

(5) Warranty information and product registration as applicable.

3.14 OPERATION AND MAINTENANCE (O&M) MANUALS

a. The Contractor shall assemble electronic notebooks (a collection of digital files) for each audio-visual communication system.

b. Notebook contents shall include the following sections:

(1) Table of Contents, with main entries for each major section and equipment category, and sub-entries for each equipment manual included.

(2) System Operating Instructions (described below).

(3) System Warranty information.

(4) Record Drawings (described above).

(a) Equipment Manuals, including manufacturer’s warranty information, manufacturers' operating instructions, manufacturers' service manuals having schematic diagrams and parts lists, and any other information pertaining to the operation and routine maintenance of each major item of electronic equipment. This documentation shall be organized and divided into the equipment type categories used in this specification (i.e. Microphones, Microphone Accessories, etc.); either as separate PDF files or as a single file with PDF bookmarks.

(5) Equipment software and configuration files, control system code and configuration files, and any software licenses.

(6) Video archive of the training session(s), described below in Section 3.12 SYSTEM TRAINING AND OPERATING ASSISTANCE.

(7) Any other documentation deemed pertinent to the operation and maintenance of the sound reinforcement system.

c. An electronic version of all the binder contents shall be provided on physical media, media type as selected by the Government. The documents shall be separated in appropriately named individual PDF files. All software files shall be included on each media copy.

d. As-built documentation must also contain a custom-generated system operation guide that details the proper setup and usage of each system in all its normal functions and common usage scenarios as defined by the Contracting Officer. This "Step-by-Step" operation guide must contain information such as a general description of the overall system(s), instructions for general system operation such as turning

the system on and off, selecting various video sources for display, routing various audio sources to the speaker systems, setting up audio bridge calls, room combining, making VTC calls, using camera presets, etc. The intent is for this manual to provide simple "how-to" instructions on operating the system. This manual must also be a supplement to the system training specified above.

(1) The operations guide must include screen captures of each touch panel page (where applicable) with descriptions of the functionality of each button.

(2) Submit revisions to the guides that include changes based on feedback from prior training sessions, other government comments, errors in documentation, or any altered control interface programming prior to the second training session.

(3) Complete the operation guide prior to the second training session system and use it for the training.

e. Post one copy of system specific equipment interconnection drawings (laminated or in a plastic bag to prevent damage) inside the front or rear door of the main equipment for each individual audiovisual system.

f. All control system software will become the property of the Government and the Government will have the right to make any desired modifications after the expiration of the system warranty.

g. At the end of the warranty period, provide an updated copy of the above to account for any modifications that may have occurred during the warranty period.

3.15 WARRANTY AND MAINTENANCE

a. Guarantee the system for a period of one year from the date of final system acceptance against defective materials, design, workmanship, and improper adjustment. Repair or replace any defective material at no expense to the Government. During the warranty period, respond to any service calls within 24 hours. Where possible, provide substitute equipment to maintain system operation during repair.

b. Provide two service calls after the acceptance of the system at months six and 12 to perform routine system maintenance and adjustment.

c. The above warranty must not void warranties issued by individual equipment manufacturers. Individual warranties valid for greater than one year must remain in full effect.

d. The above warranty must not void any rights guaranteed by law to the Government.

e. The above warranty does not pertain to Government provided equipment.

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SECTION 28 31 76

INTERIOR FIRE ALARM AND MASS NOTIFICATION SYSTEM, ADDRESSABLE

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)

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME A17.1/CSA B44	(2019) Safety Code for Elevators and Escalators

FM GLOBAL (FM)

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

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	(2023) National Electrical Code
NFPA 72	(2022; ERTA 22-1) 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 3-600-01	(2016; with Change 6, 2021) Fire Protection Engineering for Facilities

UFC 3-601-02	(2021) Fire Protection Systems Inspection, Testing, and Maintenance
UFC 4-010-06	(2023) Cybersecurity of Facility-Related Control Systems
UFC 4-021-01	(2010; Change 1 January) Mass Notification Systems

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

47 CFR 15	Radio Frequency Devices
47 CFR 90	Private Land Mobile Radio Services

UNDERWRITERS LABORATORIES (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 497A	(2001; Bul. 2019) UL Standard for Safety Secondary Protectors for Communications Circuits
UL 497B	(2004; Reprint Feb 2022) UL Standard for Safety Protectors for Data Communications and Fire Alarm Circuits
UL 864	(2023) 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 Dec 2022) 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

In addition, refer to the following sections for related work and coordination:

Section 21 13 13 WET PIPE SPRINKLER SYSTEM, FIRE PROTECTION
Section 23 30 00 HVAC AIR DISTRIBUTION
Section 14 24 23 HYDRAULIC PASSENGER ELEVATORS for additional work related to elevators.
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 systems complete and ready for operation. Design and installation must comply with NFPA 72, UFC 3-600-01, UFC 4-021-01,UFC 4-010-06 and RAFB Base Facility Standard.

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 and final 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 (FACU/ACU)

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 information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.

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, AE

Instructions; G, AE

Wiring Diagrams; G, AE

System Layout; G, AE

Notification Appliances; G, AE

Initiating devices; G, AE

Amplifiers; G, AE

Battery Power; G, AE

Voltage Drop Calculations; G, AE

SD-03 Product Data

Fire Alarm and Mass Notification Control Unit (FACU/ACU); G, AE

Local Operating Console (LOC); G, AE

Amplifiers; G, AE

Tone Generators; G, AE

Digitalized voice generators; G, AE

Manual Stations; G, AE

Smoke Detectors; G, AE

Duct Smoke Detectors; G, AE

Addressable Interface Devices; G, AE

Addressable Control Modules; G, AE

Notification Appliances; G, AE

Textual Display Sign Control Panel; G, AE

Textual Display Signs; G, AE

Batteries; G, AE

Battery Chargers; G, AE

Supplemental Notification Appliance Circuit Panels; G, AE

Auxiliary Power Supply Panels; G, AE

Surge Protective Devices; G, AE

Alarm Wiring; G, AE

Back Boxes and Conduit; G, AE

Ceiling Bridges for Ceiling-Mounted Appliances; G, AE

Terminal Cabinets; G, AE

Automatic Fire Alarm Transmitters (including housing); G, AE

Radio Transmitter and Interface Panels; G, AE

Mass Notification Transceiver; G, AE

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 FACU/ACU(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, FACU/ACU, 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 "A", or to signaling line circuits (SLC) Class "A" and installed in accordance with NFPA 72.

b. Connect notification appliances to notification appliance circuits (NAC) Class "A".

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 FACU/ACU to bypass the automatic notification appliance circuits, fire reporting system and air handler shutdown features. Operation of this programmed action must indicate on the FACU/ACU display as a supervisory or trouble condition. Notification appliance bypass must be selectable by floor.

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, 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 FACU/ACU, and on the remote annunciator.

(3) Actuation of alarm notification appliances.

(4) Recording of the event electronically in the history log of the FACU/ACU.

(5) Operation of a sprinkler waterflow switch serving an elevator machinery room or elevator shaft must operate shunt trip circuit breaker(s) to shut down power to the elevators in accordance with ASME A17.1/CSA B44.

m. A supervisory signal must automatically initiate the following functions:

(1) Visual indication of the device operated on the FACU/ACU, and on the remote annunciator. Indication on the graphic annunciator must be by floor, zone or circuit, and type of device.

(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 FACU/ACU.

n. A trouble condition must automatically initiate the following functions:

(1) Visual indication of the device operated on the FACU/ACU, Video Display unit (VDU), and on the remote annunciator. Indication on the graphic annunciator must be by floor, zone or circuit, and type of device.

(2) Transmission of a trouble signal to the fire department.

(3) Recording of the event electronically in the history log of the FACU/ACU.

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.

p. Activation of a LOC pushbutton must activate the audible and visual alarms in the facility. The audible message must be the one associated with the pushbutton activated.

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 FACU/ACU and remote FACU/ACU, 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 FACU/ACU 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.

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 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" 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.

1.8.1.13 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 III (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 III or IV fire alarm technician must supervise the installation of the fire alarm/mass notification 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.

1.8.2.4 Installer

NICET Level II technician 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 III or 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

Coordinate with Robins Air Force Base CE for type and quantity of required spare parts in the manufacturer's original unopened containers.

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. FACU/ACU

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. Master all keys and locks to a single key as required by the Installation Fire Department.

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 instructions on the interior of the FACU/ACU. 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 (FACU/ACU) 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. If more than a single unit is required at a location to form a complete control unit, the unit cabinets 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 FACU/ACU 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 deactivating 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 FACU/ACU 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 FACU/ACU 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 throughout a selected floor or floors or all call. The system must be capable of

operating all speakers at the same time. The Audible Notification System must support Public Address (PA) paging for the facility. This must be accomplished with the provision of a separate microphone with a head unit that interfaces with the FACU/ACU. The public address paging function must not override any fire alarm or mass notification functions. The microphone must be hand-held style. Hand-held microphones must be housed in a separate protective cabinet. The cabinet must be accessible without the use of a key. The location of the microphone(s) must be approved by the Designated Fire Protection Engineer (DFPE). Activation of the public address microphone must not initiate activation of visual notification appliances or LED text displays.

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 FACU/ACU. 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, and public address (PA) functions. 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 female 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 meet pre-recorded message requirements of RAFB Base Facility Standard.

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

Provide an interface radio transceiver and antenna that will communicate with the base-wide “Big-Voice” system meeting the Base (78 ABW/SC) requirements. Robins AFB currently uses the UVIC UltraVoice® Indoor Controller with an UltraVoice® Audio and Relay Module (UVARM) manufactured by Federal Signal Safety and Security Systems to interface with the Mass Notification System (MNS). The autonomous control unit must receive commands/messages from the central control unit and provide status information.

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 FACU/ACU 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 FACU/ACU.

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 FACU/ACU 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, 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 FACU/ACU. The housing for the LOC must not be lockable. The LOC must have public address capability with the provision of a separate microphone. The PA paging function must not override any alarm or notification functions. The PA microphone must be hand-held style. Hand-held microphones must be housed in a separate protective cabinet. The cabinet must be accessible without the use of a key. The location of the microphone must be approved by the Designated Fire Protection Engineer (DFPE). Activation of the PA microphone must not initiate activation of visual notification appliances or LED text displays. The PA paging function must not override any alarm or notification functions.

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 FACU/ACU.

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 FACU/ACU, terminal cabinet, or in the FACU/ACU. Individual amplifiers must be 100 watts maximum.

2.5.1 Operation

The system must automatically operate and control all building speakers except those installed in the stairs and within elevator cabs. The speakers in the stairs and elevator cabs must operate only when the

microphone is used to deliver live messages.

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 Public Address Paging Function. Microphone inputs must be of the low impedance, balanced line type. Microphone 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.

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 REMOTE ANNUNCIATOR

2.6.1 LCD Annunciator

Provide a semi-recessed mounted annunciator that includes an LCD display. The display must indicate the device in trouble/alarm or any supervisory device. Display the device name, address. The remote annunciator must duplicate functions of the FACU/ACU for message display, fire alarm, supervisory alarm, and trouble conditions, visual and audible notification, and system reset functions. Remote annunciator must require the use of a key for accessing the reset, control and other functions.

A building floor plan must be provided and mounted (behind Plexiglass or similar protective material) at the annunciator location. The floor plan must indicate all rooms by name and number including the locations of stairs and elevators. The floor plan must show all devices and their programmed address to facilitate identification of their physical location from the LCD display information.

2.7 MANUAL STATIONS

Provide metal or plastic, semi-flush 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.

2.8 SMOKE DETECTORS

2.8.1 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 FACU/ACU.

b. Provide self-restoring type detectors that do not require any readjustment after actuation at the FACU/ACU 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.

2.8.2 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. It is not permitted to cut the duct insulation to install the duct detector directly on 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 FACU/ACU.

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 FACU/ACU.

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.

2.9 ADDRESSABLE INTERFACE DEVICES

The initiating device being monitored must be configured as a Class "A" 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.

2.10 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. 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 A 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.

2.11 NOTIFICATION APPLIANCES

2.11.1 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 that is painted white.

2.11.1.1 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 wall mounted unit. All inputs must be

polarized for compatibility with standard reverse polarity supervision of circuit wiring via the FACU/ACU.

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.

2.11.2 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 letters of contrasting color. 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 and a minimum of 15 candela based on the UL 1971 test. Strobe must be surface mounted.

2.11.3 Textual Display Signs

Textual display signs must be LED flat panel and must not exceed 16 inches long by 6 inches high by 3 inches deep with a height necessary to meet the requirements of NFPA 72. The text display must spell out the word "EVACUATE" or "ANNOUNCEMENT" and the remainder of the emergency instructions as appropriate. The design of text display must be such that it cannot be read when not illuminated.

2.12 ELECTRIC POWER

2.12.1 Primary Power

Power must be 120 VAC 60 Hz service for the FACU/ACU from the AC service to the building in accordance with NFPA 72.

2.13 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.

2.13.1 Batteries

Provide sealed, maintenance-free, sealed lead acid batteries as the source for emergency power to the FACU/ACU. 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.

2.13.1.1 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.

2.13.1.2 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.

2.13.2 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.

2.14 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 FACU/ACU 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.

(3) For alarm telephone dialers: UL 497A listed, series connected, 130-volt, 150 mA rated with self-resetting fuse, dialer circuit protector with modular plug and play.

(4) For IP-DACTS: UL 497B listed, series connected, 6.4-volt, 1.5A rated with 20 kA/pair surge current, data network protector with modular plug and play.

2.15 WIRING

Provide wiring materials under this section as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM with the additions and modifications specified herein.

2.15.1 Alarm Wiring

IDC and SLC wiring must be solid copper cable in accordance with the manufacturers requirements. Copper signaling line circuits and initiating device circuit field wiring must be No. 18 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 FACU/ACU. 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.

2.16 INTERFACE TO THE BASE-WIDE MASS NOTIFICATION NETWORK

2.16.1 Radio

The mass notification transceiver must be bi-direction and meet all the requirements of paragraph, RADIO TRANSMITTER AND INTERFACE PANELS as specified in this specification section. The transceiver utilized in the mass notification system must be capable of the following:

a. Communication with the central control/monitoring system to provide supervision of communication link and status changes are reported by automatic and manual poll/reply/acknowledge routines.

b. All monitored points/status changes are transmitted immediately and at programmed intervals until acknowledged by the central control/monitoring system.

c. Each transceiver must transmits a unique identity code as part of all messages; the code is set by the user at the transceiver.

2.17 AUTOMATIC FIRE ALARM TRANSMITTERS

2.17.1 Radio Transmitter and Interface Panels

Transmitters must be compatible with Robins AFB 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, and RAFB Base Facility Standard. Transmitter electronics module must be contained within the physical housing as an integral, removable assembly. At the contractors option, and if listed, the transmitter may be housed in the same control unit as the FACU/ACU. At a minimum, transmitter equipment must be mounted within 3 feet of the FACU it serves. 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. FACU must transmit Contact ID codes through radio transmitter. In addition to Contact ID codes, contractor must provide hardwired inputs from the fire alarm control panel as required by RAFB Base Facility Standard.

2.17.1.1 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.

2.17.1.2 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.

2.17.1.3 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. Transmitter cabinet must be equipped with a tamper switch and connected to hardwired input as required by RAFB Base Facility Standard.

2.17.1.4 Antenna

Antenna must be a 7788F AES mount radio transceiver antenna per Robins AFB Facility Standards. 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.

2.17.2 Signals to Be Transmitted to the Base Receiving Station

Signals referenced in RAFB Base Facility Standard must be sent to base receiving station.

2.18 SYSTEM MONITORING

2.18.1 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, unless they are within the same room, then a maximum of five can use the same 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 (FACU/ACU)

Locate the FACU/ACU where indicated on the drawings. Recess 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 FACU/ACU. Locate the document storage cabinet adjacent to the FACU/ACU unless the Contracting Officer directs otherwise.

3.2.2 Battery Cabinets

When batteries will not fit in the FACU/ACU, locate battery cabinets below or adjacent to the FACU/ACU. 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.

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 FACU/ACU or LOC so as to cause feedback when the microphone is in use.

3.2.5 Smoke and Heat Detectors

Locate detectors as indicated on the drawings 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 LCD REMOTE Annunciator

Locate the LCD annunciator as shown on the drawings. Mount the annunciator, with the top 6 feet above the finished floor or center the annunciator at 5 feet, whichever is lower.

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 workmanlike 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 FACU/ACU 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 FACU/ACU.

c. Pigtail or T-tap connections to signal line circuits, initiating device circuits, supervisory alarm circuits, and notification appliance circuits are prohibited.

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.

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.

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.

g. For Class "A" circuits with conductor lengths of 10 feet or less, the conductors must be permitted to be installed in the same raceway in accordance with NFPA 72.

3.3.5 Conductor Terminations

Labeling of conductors at terminal blocks in terminal cabinets, FACU/ACU, 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, FACU/ACU, and remote FACU/ACU 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 III or IV Fire Alarm Technician, and the representative of the installing company, and reviewed by the QFPE 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 Designated Fire Protection Engineer Contracting Officer's Representative (COR), 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 FACU/ACU. 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.

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.

3.9.3 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

Installing contractor must service and maintain fire alarm system and

related equipment throughout duration of B110 Renovation project. Contractor must perform fire alarm inspection and system testing in accordance with NFPA 72 requirements throughout the duration of project construction. Fire alarm system warranty period to begin after B110 Renovation project is complete and the facility is turned over to Robins end user. Contractor is responsible for repair services throughout the duration of project construction.

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 system. 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 --

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SECTION 31 00 00

EARTHWORK

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	(2017) 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	(2024) 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	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C150/C150M	(2022) Standard Specification for Portland Cement
ASTM C260/C260M	(2010a; R 2016) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C618	(2023; E 2023) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C989/C989M	(2024) Standard Specification for Slag Cement for Use in Concrete and Mortars
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 D2321	(2020) Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
ASTM D2487	(2017; E 2020) 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 D5268	(2019) Topsoil Used for Landscaping Purposes
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 600/4-79/020	(1983) Methods for Chemical Analysis of

	Water and Wastes
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 SW, SP, SM, SC, SP-SC, CL, ML, CL-ML. Maximum particle size to be no greater than 1.5 inches in any dimension.

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 Hard/Unyielding Materials

Hard/Unyielding materials comprise weathered rock, dense consolidated deposits, or conglomerate materials which are not included in the definition of "rock" with stones greater than 3 inch in any dimension or as defined by the pipe manufacturer, whichever is smaller. These materials usually require the use of heavy excavation equipment, ripper teeth, or jack hammers for removal.

1.2.10 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.

1.2.11 Expansive Soils

Expansive soils are defined as soils that have an expansion index greater than 20 when tested in accordance with ASTM D4829.

1.2.12 Rock

Solid homogeneous interlocking crystalline material with firmly cemented, laminated, or foliated masses or conglomerate deposits, neither of which can be removed without systematic drilling and blasting, drilling and the use of expansion jacks or feather wedges, or the use of backhoe-mounted pneumatic hole punchers or rock breakers; also large boulders, buried masonry, or concrete other than pavement exceeding 1/2 cubic yard in volume. Removal of hard material will not be considered rock excavation because of intermittent drilling and blasting that is performed merely to increase production.

1.2.13 Degree of Compaction (Proctor)

Degree of compaction required, except as noted in the second sentence, is expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D1557 abbreviated as a percent of laboratory maximum 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 density in accordance with AASHTO T 180-21 paragraph 1.5, Note 1.

1.2.14 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.

1.2.15 Borrow

Soil brought to the project site from an external location for the purposes of project construction.

1.2.16 Subgrade

Earth materials directly below foundations and directly below granular base materials in building slab and pavement areas including shoulders.

1.3 SUBSURFACE DATA

Subsurface soil boring logs are shown in an Attachment to these specifications. These data represent available subsurface information; however, variations may exist between boring locations.

1.4 CRITERIA FOR BIDDING

Base bids on the following criteria:

a. Surface elevations are as indicated.

b. Pipes or other artificial obstructions, except those indicated, will not be encountered.

c. Ground water elevations indicated by the boring log were those existing at the time subsurface investigations were made and do not necessarily represent ground water elevation at the time of construction.

d. Ground water elevation is 8 feet below existing surface elevation.

e. Material character is indicated by the boring logs.

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-01 Preconstruction Submittals

Excavation and Trenching Plan; G

Borrow 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

1.6 QUALITY CONTROL

1.6.1 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.

1.6.2 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.

1.6.3 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 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 Fill

Materials classified as SW, SP, SM, SC, SP-SM, SP-SC, or CL, in accordance with ASTM D2487. Select material type appropriate for the intended purpose.

Acceptable parameters for low plasticity cohesive soil (CL, CL-ML, ML, SM, SC) include a Liquid Limit less than 45, Plasticity Index less than 25, and less than 25 percent retained on No. 200 sieve. Acceptable parameters for granular soil (SP, SM, SC, and SW) include less than 50 percent passing No. 200 sieve. Acceptable parameters for on-site soils (SM, SC, and SP-SC) include a Liquid Limit less than 45 and a Plasticity Index less than 25.

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 and excavations 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. Topsoil material will be in accordance with ASTM D5268.

2.1.4 Utility Bedding Material

Except as specified otherwise in the individual piping section, provide bedding for buried piping in accordance with AWWA C600 and ASTM D2321. Install bedding for plastic piping to spring line of pipe. Utility bedding material may include the following:

2.1.4.1 Class I

Angular, 0.25 to 1.5 inch, graded stone, including a number of fill materials that have regional significance such as coral, slag, cinders, crushed stone, and crushed shells.

2.1.4.2 Class II

Coarse sands and gravels with maximum particle size of 1.5 inch, including various graded sands and gravels containing small percentages of fines, generally granular and noncohesive, either wet or dry. Soil Types GW, GP, SW, and SP are included in this class as specified in ASTM D2487.

2.1.4.3 Sand

Clean, coarse-grained sand classified as SW or SP by ASTM D2487 for bedding.

2.1.4.4 Gravel and Crushed Stone

Clean, coarsely graded natural gravel, crushed stone or a combination thereof identified as GW or GP in accordance with ASTM D2487 for bedding and backfill. Do not exceed maximum particle size of 3 inches.

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 maximum unconfined compressive strength to be 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 polyethylene plastic and 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 within and/or outside of

Government property meeting the requirements of paragraphs STRUCTURAL FILL and TOPSOIL.

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. 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.

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 within the limits of the project site, selected by the Contractor, from approved sources. Submit a Borrow Plan that includes materials to be excavated, stockpile locations, proposed slopes, drainage, and closure. 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 Contractor Furnished Borrow Area(s)

Obtain approved borrow materials from approved offsite sources. If a borrow source is selected that is not a commercial entity from which soil material is directly purchased, submit a Borrow Plan that includes the borrow source location, geotechnical test results showing the fill material meets the Contract requirements, environmental test results in accordance with paragraph ENVIRONMENTAL REQUIREMENTS FOR OFF-SITE SOIL, and any Federal, State, and local permits required for excavation and reclamation of the borrow area.

3.2.2 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. Determine TPH concentrations by using EPA 600/4-79/020 Method 418.1. 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 indicated on the plans. Strip existing surface materials to a depth of 4 inches below the existing ground surface in areas designated as Clear and Grub on the plans. Strip in all areas within the planned limits of disturbance. All stripped materials not suitable for reuse as topsoil will be wasted in specified disposal area. Screen all stripped soils to remove roots and organic materials prior disposal.

Strip suitable soil from the site where excavation or grading is indicated and stockpile separately from other excavated material. Protect topsoil and keep in segregated piles until needed.

3.3.2 Proof Rolling

Perform proof rolling on exposed subgrade that is unfrozen and free of surface water (wet conditions resulting from rainfall). Notify the Contracting Officer a minimum of three days prior to proof rolling.

After stripping, 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 loaded tandem axle dump truck and 15 ton, pneumatic-tired or smooth drum roller. Operate the roller and truck 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 and unsatisfactory 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, 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 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 Ditches, Gutters, and Channel Changes

Finish excavation of ditches, gutters, and channel changes by cutting accurately to the cross sections, grades, and elevations shown. Do not excavate below grades shown. Backfill excessive excavation as directed by the Contracting Officer, with satisfactory, compacted, material or with suitable stone or cobble to grades shown. Dispose excavated material as shown or as directed. Do not allow material to be deposited within 4 feet from edge of a ditch. Maintain excavations free from detrimental quantities of leaves, brush, sticks, trash, and other debris until final acceptance of the work.

3.4.2 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.

3.4.2.1 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 3 inch or greater in any dimension, or as recommended by the pipe manufacturer, whichever is smaller, to avoid point bearing.

3.4.2.2 Removal of Unyielding Material

Where unyielding material is encountered in the bottom of the trench, notify the Contracting Officer. Following approval, remove such material 4 inch below the required grade and replaced with suitable materials as provided in paragraph FILLING AND COMPACTION.

3.4.2.3 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.

3.4.2.4 Excavation for Appurtenances

Provide excavation for manholes or similar structures of sufficient size to permit the placement and removal of forms for the full length and width of structure footings and foundations as shown.

3.4.2.5 Gas Distribution

Excavate trenches to a depth that will provide a minimum 36 inches of cover in other excavation.

3.4.2.6 Water Lines

Excavate trenches to a depth that provides a minimum cover of 3 feet from the existing ground surface, or from the indicated finished grade, whichever is lower, to the top of the pipe. For fire protection yard mains or piping, an additional 6 inch of cover is required.

3.4.3 Underground Utilities

Perform work adjacent to utilities as indicated. 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.

3.4.4 Structural Excavation

For new pavement areas including exterior concrete pads, over-excavate to a minimum of 12 inches below bottom of new pavement/pad base course, scarify, moisture-condition, and compact to at least 95 percent.

Make excavations to the lines, grades, and elevations shown, or as

directed. Provide trenches and foundation pits of sufficient size to permit the placement and removal of forms for the full length and width of structure footings and foundations as shown. Clean rock or other hard foundation material of loose debris and cut to a firm, level, stepped, or serrated surface. Remove loose disintegrated rock and thin strata.

Concrete placement is not allowed until footing subgrades have been inspected and approved by the Contracting Officer.

3.4.5 Rock Excavation and Blasting

Excavate rock encountered in the cut section to a depth of 6 inches below finished grade and replace with satisfactory material. Blasting will not be permitted.

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 and 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 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.

3.5.3 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.

3.6 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 plus or minus 2 percent of optimum moisture. 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 92 percent of ASTM D1557. 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 density for cohesive soils and 90 percent maximum density for cohesionless soils. Do not permit compaction by water flooding or jetting. Apply this requirement to all other areas not specifically designated above.

3.6.1.5 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.

3.6.1.6 Buried Tape And Detection Wire

3.6.1.6.1 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.

3.6.1.6.2 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 density for cohesive materials or 95 percent of laboratory maximum 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 within range of plus 2 or minus 2 percent of optimum moisture content at the time of compaction.

3.6.3 Backfill for Appurtenances

After the manhole 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 92 percent of ASTM D1557.

3.6.6.2 Adjacent Areas

Compact areas within 5 feet of structures to 95 percent of ASTM D1557.

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 ballast, subbase, base, or pavement is placed. Do not permit the storage or stockpiling of materials on finished subgrade. Do not lay subbase, base course, ballast, or pavement until the subgrade has been checked and approved, and in no case place subbase, base, surfacing, pavement, or ballast on a muddy, spongy, frozen or otherwise unstable subgrade.

Finish the surface of excavations 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 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.

3.7.2 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.

3.7.3 Topsoil and Seed

Provide as specified in Section 32 92 23 SODDING.

On areas to receive topsoil, prepare the compacted subgrade soil to a 2 inches depth for bonding of topsoil with subsoil. Spread topsoil evenly. 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. Remove from the site any surplus of topsoil from excavations and gradings. Obtain material required for topsoil in excess of that produced by excavation within the grading limits from areas indicated.

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 Utility Bedding Material General Fill	Density - ASTM D1556/D1556M	One test per 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 Utility Bedding Material General Fill	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 Utility Bedding Material General Fill	Moisture Density Relationship - ASTM D1557	One representative test per fill and backfill, or when any change in material occurs which may affect the optimum moisture content or laboratory maximum density. Sample to be taken from stockpile or location of placement.
Structural Fill Utility Bedding Material General Fill	Relative Density - ASTM D4253 and ASTM D4254	One test 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 Utility Bedding Material General Fill	Gradation - ASTM C136/C136M	One representative test per fill and backfill, or when any change in material occurs which may affect the optimum moisture content or laboratory maximum density. Sample to be taken from stockpile or location of placement.
Structural Fill Utility Bedding Material General Fill	Atterberg Limits - ASTM D4318	One representative test per fill and backfill, or when any change in material occurs which may affect the optimum moisture content or laboratory maximum density. Sample to be taken from stockpile or location of placement.

-- End of Section --

SECTION 32 11 20

BASE COURSE FOR RIGID PAVING

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 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	(2019) 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 D2487	(2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
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 E11	(2022) 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. 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.

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.

1.5 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	

TABLE 1	
Rigid Pavement Base Course	Minimum 95 percent

1.6.2 Test Section

A test section is not required.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Rigid Pavement Base Course

Provide aggregates consisting of crushed stone or 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 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 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.

d. Wear.

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. For cohesionless underlying courses or subgrades containing sands or gravels, as defined in ASTM D2487, stabilize the surface prior to placement of the overlying course. Stabilize by mixing the overlying course material into the underlying course and compacting by approved methods. Consider the stabilized material as part of the underlying course and meet all requirements of the underlying course. Do not allow traffic or other operations to disturb the finished underlying course and maintain in a satisfactory condition until the overlying course is placed.

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 EDGES OF RIGID PAVEMENT BASE COURSE

Place approved material along the outer edges of the rigid pavement base course in sufficient quantity to compact to the thickness of the course being constructed. When the course is being constructed in two or more lifts, simultaneously roll and compact at least a 2 foot width of this shoulder material with the rolling and compacting of each lift of the rigid pavement base course, as directed.

3.10 FINISHING

Finish the surface of the top lift of rigid pavement base course after final compaction 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 completed area.

b. Perform gradation on every lift 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. 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. No additional payments will be made for materials that have to be replaced.

-- End of Section --

SECTION 32 13 14.14

CONCRETE PAVING FOR SMALL AIRFIELD PROJECTS

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

AMERICAN CONCRETE INSTITUTE (ACI)

ACI 201.1R	(2008) Guide for Conducting a Visual Inspection of Concrete in Service
ACI 211.1	(1991; R 2009) Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete
ACI 214R	(2011) Evaluation of Strength Test Results of Concrete
ACI 305R	(2020) Guide to Hot Weather Concreting
ACI 306R	(2016) Guide to Cold Weather Concreting
ACI 309R	(2005) Guide for Consolidation of Concrete
ACI 325.14R	(2017) Guide for Design and Proportioning of Concrete Mixtures for Pavements

ASTM INTERNATIONAL (ASTM)

ASTM A184/A184M	(2019) Standard Specification for Welded Deformed Steel Bar Mats for Concrete Reinforcement
ASTM A185/A185M	(2007) Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete
ASTM A615/A615M	(2024) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A996/A996M	(2016) Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement

ASTM A1064/A1064M	(2024) Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
ASTM A1078/A1078M	(2019) Standard Specification for Epoxy-Coated Steel Dowels in Concrete Pavement
ASTM C31/C31M	(2024b) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C33/C33M	(2024) Standard Specification for Concrete Aggregates
ASTM C39/C39M	(2024) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
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 C114	(2023) Standard Test Methods for Chemical Analysis of Hydraulic Cement
ASTM C117	(2023) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C123/C123M	(2023) Standard Test Method for Lightweight Particles in Aggregate
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	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C138/C138M	(2023) Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
ASTM C142/C142M	(2017; R 2023) Standard Test Method for Clay Lumps and Friable Particles in Aggregates
ASTM C143/C143M	(2020) Standard Test Method for Slump of Hydraulic-Cement Concrete

ASTM C150/C150M	(2022) Standard Specification for Portland Cement
ASTM C172/C172M	(2017) Standard Practice for Sampling Freshly Mixed Concrete
ASTM C174/C174M	(2017) Standard Test Method for Measuring Thickness of Concrete Elements Using Drilled Concrete Cores
ASTM C192/C192M	(2019) Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
ASTM C231/C231M	(2024) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C260/C260M	(2010a; R 2016) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C294	(2012; R 2017) Standard Descriptive Nomenclature for Constituents of Concrete Aggregates
ASTM C295/C295M	(2019) Standard Guide for Petrographic Examination of Aggregates for Concrete
ASTM C494/C494M	(2024) Standard Specification for Chemical Admixtures for Concrete
ASTM C618	(2023; E 2023) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C666/C666M	(2015) Resistance of Concrete to Rapid Freezing and Thawing
ASTM C881/C881M	(2020a) Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C989/C989M	(2024) 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 C1064/C1064M	(2023) Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete
ASTM C1077	(2024) Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation

ASTM C1260	(2023) Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
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 C1646/C1646M	(2016) Making and Curing Test Specimens for Evaluating Frost Resistance of Coarse Aggregate in Air-Entrained Concrete by Rapid Freezing and Thawing
ASTM C1895	(2020) Standard Test Method for Determination of Mohs Scratch Hardness
ASTM D75/D75M	(2019) Standard Practice for Sampling Aggregates
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 D2995	(2023) Determining Application Rate of Bituminous Distributors
ASTM D3665	(2012; R 2017) Standard Practice for Random Sampling of Construction Materials
ASTM D4791	(2019) Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 300	(1990) Specifications for Membrane-Forming Compounds for Curing Concrete
COE CRD-C 521	(1981) Standard Test Method for Frequency and Amplitude of Vibrators for Concrete

U.S. DEPARTMENT OF DEFENSE (DOD)

TSPWG M 3-250-04.97-05	(2019) Proportioning Concrete Mixtures with Graded Aggregates for Rigid Airfield Pavements

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-01 Preconstruction Submittals

Proposed Techniques; G

SD-03 Product Data

Dowels; G

Equipment

SD-05 Design Data

Preliminary Proposed Proportioning; G, AE

SD-06 Test Reports

Batch Tickets

Contractor Quality Control Reports

Sampling and Testing; G

Repair Recommendations Plan; G

SD-07 Certificates

Contractor Quality Control Staff; G

Laboratory Accreditation

1.3 QUALITY CONTROL

1.3.1 Contractor Quality Control (CQC) Staff

Reference Section 01 45 00 QUALITY CONTROL for general CQC personnel qualification requirements. Submit the Contractor Quality Control Staff for approval. Provide American Concrete Institute certificates of CQC staff. All Contractor Quality Control personnel assigned to concrete construction are required to be American Concrete Institute (ACI) certified in the following grade:

a. Identify an individual within the onsite work organization as the Concrete Paving CQC Manager, who is responsible for overall management of concrete paving CQC and has the authority to act in all concrete paving CQC matters including authority to stop concrete paving work which is out of compliance.

The minimum requirements for the Concrete Paving CQC Manager consist of 8 years airfield concrete paving experience similar to work required under this contract with a minimum of 3 years in a concrete paving CQC role. The Concrete Paving CQC Manager is a separate person, and is in addition to the CQC System Manager identified in Section

01 45 00 QUALITY CONTROL.

b. CQC staff is required to oversee all aspects of sawing operations (sawing, flushing, vacuuming, checking for random cracking, lighting).

c. Lead Foreman or Journeyman of the Concrete Placing, Finishing, and Curing Crews: ACI Advanced Concrete Flatwork Finisher.

d. Field Testing Technicians: ACI Concrete Field Testing Technician, Grade I.

e. Laboratory Testing Technicians: ACI Concrete Strength Testing Technician and ACI Concrete Laboratory Testing Technician, Level 1.

1.3.2 Other Staff

Submit for approval, the qualifications and resumes for the following staff:

a. Petrographer: Bachelor of Science degree in geology or petrography, trained in petrographic examination of concrete aggregate according to ASTM C294 and ASTM C295/C295M and trained in identification of the specific deleterious materials and tests identified in this specification. Detail the education, training and experience related to the project-specific test methods and deleterious materials in the Petrographer Resume and submit at least 20 days before petrographic and deleterious materials examination is to commence.

b. Licensed Surveyor: Perform all survey work under the supervision of a Licensed Surveyor.

c. Concrete Batch Plant Operator: National Ready Mix Concrete Association (NRMCA) Plant Manager certification.

1.3.3 Preconstruction Testing of Materials

All sampling and testing is required to be performed by an approved commercial laboratory. For cementitious materials and chemical admixtures use a laboratory maintained by the manufacturer of the material. Materials are not allowed to be used until notice of acceptance has been given. Additional payment or extension of time is not allowed due to failure of any material to meet project requirements.

1.3.3.1 Aggregates

Sample aggregates in the presence of a Government Representative. Obtain samples in accordance with ASTM D75/D75M that are representative of the materials to be used for the project. Perform all aggregate tests no earlier than one year prior to initial submission of the proportioning studies submittal.

1.3.3.2 Chemical Admixtures, Curing Compounds, and Epoxies

Submit certified copies of test results of admixtures, curing compounds, and epoxies that are going to be used on the project at least 30 days before the material is used. Provide test results less than 5 years old prior to use in the work. Reject if the test results do not meet the Level 2 proof of compliance requirements of ASTM C494/C494M.

1.3.3.3 Cementitious Materials

Cement, slag cement, and pozzolan will be accepted on the basis of manufacturer's certification of compliance, accompanied by mill test reports showing that the material in each shipment meets the requirements of the referenced test standard under which it is provided. Provide mill test reports no more than 6 months old prior to use in the work. Do not use cementitious materials until notice of acceptance has been given. Cementitious materials may be subjected to testing by the Government from samples obtained at the mill, at transfer points, or at the project site. If tests prove that a cementitious material that has been delivered is unsatisfactory, promptly remove it from the project site.

1.3.4 Acceptability of Work

The materials and the pavement itself will be accepted on the basis of production testing. The Government may make check tests to validate the results of the production testing. If the results of the production testing vary by less than 2.0 percent of the Government's test results, the results of the production testing will be used. If the results of the Government and production tests vary by 2.0 percent, but less than 4.0 percent, the average of the two will be considered the value to be used. If these vary by 4.0 percent or more, carefully evaluate each sampling and testing procedure and obtain another series of Government and production tests on duplicate samples of material. If these vary by 4.0 percent or more, use the results of the tests made by the Government and the Government will continue check testing of this item on a continuous basis until the two sets of tests agree within less than 4.0 percent on a regular basis. Testing performed by the Government does not relieve the specified testing requirements.

1.4 DELIVERY, STORAGE, AND HANDLING

1.4.1 Bulk Cementitious Materials

Provide all cementitious materials in bulk at a temperature, as delivered to storage at the site, not exceeding 150 degrees F. Provide sufficient cementitious materials in storage to sustain continuous operation of the concrete mixing plant while the pavement is being placed. Provide separate facilities to prevent any intermixing during unloading, transporting, storing, and handling of each type of cementitious material.

1.4.2 Aggregate Materials

Store aggregate at the site of the batching and mixing plant avoiding breakage, segregation, intermixing or contamination by foreign materials. Store each size of aggregate from each source separately and allow the fine aggregate and the smallest size coarse aggregate to drain. Provide a minimum 24 inch thick sacrificial layer left undisturbed for each aggregate stored on ground or provide a hard surface course beneath the stockpiles. Maintain sufficient aggregate at the site at all times to permit continuous uninterrupted operation of the mixing plant at the time concrete pavement is being placed. Do not allow tracked equipment on coarse aggregate stockpiles.

1.4.3 Other Materials

Store reinforcing bars and accessories above the ground on supports. Store all materials to avoid contamination and deterioration.

1.5 ACCEPTANCE

1.5.1 Acceptance Requirements

Provide all sampling and testing required for acceptance including batch tickets. Select sample locations on a random basis in accordance with ASTM D3665. Individuals performing sampling, testing and inspection duties are required to meet the qualifications of the accredited laboratory. The Government reserves the right to direct additional samples and tests for any area which appears to deviate from the specification requirements. Testing in these areas are additional and must meet the same requirements as random tests. Provide facilities and personnel where directed to assist in obtaining samples for any Government testing. Acceptance of work is based on compliance with the pavement characteristics discussed below.

1.5.2 Concrete Strength

Acceptance test results are the average strengths of two specimens tested at 28 days. The strength of the concrete is considered satisfactory so long as every average of three consecutive acceptance test results equal or exceeds the specified compressive strength (f'c) and no individual test result falls below f'c by more than 500 psi. Remove and replace the deficient area where any portion of the work fails to meet the acceptance criteria for concrete strength, at no additional cost to the Government.

1.5.3 Thickness

Provide the pavement design thickness required. Measure pavement thickness in accordance with ASTM C174/C174M using cores taken from the completed pavement section. Record and report all pavement thicknesses. If any thicknesses deviate from the design thickness by more than the values listed in Table 1 Maximum Job Thickness Deviations, remove and replace full panels as necessary to bring the pavement within tolerance.

Table 1
Maximum Job Thickness Deviations

Job Design Thickness	Individual Thickness Deficiency Greater than or Equal to	Average Job Thickness Deficiency Greater than or Equal to
Greater than or equal to 8 inches	0.75 inch	0.50 inch
Less than 8 inches	0.50 inch	0.25 inch

1.5.4 Surface Smoothness

Provide all other airfield areas with a variation from a straight edge not greater than 1/4 inch in either the longitudinal or transverse direction. Perform all smoothness testing on each design lane and report all measurements to the nearest 1/16 in. Perform the testing at 5 foot intervals. Smoothness requirements do not apply over crowns, drainage structures, or similar penetrations. Where more than 20.0 percent of the measurements exceed the tolerance, remove and replace full panels at no

additional cost to the Government to bring the full design lane within tolerance.

1.5.5 Grade

Provide finished surfaces of all airfield pavements that vary less than 1/2 inch above or below the plan grade line or elevation indicated. The above deviations from the approved grade line and elevation are not permitted in areas where closer conformance with the planned grade and elevation is required for the proper functioning of appurtenance structures. Provide finished surfaces of new abutting pavements that coincide at their juncture. Provide horizontal control of the finished surfaces of all airfield pavements that vary not more than 1/2 inch from the design joint alignment indicated. Remove and replace full panels where the deviation from grade exceeds the specified tolerances by 50 percent or more, at no additional cost to the Government.

1.5.6 Diamond Grinding

The maximum depth of diamond grinding is 1/4 inch. Remove and replace all pavement areas requiring plan grade or surface smoothness corrections in excess of the maximum diamond grinding depth permitted, at no additional cost to the Government.

Submit a Diamond Grinding Plan for review and approval prior to diamond grinding. At a minimum, include the daily reports for the deficient areas, the location and extent of deficiencies, corrective actions, and equipment. Those performing diamond grinding are required to have a minimum of three years experience in diamond grinding of airfield 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 and area are limited above. Reduce high areas by diamond grinding the hardened concrete with an approved equipment after the concrete is at a minimum age of 14 days. Remove and replace all pavement areas requiring plan grade or surface smoothness corrections in excess of the limits specified above in conformance with paragraph REPAIR, REMOVAL AND REPLACEMENT OF NEWLY CONSTRUCTED SLABS. All areas in which diamond grinding has been performed are subject to the thickness tolerances specified in paragraph THICKNESS, above.

Prior to production diamond grinding operations, perform a test section at the approved location. Perform a test section that consists of a minimum of two adjacent passes with a minimum length of 40 feet to allow evaluation of the finish, transition between adjacent passes, and the results of crossing a transverse joint. Production diamond grinding operations are not to be performed prior to approval.

1.5.6.1 Bumps

Reduce any bumps by diamond grinding areas exceeding the tolerances shown by the smoothness measurements. Continue diamond grinding until the tolerances for surface smoothness are met. Taper such diamond grinding in all directions to provide smooth transitions to areas not requiring diamond grinding. Perform additional smoothness measurements in all areas corrected by diamond grinding and report results to the nearest 1/16 in.

1.5.7 Deficient Areas

The size of a deficient area is measured as one or more failing tests or

measurements that are in between two passing tests. Deficient areas may be reduced in size by performing additional tests or measurements to show areas that meet the requirements for acceptance.

1.5.8 Laboratory Accreditation

Provide laboratory and testing facilities. Submit accreditation of the commercial laboratory by an independent evaluation authority, indicating conformance to ASTM C1077, including all applicable test procedures identified in this specification. If multiple laboratories are proposed, identify which tests will be conducted by each. Submit accreditation documentation a minimum of 30 days before any specified testing is performed. The laboratories performing the tests are required to be accredited in accordance with ASTM C1077, including ASTM C78/C78M and ASTM C1260. Provide current accreditation and include the required and optional test methods, as specified.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

This section is intended to stand alone for construction of concrete airfield pavement. However, where the construction covered herein interfaces with other sections, construct each interface to conform to the requirements of both this section and the other section including tolerances for both.

2.2 CEMENTITIOUS MATERIALS

Provide cementitious materials consisting of blended cement or portland cement in combination with supplementary cementitious materials (SCM), that conform to appropriate specifications listed below. New submittals are required when the cementitious materials sources or types change.

2.2.1 Portland Cement

Provide portland cement conforming to ASTM C150/C150M, Type II.

2.2.2 Pozzolan

2.2.2.1 Fly Ash

Provide fly ash conforming to ASTM C618, Class F including the optional requirement for uniformity and a loss on ignition not exceeding 3 percent. Provide Class F fly ash for use in mitigating Alkali-Silica Reactivity with a total equivalent alkali content less than 4 percent.

2.2.2.2 Raw or Calcined Natural Pozzolan

Provide natural pozzolan that is raw or calcined and conforms to ASTM C618, Class N, including the optional requirements for uniformity and a loss on ignition not exceeding 6 percent. Provide Class N pozzolan for use in mitigating Alkali-Silica Reactivity with a total equivalent alkali content less than 4 percent.

2.2.2.3 Ultra Fine Fly Ash and Ultra Fine Pozzolan

Provide 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 of at least 95 percent of the control specimens.

b. The average particle size is a maximum of 6 microns.

2.2.3 Slag Cement

Provide slag cement (ground-granulated blast-furnace slag) that conforms to ASTM C989/C989M, Grade 100 or Grade 120.

2.2.4 Supplementary Cementitious Materials (SCM) Content

Provide a concrete mix that contains one of the SCMs in Table 2 within the ranges specified therein.

TABLE 2

SUPPLEMENTARY CEMENTITIOUS MATERIALS CONTENT

Supplementary Cementitious Material	Minimum Content (percent)	Maximum Content (percent)
Class F Fly Ash and Class N Pozzolan	25	35
Slag Cement	40	50

2.3 AGGREGATES

2.3.1 Aggregate Sources

2.3.1.1 Durability of Coarse Aggregate

Provide durable aggregate that meets one of the following requirements:

a. Provide aggregate with a satisfactory service record in freezing and thawing of at least 5 years successful service in three concrete paving projects. Include a condition survey of the existing concrete and a review of the concrete-making materials, including coarse aggregates, cement, and mineral admixtures in the service record. Consider the previous aggregate source and test results, cement mill certificate data, mineral admixture chemical and physical composition, and the mix design (cement factor and water-cementitious material ratio) in the review. Provide service record performed by an independent third party professional engineer, petrographer, or concrete materials engineer along with their resume. Include photographs and a written report addressing D-cracks and popouts in accordance with ACI 201.1R in the service record.

b. Provide coarse aggregate with a durability factor of 80 or more when subjected to freezing and thawing of specimens prepared in accordance with ASTM C1646/C1646M and tested in accordance with ASTM C666/C666M, Procedure A. Test all coarse aggregate size groups and sources proposed for use individually. Historical data, within 2 years of proportioning studies submission, that is representative of material on the project may be provided.

c. Provide coarse aggregate with a maximum sodium sulfate soundness loss of 12 percent, or with a magnesium sulfate soundness loss of 18 percent after five cycles when tested in accordance with ASTM C88.

2.3.1.2 Alkali-Silica Reactivity

Evaluate and test fine and coarse aggregates to be used in all concrete for alkali-aggregate reactivity. Test all aggregate fractions, size groups, and sources proposed for use individually.

a. Evaluate the fine and coarse aggregates separately using ASTM C1260. If the expansion is less than 0.30 percent after 14 days of immersion in a 1N NaOH solution, provide a SCM within the limits of Table 2.

b. If any individual aggregate has an expansion greater than 0.30 percent after 14 days of immersion in a 1N NaOH solution, reject the aggregate(s) and submit new aggregate sources for retesting. As an alternative provide low alkali portland cement or blended cement and SCM within the limits of Table 2 that has a measured expansion less than 0.08 percent after 28 days of immersion in 1N NaOH solution in accordance with ASTM C1567.

2.3.1.3 Combined Aggregate Gradation

In addition to the grading requirements specified for coarse aggregate and for fine aggregate, provide the combined aggregate grading meeting the following requirements:

a. Provide materials selected and the proportions used such that when the Coarseness Factor (CF) and the Workability Factor (WF) are plotted on a diagram as described in d. below, the point and its associated production tolerance thus determined falls within the parallelogram described therein. Refer to TSPWG M 3-250-04.97-05 for combined aggregate plot area recommendations for the intended placement technique(s).

b. Determine the Coarseness Factor (CF) from the following equation:

$$CF = \frac{\text{(cumulative percent retained on the 3/8 inch sieve)(100)}}{\text{(cumulative percent retained on the No. 8 sieve)}}$$

c. The Workability Factor (WF) is defined as the percent passing the No. 8 sieve based on the combined aggregate gradation. Adjust the WF, prorated upwards only, by 2.5 percentage points for each 94 pounds per cubic yard of cementitious material greater than 564 pounds per cubic yard.

d. Plot a diagram using a rectangular scale with WF on the Y-axis with units from 20 (bottom) to 45 (top), and with CF on the X-axis with units from 80 (left side) to 30 (right side). On this diagram, plot a parallelogram with corners at the following coordinates (CF-75, WF-28), (CF-75, WF-40), (CF-45, WF-32.5), and (CF-45, WF-44.5). If the point determined by the intersection of the computed CF and WF does not fall within the above parallelogram, revise the grading of each size of aggregate used and the proportions selected as necessary.

e. Plot the associated production tolerance limits, identified in Table 8, around the CF and adjusted WF point.

2.3.2 Coarse Aggregate

2.3.2.1 Material Composition

Provide coarse aggregate consisting of crushed or uncrushed gravel, crushed stone, or a combination thereof. Provide aggregates, as delivered to the mixers, consisting of clean, hard, uncoated particles meeting the requirements of ASTM C33/C33M except as specified herein. Provide coarse aggregate with no more than 40 percent loss when subjected to the Los Angeles abrasion test in accordance with ASTM C131/C131M. Provide coarse aggregates with a maximum sodium sulfate soundness loss of 12 percent, or with a magnesium sulfate soundness loss of 18 percent after five cycles when tested in accordance with ASTM C88.

2.3.2.2 Particle Shape Characteristics

Provide particles of the coarse aggregate that are generally spherical or cubical in shape. The quantity of flat particles and elongated particles in any size group coarser than the 3/8 inch sieve are not allowed to exceed 20 percent by weight as determined by the Flat Particle Test and the Elongated Particle Test of ASTM D4791. A flat particle is defined as one having a ratio of width to thickness greater than 3; an elongated particle is one having a ratio of length to width greater than 3.

2.3.2.3 Size and Grading

Provide coarse aggregate with a nominal maximum size of 1.5 inches with a minimum of 10 percent retained on the 1.0 inch sieve of the proposed combined aggregate gradation that meets the criteria of paragraph COMBINED AGGREGATE GRADATION. Grade and provide the coarse aggregates in a minimum of two size groups meeting the individual grading requirements of ASTM C33/C33M, Size No. 4 (1.5 ins. to 0.75 in.) and Size No. 67 (0.75 in. to No. 4). A third coarse aggregate size group may be required to meet the criteria of paragraph COMBINED AGGREGATE GRADATION. Mix designs that include a minimum of three coarse aggregate size groups can use grading limits not defined by ASTM C33/C33M provided all other requirements are met. Provide upper and lower grading limits of historic gradations for all proposed coarse aggregates not defined by ASTM C33/C33M.

2.3.2.4 Deleterious Materials - Airfield Pavements

The amount of deleterious material in each size group of coarse aggregate is not allowed to exceed the limits shown in Table 3 below, determined in accordance with the test methods shown.

TABLE 3

LIMITS OF DELETERIOUS MATERIALS IN COARSE AGGREGATE FOR AIRFIELD PAVEMENTS

Materials (d)	Percentage by Mass
Clay lumps and friable particles (ASTM C142/C142M)	1.0
Material finer than No. 200 sieve (a) (ASTM C117)	1.0

TABLE 3	
LIMITS OF DELETERIOUS MATERIALS IN COARSE AGGREGATE FOR AIRFIELD PAVEMENTS	
Materials (d)	Percentage by Mass
Lightweight particles (b) (ASTM C123/C123M)	0.5
Chert, cherty stone, and other aggregates (less than 2.40 Sp. Gr.) (c) (ASTM C123/C123M and ASTM C295/C295M)	1.0
(a) Limit for material finer than No. 200 sieve is allowed to be increased to 1.5 percent for crushed aggregates if the fine material consists of crusher dust that is essentially free from clay or shale. Use X-Ray Diffraction or other appropriate techniques as determined by petrographer to quantify amount and justify increase.	
(b) Test with a separation medium with a density of Sp. Gr. of 2.0. This limit does not apply to coarse aggregate manufactured from blast-furnace slag unless contamination is evident.	
(c) Chert is defined as a rock composed of quartz, chalcedony or opal, or any mixture of these forms of silica. It is variable in color. The texture is so fine that the individual mineral grains are too small to be distinguished by the unaided eye. Its hardness is such that it scratches glass but is not scratched by a knife blade. It may contain impurities such as clay, carbonates, iron oxides, and other minerals. Cherty stone is defined as any type of rock (generally limestone) that contains chert as lenses and nodules, or irregular masses partially or completely replacing the original stone. Other aggregates consist of obsidian, ash tuff, and palygorskite.	
(d) Perform testing in accordance with the referenced test methods, except use the minimum sample size specified below.	

2.3.2.5 Testing for Deleterious Materials in Coarse Aggregate

No extension of time or additional payment due to any delays caused by the testing, evaluation, or personnel requirements is allowed. The minimum test sample size of the coarse aggregate is 33 pounds for the 3/4 inch and larger maximum size and 19 pounds for the No. 4 to 3/4 inch coarse aggregate. Provide facilities for the ready procurement of representative test samples.

2.3.3 Fine Aggregate

2.3.3.1 Composition

Provide fine aggregate consisting of natural sand, manufactured sand, or a combination of the two, each composed of clean, hard, durable particles meeting the requirements of ASTM C33/C33M. Stockpile and batch each type of fine aggregate separately. Provide fine aggregate with particles that are generally spherical or cubical in shape. For fine aggregate provided as a combination of sources, test each source individually.

2.3.3.2 Grading

Provide fine aggregate, as delivered to the mixer, with a grading that conforms to the requirements of ASTM C33/C33M and having a fineness modulus of not less than 2.50 nor more than 3.40. For fine aggregate supplied as a combination of sources, determine the fineness modulus on a composite sample.

2.3.3.3 Deleterious Material

The minimum test sample size for fine aggregate proposed for use in airfield paving is 10 pounds. The amount of deleterious material in the fine aggregate is not to exceed the limits listed in table 4 when performed on the full sample:

TABLE 4

LIMITS OF DELETERIOUS MATERIALS IN FINE AGGREGATE

Material	Percentage by Mass
Clay lumps and friable particles ASTM C142/C142M	1.0
Material finer than No. 200 sieve ASTM C117	3.0
Lightweight particles ASTM C123/C123M using a medium with a density of Sp. Gr. of 2.0	0.5
Total of all above	3.0

2.4 CHEMICAL ADMIXTURES

2.4.1 General Requirements

Only use chemical admixtures when the specific admixture type and manufacturer is the same material used in the mixture proportioning studies. Provide air-entraining admixture conforming to ASTM C260/C260M. Use an accelerating admixture conforming to ASTM C494/C494M, Type C or Type E, when specified in paragraph MIXTURE PROPORTIONS below provided it is not used to reduce the amount of cementitious material. Calcium chloride and admixtures containing calcium chloride are not allowed. Provide retarding or water-reducing admixture that meet the requirements of ASTM C494/C494M, Type A, B, or D, except that the 6-month and 1-year compressive strength tests are waived. Type S specific performance admixtures are not allowed. ASTM C1017/C1017M flowable admixtures are not allowed.

2.4.2 High Range Water Reducing Admixture (HRWRA)

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.

2.5 MEMBRANE FORMING CURING COMPOUND

Provide membrane forming curing compound that conforms to COE CRD-C 300 and is white pigmented.

2.6 WATER

Provide water for mixing and curing that is fresh, clean, potable, and free of injurious amounts of oil, acid, salt, or alkali, except that non-potable water, or water from concrete production operations, can be used if it meets the requirements of ASTM C1602/C1602M.

2.7 JOINT MATERIALS

2.7.1 Expansion Joint Material

Provide preformed expansion joint filler material conforming to ASTM D1751 or ASTM D1752 Type II or III. Provide expansion joint filler that is 3/4 inch thick, unless otherwise indicated, and provided in a single full depth piece.

2.7.2 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.

2.8 REINFORCING

Provide reinforcement that is free from loose, flaky rust, loose scale, oil, grease, mud, or other coatings that might reduce the bond with concrete. Removal of thin powdery rust and tight rust is not required. However, reinforcing steel which is rusted to the extent that it does not conform to the required dimensions or mechanical properties is not allowed to be used.

2.8.1 Reinforcing Bars and Bar Mats

Provide deformed reinforcing bars conforming to ASTM A615/A615M, Grade 60 or ASTM A996/A996M, Grade 60. Provide bar mats conforming to ASTM A184/A184M.

2.8.2 Welded Wire Reinforcement

Provide welded wire reinforcement that is deformed or smooth, conforming to ASTM A1064/A1064M or ASTM A185/A185M, and provided in flat sheets.

2.9 DOWELS

2.9.1 Dowels

Provide dowels in single piece bars fabricated or cut to length at the shop or mill before delivery to the site. Dowels are to be free of loose, flaky rust and loose scale and be clean and straight. Dowels may be sheared to length provided that the deformation from true shape caused by shearing does not exceed 0.04 inch on the diameter of the dowel and does not extend more than 0.04 inch from the end of the dowel. Dowels are required to be smooth steel bars conforming to ASTM A615/A615M, Grade 40 or 60; ASTM A996/A996M, Grade 50 or 60. Epoxy coat dowels in conformance with Type 1 coating requirements of ASTM A1078/A1078M, to include the ends. Provide grout retention rings that are fully circular metal or plastic devices capable of supporting the dowel until the epoxy hardens. Dowel sleeves or inserts are not permitted.

2.9.2 Dowel Bar Assemblies

Provide dowel bar assemblies that consist of a framework of metal bars or wires arranged to provide rigid support for the dowels throughout the paving operation, with a minimum of four continuous bars or wires extending along the joint line. Provide dowels that are welded to the assembly or held firmly by mechanical locking arrangements that prevent them from rising, sliding out, or becoming distorted during paving operations.

2.10 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 required for use as patching materials for complete filling of spalls, saw-cut runouts, 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 required for bonding freshly mixed portland cement concrete or mortar or freshly mixed epoxy resin concrete or mortar to hardened concrete.

2.11 EQUIPMENT

Maintain all plant, equipment, tools, and machines used in the work in satisfactory working conditions at all times. Submit the following:

a. Details and data on the batching and mixing plant prior to plant assembly including manufacturer's literature showing that the equipment meets all requirements specified herein.

b. Obtain National Ready Mixed Concrete Association (NRMCA) certification of the concrete plant, at no expense to the Government. Provide inspection report of the concrete plant by an engineer approved by the NRMCA. A list of NRMCA approved engineers is available on the NRMCA

website at http://www.nrmca.org. Submit a copy of the NRMCA QC Manual Section 3 Concrete Plant Certification Checklist, NRMCA Certificate of Conformance, and Calibration documentation on all measuring and weighing devices prior to uniformity testing.

c. A description of the equipment proposed for transporting concrete mixture from the central mixing plant to the paving equipment.

d. A description of the equipment proposed for the machine and hand placing, consolidating and curing of the concrete mixture. Manufacturer's literature on the paver and finisher, together with the manufacturer's written instructions on adjustments and operating procedures necessary to assure a tight, smooth surface on the concrete pavement. The literature is required to show that the equipment meets all details of these specifications.

2.11.1 Truck

Truck mixers are not allowed for mixing or transporting slipformed paving concrete. Provide only truck mixers designed for mixing or transporting paving concrete with extra large blading and rear opening specifically for low-slump paving concrete. Provide truck mixers, the mixing of concrete therein, and concrete uniformity and testing thereof that conform to the requirements of ASTM C94/C94M. Determine the number of revolutions between 70 to 100 for truck-mixed concrete and the number of revolutions for shrink-mixed concrete by uniformity tests as specified in ASTM C94/C94M and in requirements for mixer performance stated in paragraph TESTING AND INSPECTION FOR CONTRACTOR QUALITY CONTROL DURING CONSTRUCTION in PART 3. If requirements for the uniformity of concrete are not met with 100 revolutions of mixing after all ingredients including water are in the truck mixer drum, discontinue use of the mixer until the condition is corrected. 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.

2.11.2 Transporting Equipment

Deliver concrete to the paving site in accordance with ASTM C94/C94M. Do not use non-agitating equipment unless total haul time is less than 15 minutes.Provide transporting equipment designed and operated to deliver and discharge the required concrete mixture completely without segregation.

2.11.3 Paver-Finisher

2.11.3.1 General

Use a heavy duty vibratory truss screed or triple roller tube paver for concrete placement.

2.11.3.2 Heavy Duty Vibratory Truss Screed

Provide a heavy duty vibratory truss screed designed specifically for

paving and finishing low slump concrete with an engine having a minimum of 9 horsepower. The truss screed is required to be easily adjustable and capable of spanning the lane being paved with a minimum weight of 18 pounds per foot of lane width. Operate the screed to shape, compact, and smooth the surface and finish the surface so that no significant amount of hand finishing except use of cutting straightedges is required. Provide adjustment for variation in lane width or thickness and to prevent more than 8 inches of the screed extending over previously placed or existing concrete.

2.11.3.3 Triple Roller Tube Paver

Provide a triple roller tube paver with an engine having a minimum of 74 horsepower. The paver is required to be easily adjustable and capable of spanning the lane being paved with a minimum weight of 480 pounds per foot of lane width. Operate the paver to shape, compact, and smooth the surface and finish the surface so that no significant amount of hand finishing except use of cutting straightedges is required.

2.11.3.4 Vibrators

Provide full-depth consolidation using immersion vibrators from a work bridge. Provide vibrators that can be operated at any desired depth within the slab and can be completely withdrawn from the concrete as required. Equip vibrators with controls to immediately stop vibration as forward motion of the work ceases. Space immersion vibrators across the paving lane as necessary to properly consolidate the concrete with a maximum clear distance between vibrators of 30 inches. Place outside vibrators within 12 inches from the lane edge. Measure the vibrator frequency and amplitude in accordance with COE CRD-C 521.

2.11.3.5 Other Types of Finishing Equipment

Grate tampers (jitterbugs), laser screeds, single or double rotating tube floats, or bridge deck finishers are not allowed.

2.11.4 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 paragraph MEMBRANE CURING. Provide hand-operated sprayers allowed by that paragraph with 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.

2.11.5 Texturing Equipment

Provide texturing equipment as specified below. Before use, demonstrate the texturing equipment on a test section, and modify the equipment as

necessary to produce the texture directed.

2.11.5.1 Burlap Drag

Securely attach a burlap drag to a separate wheel mounted frame spanning the paving lane or to one of the other similar pieces of equipment. Provide length of the material between 24 to 36 inches dragging flat on the pavement surface. Provide burlap drag with a width at least equal to the width of the slab. Provide clean, reasonably new burlap material, completely moistened before start of use, and keep clean and maintained moist during use. Provide burlap conforming to AASHTO M 182, Class 3 or 4.

2.11.5.2 Broom

Apply surface texture using an approved stiff bristle broom drag of a type that provides a uniformly scored surface transverse to the pavement center line. Provide broom with handles longer than the width of slab to be finished capable of traversing the full width of the pavement at a uniform speed and with a uniform pressure that results in scores uniform in appearance and approximately 1/16 inch in depth but not more than 1/8 inch in depth.

2.11.6 Sawing Equipment

Provide saws capable of sawing to the full depth required.

2.11.6.1 Diamond Saw

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. 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.

2.11.6.2 Wheel Saw

Provide wheel saws used in the removal of concrete with large diameter tungsten carbide tipped blades mounted on a heavy-duty chassis which produce a saw kerf at least 1-1/2 inches wide.

2.11.7 Straightedge

Provide and maintain at the job site, in good condition, a minimum 12 foot straightedge for each paving train for testing the hardened portland cement concrete surfaces. Provide straightedges constructed of aluminum or magnesium alloy and blades of box or box-girder cross section with flat bottom, adequately reinforced to insure rigidity and accuracy. Provide straightedges with handles for operation on the pavement.

2.11.8 Work Bridge

Provide a self-propelled working bridge capable of spanning the required paving lane width where workmen can efficiently and adequately reach the pavement surface.

2.11.9 Diamond Grinding of PCC Surfaces

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 55 to 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. Provide diamond grinding machine equipped to flush and vacuum the pavement surface. Dispose of all debris from diamond grinding operations off Government property.

2.12 SPECIFIED CONCRETE STRENGTH AND OTHER PROPERTIES

2.12.1 Specified Compressive Strength

Specified flexural strength, R, for concrete is 650 psi at 28 days, as determined by tests made in accordance with ASTM C78/C78M of beams fabricated and cured in accordance with ASTM C192/C192M.

2.12.2 Water-Cementitious Materials Ratio

The allowable water-cementitious material ratio is 0.45. The water-cementitious material ratio is the equivalent water-cement ratio as determined by conversion from the weight ratio of water to cement plus SCM by the mass equivalency method described in ACI 211.1.

2.12.3 Air Content

Provide concrete that is air-entrained with a total air content of 6.0 plus or minus 1.5 percentage points, at the point of placement. Determine air content in accordance with ASTM C231/C231M.

2.12.4 Slump

The maximum allowable slump of the concrete at the point of placement is 3 inches for pavement constructed with fixed forms.

2.12.5 Concrete Temperature

The temperature of the concrete as delivered is required to conform to the requirements of paragraphs PAVING IN HOT WEATHER and PAVING IN COLD WEATHER, in PART 3. Determine the temperature of concrete in accordance with ASTM C1064/C1064M.

2.13 MIXTURE PROPORTIONS

2.13.1 Composition

Provide concrete composed of cementitious material, water, fine and coarse aggregates, and admixtures. Include supplementary Cementitious Materials (SCM) choice and usage in accordance with paragraph SUPPLEMENTARY CEMENTITIOUS MATERIALS (SCM) CONTENT. Provide a minimum total cementitious materials content of 517 pounds per cubic yard. Limit the total alkali loading contributed by the portland cement or the portland cement portion of a blended cement to a maximum of 3.0 lb per cubic yard.

Calculate the alkali loading as the product of the portland cement content of the concrete multiplied by the alkali content of the portland cement or the portland cement portion of the blended cement, divided by 100. Determine the alkali content in accordance with ASTM C114.

2.13.2 Proportioning Studies

Perform trial design batches, mixture proportioning studies, and testing, at no expense to the Government. Submit for approval the Preliminary Proposed Proportioning to include items a., b., and i. below a minimum of 7 days prior to beginning the mixture proportioning study. Submit the results of the mixture proportioning studies signed and stamped by the registered professional engineer having technical responsibility for the mix design study, and submitted at least 30 days prior to commencing concrete placing operations. Include a statement summarizing the maximum nominal coarse aggregate size and the weights and volumes of each ingredient proportioned on a one cubic yard basis. Base aggregate quantities on the mass in a saturated surface dry condition. Provide test results demonstrating that the proposed mixture proportions produce concrete of the qualities indicated. Base methodology for trial mixtures having proportions, slumps, and air content suitable for the work as described in ACI 211.1 and ACI 325.14R. Submit test results including:

a. Coarse and fine aggregate gradations and plots. Include historic gradation averages and standard deviations on individual sieves for each aggregate size group if available.

b. Combined aggregate gradation and coarseness vs. workability plots.

c. Coarse aggregate quality test results including deleterious materials.

d. Fine aggregate quality test results including deleterious materials.

e. Mill certificates for cement and supplementary cementitious materials.

f. Certified test results for air entraining, water-reducing, retarding, and non-chloride accelerating admixtures.

g. Specified compressive strength, slump, and air content.

h. Documentation of required average compressive strength, f'cr.

i. Recommended proportions and volumes for proposed mixture and each of three trial water-cementitious materials ratios.

j. Individual cylinder breaks.

k. Flexural strength summaries and plots.

l. Historical record of ACI 214R strength test results, documenting production standard deviation (if available).

m. Narrative discussing methodology on how the mix design was developed in accordance with ACI 211.1 and ACI 325.14R.

n. Alternative aggregate blending to be used during the test section if necessary to meet the required surface and consolidation requirements.

2.13.2.1 Water-Cementitious Materials Ratio

Perform at least three different water-cementitious materials ratios, which produce a range of strength encompassing that required on the project. The maximum water-cementitious materials ratio of the approved mix design becomes the maximum water-cementitious materials ratio for the project, and in no case exceeds 0.45.

2.13.2.2 Trial Mixture Studies

Perform separate sets of trial mixture studies made for each combination of cementitious materials and each combination of admixtures proposed for use. No combinations are to be used until proven by such studies, except that, if approved in writing and otherwise permitted by these specifications, an accelerating or retarding admixture can be used without separate trial mixture study. Perform separate trial mixture studies for each placing method (fixed form or hand placement) proposed. Report the temperature of concrete in each trial batch. Design each mixture to promote easy and suitable concrete placement, consolidation and finishing, and to prevent segregation and excessive bleeding. Proportion laboratory trial mixtures for maximum permitted slump and air content.

2.13.2.3 Mixture Proportioning for Compressive Strength

Follow the step by step procedure below:

a. Fabricate all beams for each mixture from the same batch or blend of batches. Fabricate and cure all beams in accordance with ASTM C192/C192M, using 6 x 6 inches steel beam molds.

b. Cure test cylinders from each mixture for 3, 7, and 28-day compressive strength tests; 3 beams to be tested per age.

c. Test beams in accordance with ASTM C39/C39M.

d. Using the average strength for each w/c at each age, plot all results from each of the three mixtures on separate graphs for w/c versus:

    3-day compressive strength
    7-day compressive strength
    28-day compressive strength

e. From these graphs select a w/c that produces a mixture giving a 28-day compressive strength equal to the required average compressive strength (f'cr) determined in accordance with the next paragraph.

f. If there is a change in materials, perform additional mixture design studies using the new materials.

g. No concrete pavement placement is allowed until the mixture proportions are approved. The approved water-cementitious materials ratio is restricted to the maximum w/c ratio and is not be increased without written approval.

h. If previous trial mixture studies have been completed and approved using the same materials within one year only one w/c ratio is required for verification purposes. Select a w/c ratio within the range of the previous trial mixture studies.

2.13.3 Required Average Flexural Strength

Establish mixture proportions during trial mixture studies that produce a required average flexural strength (Ra) exceeding the specified flexural strength (R) by the amount indicated below.

2.13.3.1 From Previous Test Records

Where a concrete production facility has previous test records current to within 24 months, establish a standard deviation in accordance with the applicable provisions of ACI 214R. Test records used to calculate the standard deviation are to be representative of materials, quality control procedures, and expected conditions. Test records are to be within 1000 psi of the strength specified for the proposed work and consist of at least 30 consecutive tests. A strength test is the average of the strengths of two specimens made from the same sample of concrete and tested at 28-days. Use the equations below to compute the required average compressive strength (f'cr):

$$f'_{cr,1} = f'_c + 1.34KS$$

$$f'_{cr,2} = f'_c + 2.33KS - 500 \text{ psi}$$

$$f'_{cr,final} = \text{larger of } f'_{cr,1} \text{ and } f'_{cr,2}$$

Where:
f'c = specified compressive strength
K = Modification factor
S = Standard Deviation

Where a concrete production facility does not have test records meeting the requirements above but does have a record based on 15 to 29 consecutive tests, establish a standard deviation as the product of the calculated standard deviation and a modification factor from Table 5

TABLE 5

MODIFICATION FACTOR FOR STANDARD DEVIATION

NUMBER OF TESTS	MODIFICATION FACTOR (K)
20	1.08
25	1.03
30 or more	1.00

2.13.3.2 Without Previous Test Records

When a concrete production facility does not have sufficient field strength test records for calculation of the standard deviation, determine the required average compressive strength (f'cr) by the following equation:

$$f'_{cr} = f'_c + 1{,}200 \text{ psi}$$

PART 3 EXECUTION

3.1 PREPARATION FOR PAVING

Perform the following actions to prepare for paving operations:

a. Concrete plant has been inspected and approved. Mixer uniformity testing for optimum mixing time has been determined.

b. All equipment in the paving train is in operational condition, ready for use, clean, and free of hardened concrete and foreign material.

c. An acceptable length of grade for concrete paving is available. All base materials are verified to conform to project plans and specification requirements.

d. Test reports for all materials in the concrete mixture are on file at the job site and at the plant site.

e. Backup testing equipment and a test equipment backup plan is available.

f. All necessary concrete placement tools such as hand tools, straight edges, hand floats, edgers, and hand vibrators are available.

g. The needed number of haul trucks are available.

h. Vibrators have been checked for frequency and amplitude. Vibrator spacing has been checked and conforms to the vibrator manufacturer recommendations.

i. Measures have been developed and taken to mitigate extreme weather conditions during paving.

j. Weather forecast for each day of paving is available and checked daily.

k. Fixed-forms and reinforcing steel is placed, clean, and adequately supported.

3.1.1 Weather Precaution

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. During these conditions, monitor and report the evaporation rate hourly.

3.1.2 Proposed Techniques

Submit placing and protection methods; paving sequence; jointing pattern; data on curing equipment; demolition of existing pavements; pavement diamond grinding equipment and procedures. Submit for approval 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; transverse and longitudinal dowel bar spacing; and identifying paving lanes and hand placement areas. Deviations from the jointing pattern shown on the drawings are not allowed without written approval of the design engineer.

c. Plan and equipment proposed to control alignment of sawn joints within the specified tolerances.

d. Data on the curing equipment, media and methods to be used.

e. Method used to measure pavement smoothness.

f. Pavement demolition work plan, presenting the proposed methods and equipment to remove existing pavement and protect pavement to remain in place.

g. Submit a Diamond Grinding Plan for review and approval prior to diamond grinding. At a minimum, include the daily reports for the deficient areas, the location and extent of deficiencies, corrective actions, and equipment. Those performing diamond grinding are required to have a minimum of three years experience in diamond grinding of airfield 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.

3.2 CONDITIONING OF UNDERLYING MATERIAL

3.2.1 General Procedures

Confirm the underlying material upon which concrete is to be placed is clean, damp, and free of debris, waste concrete, waste cement, frost, ice, standing water, and running water. Confirm the underlying material is well drained and has been satisfactorily graded and uniformly compacted in accordance with Section 32 11 20 BASE COURSE FOR RIGID PAVING prior to setting forms or placement of concrete. Rework and compact any underlying material disturbed by construction operations to specified density immediately in front of the paver.

3.2.2 Traffic on Underlying Material

Transporting equipment is not to be allowed to operate on the prepared and compacted underlying material in front of the paver-finisher. Subject to specific approval, crossing of the prepared underlying material at specified intervals for construction purposes may be permitted, provided rutting or indentations do not occur. Rework and repair the surface before concrete is placed.

3.3 WEATHER LIMITATIONS

3.3.1 Placement and Protection During 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. Immediately cover and protect all unhardened concrete from rain or other

damaging weather. Suspend placement of concrete whenever rain, high winds, or other 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.

Remove and replace any slab damaged by rain or other weather full depth by full slab width to the nearest original joint as specified in paragraph REPAIR, REMOVAL AND REPLACEMENT OF NEWLY CONSTRUCTED SLABS, at no expense to the Government.

3.3.2 Paving in Hot Weather

Prepare for hot weather paving in accordance with ACI 305R. When the ambient temperature during paving is expected to exceed 90 degrees F, properly place and finish the concrete in accordance with procedures previously submitted, approved, and as specified herein. Provide concrete that does not exceed 95 deg F when measured in accordance with ASTM C1064/C1064M at the time of delivery. Cool the mixing water or aggregates or place in the cooler part of the day to obtain an adequate placing temperature. Cool steel forms and reinforcing as needed to maintain steel temperatures below 120 degrees F. Cool or protect transporting and placing equipment if necessary to maintain proper concrete placing temperature. Keep the finished surfaces of the newly laid pavement damp by applying a fog spray (mist) with approved spraying equipment until the pavement is covered by the curing medium.

3.3.3 Prevention of Plastic Shrinkage Cracking

Develop and institute measures to prevent plastic shrinkage cracks during weather with low humidity, high temperature, or appreciable winds. Halt further placement of concrete if plastic shrinkage cracking occurs 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, further protect the concrete placement 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 monomolecular films in the finishing process. Immediately commence curing procedures when such water treatment is stopped. Repair plastic shrinkage cracks in accordance with paragraph REPAIR, REMOVAL AND REPLACEMENT OF NEWLY CONSTRUCTED SLABS. Never trowel over or fill plastic shrinkage cracks with slurry.

3.3.4 Paving in Cold Weather

Cold weather paving is required to conform to ACI 306R. During periods of cold-weather protection make daily reports of pertinent temperatures. Use special protection measures, as specified herein, if freezing temperatures are anticipated or occur before the expiration of the specified curing period. Do not begin placement of concrete unless the ambient temperature is at least 35 degrees F and rising. Thereafter, halt placement of concrete whenever the ambient temperature drops below 40 degrees F. When the ambient temperature is less than 50 degrees F, the temperature of the concrete when placed is required to be not less than 50 degrees F nor more than 75 degrees F. Provide heating of the mixing water or aggregates as required to regulate the concrete placing temperature. Provide materials entering the mixer that are free from ice, snow, or frozen lumps. Do not incorporate salt, chemicals, or other materials in the concrete to prevent freezing. Provide covering and other means for maintaining 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. Remove pavement slabs, full depth by full width, damaged by freezing or falling below freezing temperature to the nearest planned joint, and replace as specified in paragraph REPAIR, REMOVAL AND REPLACEMENT OF NEWLY CONSTRUCTED SLABS, at no expense to the Government.

3.4 CONCRETE PRODUCTION

Provide batching, mixing, and transporting equipment with a capacity sufficient to maintain a continuous, uniform forward movement of the paving operation. Deposit concrete transported in truck mixers in front of the paver within 90 minutes from the time cement has been charged into the mixer drum of the plant or truck mixer. If the ambient temperature is above 90 degrees F, the time is reduced to 60 minutes. Accompany every load of concrete delivered to the paving site with a batch ticket from the operator of the batching plant. Provide batch ticket information required by ASTM C94/C94M on approved forms. In addition provide design quantities in mass or volume for all materials, batching tolerances of all materials, and design and actual water cementitious materials ratio on each batch delivered, the water meter and revolution meter reading on truck mixers and the time of day. Provide batch tickets for each truck delivered to the placing foreman to maintain on file. Submit batch tickets to the Government weekly.

3.4.1 Batching and Mixing Concrete

Maintain scale pivots and bearings clean and free of rust. Remove any equipment which fails to perform as specified immediately from use until properly repaired and adjusted, or replaced.

3.4.2 Transporting and Transfer - Spreading Operations

Deposit concrete as close as possible to its final position in the paving lane. Operate all equipment to discharge and transfer concrete without segregation. Dumping of concrete in discrete piles is not permitted. Operate non-agitating equipment only on smooth roads and for haul time less than 15 minutes. No transfer or spreading operation which requires the use of front-end loaders, dozers, or similar equipment to distribute the concrete is permitted. Do not exceed a free vertical drop of 3 feet at any point in concrete conveyance. No equipment is permitted to operate on the grade in front of the paver.

3.5 PAVING

3.5.1 General Requirements

Construct pavement with paving and finishing equipment utilizing rigid fixed forms. Control paving equipment and its operation with all other operations such that the paver-finisher has a continuous forward movement at a reasonably uniform speed from beginning to end of each paving lane. Failure to achieve a continuous forward motion requires halting operations, regrouping, and modifying procedures, equipment, or mix proportions to achieve this requirement. Personnel are not permitted to walk or operate in the plastic concrete at any time. Select paving equipment and procedures which can properly operate on open-graded drainage layers without causing displacement or other damage.

3.5.2 Consolidation

Consolidate the concrete full-depth by use of immersion vibrators operated from a work bridge spanning the lane of placement. Do not use vibrators to transport or spread the concrete. Insert vibrators into the concrete to a depth that provides the best full-depth consolidation but not closer to the underlying material than 2 inches. Insert hand-operated vibrators between 6 to 15 inches on centers. Do not use hand-operated vibrators in the concrete in one location for more than 20 seconds. If vibrators cause visible tracking in the paving lane, or there are any other indications of inadequate consolidation (honeycomb along the edges, large air pockets or other voids, or any other evidence), discontinue paving operations until equipment and procedures have been modified to prevent it. Excessive vibration is not permitted. See ACI 309R for additional guidance on internal consolidation. Provide at least one additional vibrator spud or sufficient parts for rapid replacement and repair of vibrators at the paving site at all times.

3.5.3 Operation

3.5.3.1 Headers

Maintain a sufficient amount of concrete ahead of the paver to provide a roll of concrete which spills over the header. Provide a sufficient amount of extra concrete to prevent any slurry that is formed and carried along ahead of the paver from being deposited adjacent to the header. Maintain the spud vibrators in front of the paver-finisher operation at the desired depth as close to the header as possible before they are lifted. Provide additional consolidation adjacent to the headers by hand-manipulated vibrators.

3.5.3.2 Fill-In Lanes

Provide provisions to prevent damage to the previously constructed or existing pavement when placing fill-in lanes. Control heavy duty vibratory truss screeds and triple roller tubes from applying excess pressure to the existing pavement and to prevent abrasion of the pavement surface. Maintain the overlapping area of existing pavement surface completely free of any loose or bonded foreign material as the paver-finisher operates across it.

3.5.4 Required Results

Adjust and operate the paver-finisher to produce a well consolidated slab throughout that is true to line and grade within specified tolerances. Provide a paver-finishing operation that produces a surface finish with a minimum, isolated amount of irregularities, tears, voids of any kind, and any other discontinuities across the pavement. Provide equipment and paving operations that produce a finished surface requiring only the use of cutting straightedges. Keep hand finishing behind the paving equipment to a minimum.

3.5.5 Fixed Form Paving

Provide paving equipment for fixed-form paving and the operation that conforms to the requirements of paragraph EQUIPMENT, and all requirements specified herein.

3.5.5.1 Forms for Fixed-Form Paving

a. Provide straight forms made of steel and in sections not less than 10 feet in length that are clean and free of rust or other contaminants. Seal any holes or perforations in forms prior to paving unless otherwise permitted. Maintain forms in place and passable by all equipment necessary to complete the entire paving operation without need to remove horizontal form supports. Provide flexible or curved forms of proper radius for curves of 100-foot radius or less. Provide wood forms for curves and fillets made of well-seasoned, surfaced plank or plywood, straight, and free from warp or bend that have adequate strength and are rigidly braced. Provide forms with a depth equal to the pavement thickness at the edge. Where the project requires several different slab thicknesses, forms may be built up to provide an increase in depth of not more than 25 percent by bolting or welding a tubular metal section or by bolting wood planks to the bottom of the form to completely cover the underside of the base of the form. Provide forms with the base width of the one-piece or built-up form not less than eight-tenths of the vertical height of the form, except provide forms 8 inches or less in vertical height with a base width not less than the vertical height of the form. Provide forms with maximum vertical deviation of top of any side form, including joints, not varying from a true plane more than 1/8 inch in 10 feet, and the upstanding leg not varying more than 1/4 inch.

b. Provide form sections that are tightly locked and free from play or movement in any direction. Provide forms with adequate devices for secure settings so that when in place they withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment.

c. Set forms for full bearing on foundation for entire length and width and in alignment with edge of finished pavement. Support forms during entire operation of placing, compaction, and finishing so that forms do not deviate vertically more than 0.01 foot from required grade and elevations indicated. Check conformity to the alignment and grade elevations shown on the drawings and make necessary corrections immediately prior to placing the concrete. Clean and oil the forms each time before concrete is placed. Concrete placement is not allowed until setting of forms has been checked and approved by the CQC team.

d. Do not anchor guide rails for fixed form pavers into new concrete or existing concrete to remain.

3.5.5.2 Form Removal

Keep forms in place at least 12 hours after the concrete has been placed. When conditions are such that the early strength gain of the concrete is delayed, leave the forms in place for a longer time. Remove forms by procedures that do not damage the concrete. Do not use bars or heavy metal tools directly against the concrete in removing the forms. Promptly repair any concrete found to be defective after form removal, using procedures specified or as directed.

3.5.6 Placing Reinforcing Steel

Provide the type and amount of steel reinforcement indicated. Regardless of placement procedure, provide reinforcing steel free from coatings which

could impair bond between the steel and concrete, with reinforcement laps as indicated. Regardless of the equipment or procedures used for installing reinforcement, adequately consolidate the entire depth of concrete.

3.5.6.1 Pavement Thickness Greater Than 12 inches

For pavement thickness of 12 inches or more, place an initial lift of concrete on the underlying material to the required elevation of the steel reinforcement, consolidate the initial lift of concrete, place the steel reinforcement upon the surface of the initial lift, place a second lift of concrete to final grade, consolidate, and finish in the required manner. When placement of the second lift causes the steel reinforcement to be displaced horizontally from its original position, provide provisions for increasing the thickness of the initial lift and depressing the steel reinforcement into the unhardened concrete to the required elevation. Limit the increase in thickness only as necessary to permit correct horizontal alignment to be maintained. Remove and replace any portions of the initial lift of concrete that have been placed more than 30 minutes without being covered with the second lift with newly mixed concrete without additional cost to the Government.

3.5.6.2 Pavement Thickness Less Than 12 Inches

For pavements less than 12 inches thick, position the reinforcement on suitable chairs or continuous mesh support devices securely fastened to the subgrade prior to concrete placement. Consolidate concrete after the steel has been placed.

3.5.7 Placing Dowels

Provide a method to install and hold dowels in position that meets the tolerances for location, alignment, and spacing of Table 6 after the pavement has been completed. Do not place longitudinal dowels closer than 0.6 times the dowel bar length to the planned joint line. If the last regularly spaced longitudinal dowel is closer than that dimension, move it away from the joint to a location 0.6 times the dowel bar length, but not closer than 6 inches to its nearest neighbor. Resolve dowel interference at a transverse joint-longitudinal joint intersection by removing the closest transverse dowel. Do not position the end of a transverse dowel closer than 12 inches from the end of the nearest longitudinal dowel. Install dowels as specified in the following subparagraphs.

TABLE 6

DOWEL ALIGNMENT TOLERANCES

Dowel Measurement	Tolerance
Horizontal alignment (a)	Maximum of 1/8 inch per foot after the pavement has been completed
Vertical alignment (b)	Maximum of 1/8 inch per foot after the pavement has been completed

TABLE 6	
DOWEL ALIGNMENT TOLERANCES	
Dowel Measurement	Tolerance
Horizontal spacing	plus or minus 5/8 inch, except as otherwise specified above
Vertical location on the face of the slab	plus or minus 1/2 inch
(a) Check horizontal alignment perpendicular to the joint edge with a framing square.	
(b) Measure the vertical alignment of the dowels parallel to the designated top surface of the pavement, except for those across the crown or other grade change joints. Measure dowels across crowns and other joints at grade changes to a level surface.	

3.5.7.1 Contraction Joints

Securely hold dowels in longitudinal and transverse contraction joints within the paving lane in place, as indicated, by means of rigid metal frames or basket assemblies of an approved type. Securely hold the basket assemblies in the proper location by means of suitable pins or anchors. Do not cut or crimp the dowel basket tie wires.

3.5.7.2 Construction Joints-Fixed Form Paving

Install dowels by the bonded-in-place method or the drill-and-dowel method. Installation by removing and replacing in preformed holes is not permitted. Prepare and place dowels across joints where indicated, correctly aligned, and securely held in the proper horizontal and vertical position during placing and finishing operations, by means of devices fastened to the forms. Provide the spacing of dowels in construction joints as indicated, except that, where the planned spacing cannot be maintained because of form length or interference with form braces, provide closer spacing with additional dowels.

3.5.7.3 Dowels Installed in Hardened Concrete

Install dowels in hardened concrete by bonding the dowels into holes drilled into the hardened concrete. Before drilling commences, cure the concrete for 7 days or until it has reached a minimum field cured compressive strength of 2500 psi. Drill holes 1/8 inch greater in diameter than the dowels into the hardened concrete using rotary-core drills. Rotary-percussion drills are permitted provided that excessive spalling does not occur at the concrete joint face. Excessive spalling is defined as spalling deeper than 1/4 inch from the joint face or 1/2 inch radially from the outside of the drilled hole. Modify the equipment and operation if excess spalling occurs. Drill depth of dowel hole within a tolerance of plus or minus 1/2 inch of the half length of the embedded dowel. Blow out the dowel hole with oil-free, compressed air upon completion of the drilling operation. Bond dowels in the drilled holes using epoxy resin. Inject epoxy resin at the back of the hole before

installing the dowel and extrude 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 grout hardens by means of a suitable metal or plastic grout retention ring fitted around the dowel. Provide dowels required between new and existing concrete in holes drilled in the existing concrete, all as specified above.

3.5.7.4 Lubricating Dowel Bars

Immediately prior to placement, wipe clean the portion of each dowel intended to move within the concrete and coat with a thin, even film of lubricating oil or light grease. Form oil is not acceptable for dowel lubrication. Do not place caps on the dowel ends.

3.6 FINISHING

Provide finishing operations as a continuing part of placing operations starting immediately behind the strike-off of the paver. Provide finishing by the vibratory truss screed or triple roller tube paver. Provide the sequence of operations consisting of transverse finishing, cutting straightedge finishing, edging of joints, and texturing . Provide a work bridge for consolidation and hand finishing operations. Use hand finishing only in isolated areas of odd slab widths or shapes and in the event of a breakdown of the mechanical finishing equipment. Keep supplemental hand finishing for machine finished pavement to an absolute minimum. Immediately stop any machine finishing operation which requires appreciable hand finishing other than a moderate amount of straightedge finishing. Make proper adjustments or replace the equipment before recommencing paving. 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 as necessary before recommencing paving. Compensate for surging behind the screeds and settlement during hardening and adjust the paving and finishing machines so that the finished surface of the concrete (not just the cutting edges of the screeds) is at the required line and grade. Maintain finishing equipment and tools in a clean and an approved working condition. Water is not allowed to be added to the surface of slabs using finishing equipment, tools, or any other method except fog (mist) sprays may be applied to slab surfaces to prevent plastic shrinkage cracking.

3.6.1 Machine Finishing With Fixed Forms

Provide a machine that is designed to ride the forms and can be operated to screed and consolidate the concrete. Replace paving equipment that causes displacement of the forms. If the equipment and procedures do not produce a surface of uniform texture, true to grade, in minimal passes, immediately stop the operation and adjust the equipment, mixture, and procedures as necessary before recommencing paving.

3.6.2 Surface Correction and Testing

Evaluate the surface for trueness with a 12 feet straightedge after all other finishing is completed but while the concrete is still plastic. Equip the straightedge with a handle 3 feet longer than the width of the placement and operate the straightedge from the sides of the pavement or from bridges. Evaluate the surface trueness with a straightedge held in successive positions parallel and at right angles to the center line of

the pavement to detect variations. Advance the straightedge along the pavement in successive stages of one-half the length of the straightedge. Eliminate minor irregularities and score marks in the pavement surface by means of cutting straightedges. Immediately fill depressions with freshly mixed concrete then strike off, consolidate with an internal vibrator, and refinish. Strike off projections above the required elevation and refinish. Continue the straightedge testing and finishing until the entire surface of the concrete is free from observable departure from the straightedge and conforms to the surface requirements specified in paragraph SURFACE SMOOTHNESS. This straightedging is not allowed to be used as a replacement for the straightedge testing of hardened concrete for acceptance. Use long-handled flat bull floats very sparingly and only as necessary to correct minor, scattered surface defects. Stop the paving operation if frequent use of bull floats is necessary. Adjust the equipment, mixture, or procedures to eliminate surface defects and frequent use of bull floats before recommencing paving. Keep finishing with hand floats and trowels to the absolute minimum necessary. Take extreme care to prevent over finishing joints and edges. Produce the surface finish of the pavement essentially by the finishing machine and not by subsequent hand finishing operations. All hand finishing operations are subject to approval.

3.6.3 Hand Finishing

Use hand finishing operations only as specified below. Provide a work bridge for full-depth consolidation operations. Walking or operating in plastic concrete is not allowed.

3.6.3.1 Finishing and Floating

Strike off and screed the concrete to the required cross section and elevation immediately after placement and full-depth consolidation. Do not overlap the floating operation more than half the length of the float between new and previously floated surfaces. If necessary, place additional concrete then consolidate, screed, and float until the specified surface, cross section, and elevation has been produced.

3.6.4 Texturing

Texture the surface of the pavement as described herein when the concrete is still plastic, before the surface sheen has disappeared, and before the curing compound is applied. Apply the texture in a single continuous drag. Multiple passes are not allowed. The corrugations produced by the drag need to be uniform in appearance and approximately 1/16 inch in depth. Thoroughly power broom all textured surfaces to remove all debris after curing is complete.

3.6.4.1 Burlap Drag Surface

Apply surface texture by dragging the surface of the pavement with an approved burlap drag in the direction of the concrete placement. Operate the drag with the fabric moist, and maintain the fabric in a clean condition. Perform the dragging so as to produce a uniform finished surface having a fine sandy texture without disfiguring marks.

3.6.4.2 Broom Texturing for Hand Finishing

Hand brooming is permitted only where hand finishing is allowed. Complete

brooming before the concrete has hardened to the point where the surface is unduly torn or roughened, but after hardening has progressed enough so that the mortar does not flow and reduce the sharpness of the scores. Overlap successive passes of the broom the minimum necessary to obtain a uniformly textured surface. Wash brooms thoroughly at frequent intervals during use. Remove worn or damaged brooms from the job site. Transversely draw the hand brooms across the surface from the center line to each edge with slight overlapping strokes.

3.6.5 Edging

Before texturing has been completed, carefully finish the edge of the slabs along the forms and at the joints with an edging tool to form a smooth rounded surface of 1/8 inch radius. Eliminate tool marks and provide edges that are smooth and true to line. Water is not allowed to be added to the surface during edging. Take extreme care to prevent overworking the concrete.

3.6.6 Pavement Penetrations

Construct recesses for the tie-down anchors, lighting fixtures, and other outlets in the pavement to conform to the details and dimensions shown. Carefully finish the concrete in these areas to provide a surface of the same texture as the surrounding area that is within the requirements for plan grade and surface smoothness.

3.7 CURING

3.7.1 Protection of Concrete

Continuously protect concrete against loss of moisture and rapid temperature changes for at least 7 days from the completion of finishing operations as required below. Have all equipment needed for adequate curing and protection of the concrete on hand and ready for use before actual concrete placement begins. If any selected method of curing does not afford the proper curing and protection against concrete cracking, remove or replace the damaged pavement, and provide another method of curing as directed.

3.7.2 Membrane Curing

Apply a uniform coating of white-pigmented, membrane-forming, curing compound to the entire exposed surface of the concrete as soon as the free water has disappeared from the surface after finishing. Apply immediately along the formed edge faces after the forms are removed. Do not allow the concrete to dry before the application of the membrane. Moisten the surface of the concrete with a fine spray of water if any drying has occurred and apply the curing compound as soon as the free water disappears. Apply the curing compound to the finished surfaces by means of an approved automatic spraying machine. Apply the curing compound with an overlapping coverage that provides a two-coat application at a coverage of 400 square feet per gallon, plus or minus 5.0 percent for each coat. A one-coat application is allowed provided it is applied in a uniform application and coverage of 200 square feet per gallon, plus or minus 5.0 percent is obtained. The application of curing compound by hand-operated, mechanical powered pressure sprayers is permitted but application rate must meet the above requirements. 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. If pinholes,

abrasions, or other discontinuities exist, apply an additional coat to the affected areas within 30 minutes. Respray curing compound to 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 curing compound to areas where the curing compound is damaged by subsequent construction operations within the curing period immediately. 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 any other possible damage to the continuity of the membrane.

3.8 JOINTS

3.8.1 General Requirements for Joints

Construct joints that conform to the locations and details indicated and are perpendicular to the finished grade of the pavement. Provide joints that are straight and continuous from edge to edge or end to end of the pavement with no abrupt offset and no gradual deviation greater than 1/2 inch. Where any joint fails to meet these tolerances, remove and replace the slabs adjacent to the joint at no additional cost to the Government. Change from the jointing pattern shown on the drawings is not allowed without written approval. Seal joints immediately following curing of the concrete or as soon thereafter as weather conditions permit as specified in Section 32 13 73.19 COMPRESSION CONCRETE PAVING JOINT SEALANT.

3.8.2 Longitudinal Construction Joints

Install dowels in the longitudinal construction joints or thickened edges as indicated.

3.8.3 Transverse Construction Joints

Install transverse construction joints at the end of each day's placing operations at a planned transverse joint. Match transverse joint locations with adjacent lanes where indicated. If concrete placement is interrupted for 30 minutes or longer, stop work and remove concrete to the nearest completed joint to form a construction joint. Provide transverse construction joints by utilizing headers or by paving through the joint then full-depth sawcutting the excess concrete. Construct pavement with the paver as close to the header as possible with the paver run out completely past the header.

3.8.4 Expansion Joints

Provide expansion joints where indicated and at all intersections of airfield pavement with structures and features that project through or into the pavement. Use joint filler of the type, thickness, and width indicated, and install to form a complete, uniform separation between the structure and the pavement or between two pavements. Attach the filler to the original concrete placement with adhesive and mechanical fasteners extending to the full slab depth. Sawcut the sealant reservoir depth from the filler after placement and curing of the adjacent slab. Tightly fit adjacent sections of filler together, with the filler extending across the full width of the paving lane or other complete distance in order to prevent entrance of concrete into the expansion space. Finish edges of the concrete at the joint face with an edger with a radius of 1/8 inch.

3.8.5 Contraction Joints

Construct transverse and longitudinal contraction joints by an initial sawcut in the concrete with a 1/8 inch blade to the indicated depth. The CQC team is required to inspect and immediately report results of all exposed lane edges for development of cracks below the saw cut during sawing of joints and again 24 hours later. If there are more than six consecutive uncracked joints after 48 hours, saw succeeding joints 25 percent deeper than originally indicated at no additional cost to the Government. Vary the time of initial sawing depending on existing and anticipated weather conditions to prevent uncontrolled cracking of the pavement. Commence sawing of the joints as soon as the concrete has hardened sufficiently to permit cutting the concrete without chipping, spalling, or tearing. Inspect the sawed faces of joints for undercutting or washing of the concrete due to the early sawing. Delay sawing if undercutting is sufficiently deep to cause structural weakness or excessive roughness in the joint. Continue the sawing operation as required during both day and night regardless of weather conditions. Saw the joints in the sequence of the concrete placement. Provide adequate lighting for night work. Illumination using vehicle headlights is not permitted. Provide a chalk line or other suitable guide to mark the alignment of the joint. Examine the concrete closely for cracks before sawing a joint and do not saw the joint if a crack has occurred near the planned joint location. Discontinue sawing if a crack develops ahead of the saw cut. Immediately after the joint is sawed thoroughly flush the saw cut and adjacent concrete surface with water and vacuum until all waste from sawing is removed from the joint and adjacent concrete surface. Properly protect the concrete from damage and cure at sawed joints. Tightly seal the top of the joint opening and the joint groove at exposed edges with cord backer rod before the concrete in the region of the joint is resprayed with curing compound. Maintain the backer rod until removal is required immediately before sawing the joint sealant reservoir. Respray the surface with curing compound as soon as residual water disappears. Seal the exposed saw cuts on the vertical faces of pilot lanes with bituminous mastic or masking tape. After expiration of the curing period, widen the upper portion of the groove by sawing with ganged diamond saw blades to the width and depth indicated for the joint sealer. Center the reservoir over the initial sawcut.

3.8.6 Thickened Edge Joints

Construct thickened edge joints as indicated on the drawings. Grade the underlying material in the transition area as shown and meet the requirements for smoothness and compaction specified for all other areas of the underlying material.

3.9 REPAIR, REMOVAL AND REPLACEMENT OF NEWLY CONSTRUCTED SLABS

3.9.1 General Criteria

Repair or provide complete removal and replacement of new pavement slabs as specified at no cost to the Government. Removal of partial slabs is not permitted. Prior to any repairs, submit a Repair Recommendations Plan detailing areas exceeding the specified limits as well as repair recommendations required to bring these areas within specified tolerances.

3.9.2 Slabs with Cracks

The Government may require cores to be taken over cracks to determine

depth of cracking. Drill cores with a minimum diameter of 6 inches and backfill with an approved concrete mixture. Perform drilling of cores and filling of holes at no expense to the Government. Clean cracks that do not exceed 2 inches in depth; then pressure inject full depth with epoxy resin, Type IV, Grade 1. Remove and replace slabs containing cracks deeper than 2 inches.

3.9.3 Removal and Replacement of Full Slabs

Remove new or existing slabs damaged during construction that contain more than 15.0 percent of any longitudinal or transverse joint edge spalled. Remove full slabs in accordance with paragraph REMOVAL OF EXISTING PAVEMENT SLAB below. Remove and replace full depth by full width of the slab. Limit the removal of slabs to the paving lane and nearest joints. Compact and shape the underlying material as specified in the appropriate section of these specifications. Cut off original damaged dowels flush with the joint face. Clean the existing concrete surfaces of all loose material and contaminants, then coat with a double application of membrane forming curing compound as a bond breaker. Install dowels of the size and spacing as specified for other joints in similar pavement by epoxy grouting them into holes drilled into the existing concrete using procedures as specified in paragraph PLACING DOWELS, above. Provide dowels for all edges of the new slab. Lightly oil or grease protruding portions of new dowels in accordance with paragraph LUBRICATING DOWEL BARS. Place concrete as specified for original construction. Take care to prevent any curing compound from contacting dowels. Prepare and seal the resulting joints around the new slab as specified for original construction.

3.9.4 Repairing Spalls Along Joints

Repair spalls along joints to a depth to restore the full joint-face support prior to placing adjacent pavement. Where directed, repair spalls along joints of new slabs, along edges of adjacent existing concrete, and along parallel cracks by first making a vertical saw cut at least 3 inches outside the spalled area and to a depth of at least 2 inches. Provide saw cuts consisting of straight lines forming rectangular areas without sawing beyond the intersecting saw cut. Chip out the concrete between the saw cut and the joint, or crack, to remove all unsound concrete and into at least 1/2 inch of visually sound concrete. Thoroughly clean the cavity thus formed with high pressure water jets supplemented with oil-free compressed air to remove all loose material. Immediately before filling the cavity, apply a prime coat to the dry cleaned surface of all sides and bottom of the cavity, except any joint face. Apply the prime coat in a thin coating and scrub into the surface with a stiff-bristle brush. Provide prime coat for portland cement repairs consisting of a neat cement grout and for epoxy resin repairs consisting of epoxy resin, Type III, Grade 1. Fill the prepared cavity with material identified in Table 7 based on the cavity volume.

TABLE 7

Spall Repairs

Volume of Prepared Cavity After Removal Operations	Material

TABLE 7	
Spall Repairs	
less than 0.03 cubic foot	epoxy resin mortar or epoxy resin or latex modified mortar
0.03 cubic foot and 1/3 cubic foot	Portland cement mortar
more than 1/3 cubic foot	Portland cement concrete or latex modified mortar

Provide portland cement concretes and mortars that consist of very low slump mixtures, 1/2 inch slump or less, proportioned, mixed, placed, consolidated by tamping, and cured, all as directed. Provide epoxy resin mortars made with Type III, Grade 1, epoxy resin, using proportions and mixing and placing procedures as recommended by the manufacturer and approved. Proprietary patching materials may be used, subject to Government approval. Place the epoxy resin materials in the cavity in layers with a maximum thickness of 2 inches. Provide adequate time between placement of additional layers such that the temperature of the epoxy resin material does not exceed 140 degrees F at any time during hardening. Provide mechanical vibrators and hand tampers to consolidate the concrete or mortar. Remove any repair material on the surrounding surfaces of the existing concrete before it hardens. Where the spalled area abuts a joint, provide an insert or other bond-breaking medium to prevent bond at the joint face. For existing joints, seal the bottom contraction crack with backer rod to prevent intrusion of primer or mortar. Saw a reservoir for the joint sealant to the dimensions required for other joints. Thoroughly clean the reservoir and then provide the sealer specified for the joints. In lieu of sawing, spalls and popouts not adjacent to joints, both less than 6 inches in maximum dimension, may be prepared by drilling a core 2 inches in diameter greater than the size of the defect, centered over the defect, and 2 inches deep or 1/2 inch into sound concrete, whichever is greater. Repair the core hole as specified above for other spalls.

3.9.5 Repair of Weak Surfaces

Weak surfaces are defined as mortar-rich, rain-damaged, uncured, or containing exposed aggregates, voids, or deleterious materials. Cores evaluated by a qualified petrographer to contain carbonation to a depth greater than 1/8 inch or Mohs hardness of less than 2, when tested in accordance with ASTM C1895, are also considered rain damaged. Diamond grind slabs containing weak surfaces less than 1/4 inch thick to remove the weak surface. Diamond grind in accordance with paragraph DIAMOND GRINDING OF PCC SURFACES. All diamond ground areas are required to meet the thickness, smoothness, and grade criteria specified in paragraph ACCEPTANCE. Remove and replace slabs containing weak surfaces greater than 1/4 inch thick.

3.10 EXISTING CONCRETE PAVEMENT REMOVAL AND REPAIR

Demolition of existing operational pavement is not allowed prior to approval of the Proportioning Studies. Remove existing concrete pavement

at locations indicated on the drawings. Inventory the pavement distresses (cracks, spalls, and corner breaks) along the pavement edge to remain prior to commencing pavement removal operations. Survey the remaining edge again after pavement removal to quantify any damage caused by removal operations. Perform both surveys in the presence of the Government. Perform repairs as indicated and as specified herein. Carefully control all operations to prevent damage to the concrete pavement and to the underlying material to remain in place. Perform all saw cuts perpendicular to the slab surface forming rectangular areas. Perform all existing concrete pavement repairs prior to paving adjacent lanes.

3.10.1 Removal of Existing Pavement Slab

Use one of the following methods when existing concrete pavement is to be removed and adjacent concrete is to be left in place:

Method 1

a. Perform the first full depth saw cut on the joint between the removal area and adjoining pavement to stay in place with a standard diamond-type concrete saw.

b. Next, perform a full depth saw cut parallel to the joint that is at least 24 inches from the joint and at least 6 inches from the end of any dowels with a wheel saw as specified in paragraph SAWING EQUIPMENT.

c. Remove all pavement beyond this last saw cut in accordance with the approved demolition work plan.

d. Remove all pavement between this last saw cut and the joint line by carefully pulling pieces and blocks away from the joint face with suitable equipment and then picking them up for removal. As an alternative, this strip of concrete may be carefully broken up and removed using hand-held jackhammers, 30 lb or less, or other approved light-duty equipment which does not cause stress to propagate across the joint saw cut and cause distress in the pavement which is to remain in place.

Method 2

a. Sawcut the slab full depth to divide it into several pieces and lift each piece out. Use suitable equipment to provide a truly vertical lift with safe lifting devices used for attachment to the slab.

3.10.2 Edge Repair

Protect the edge of existing concrete pavement against which new pavement abuts from damage at all times. Remove and replace slabs which are damaged during construction as directed at no cost to the Government. Repair of previously existing damaged areas is considered a subsidiary part of concrete pavement construction. Saw off all exposed keys and keyways full depth.

3.10.2.1 Spall Repair

Repair spalls caused by construction activities for slabs that have less than 15.0 percent spalling along any edge. Provide repair materials and procedures as previously specified in paragraph REPAIRING SPALLS ALONG JOINTS. Remove and replace full slabs containing more than 15.0 percent

spalling along any edge in accordance with paragraph REMOVAL AND REPLACEMENT OF FULL SLABS.

3.10.2.2 Underbreak and Underlying Material

Repair all underbreak by removal and replacement of the damaged slabs in accordance with paragraph REMOVAL AND REPLACEMENT OF FULL SLABS above. Protect the underlying material adjacent to the edge of and under the existing pavement to remain from damage or disturbance during removal operations and until placement of new concrete. Replace the concrete panels with the dimensions shown on the drawings or as directed. Maintain sufficient underlying material in place outside the joint line to completely prevent disturbance of material under the pavement which is to remain in place. Remove and replace any slab with underlying material that is disturbed or loses its compaction.

3.11 PAVEMENT PROTECTION

3.11.1 Existing Pavement Protection

Protect existing pavement from all damage. Placement of aggregates, rubble, or other similar construction materials is not allowed on existing pavement. Take special care in areas where traffic uses or crosses active airfield pavement. Power broom existing pavements at least daily when traffic operates. Immediately clean up spillage of concrete or other materials upon occurrence. Provide equipment that does not damage or spall existing concrete when trafficking and provide means to protect joints and edges as necessary to prevent damage.

3.11.2 New Pavement Protection

Protect new pavement against all damage prior to final acceptance of the work by the Government. Placement of aggregates, rubble, or other similar construction materials on airfield pavements is not allowed. Exclude traffic from the new pavement by erecting and maintaining barricades and signs until the concrete is at least 14 days old or for a longer period if so directed. Operation of the hauling and paving equipment is permitted on the new pavement as a construction expedient after the pavement has been cured for 7 days, the joints have been sealed or otherwise protected, the concrete has attained a minimum field cured compressive strength of 3,500 psi, and approved means are provided to prevent damage to the slab edges. Fabricate and field cure specimens in accordance with ASTM C31/C31M. Continuously maintain and completely clean all new pavement carrying construction traffic or equipment. Immediately clean up spillage of concrete or other materials upon occurrence. For fill-in lanes, provide equipment that does not damage or spall the edges or joints of the previously constructed pavement.

3.12 TESTING AND INSPECTION FOR CONTRACTOR QUALITY CONTROL DURING CONSTRUCTION

3.12.1 Testing and Inspection by Contractor

Perform sampling and testing of aggregates, cementitious materials (cement, slag cement, and pozzolan), and concrete during construction to determine compliance with the specifications. Select sample locations on a random basis in accordance with ASTM D3665. Provide facilities and labor as may be necessary for procurement of representative test samples. Furnish sampling platforms and belt templates to obtain representative

samples of aggregates from charging belts at the concrete plant. Obtain samples of concrete at the point of delivery to the paver. Testing by the Government in no way relieves the specified testing requirements. Perform the inspection and tests described below, and based upon the results of these inspections and tests, take the action required and submit reports as required. Perform this testing regardless of any other testing performed by the Government.

3.12.2 Sampling and Testing Concrete

Obtain one random composite sample of concrete in accordance with ASTM C172/C172M from one batch or truckload at the frequency shown in Table 7. Fabricate and cure six test cylinders 6 x 12 inches in accordance with ASTM C31/C31M and test them in accordance with ASTM C39/C39M. Test two test cylinders at 7 days, two cylinders at 28 days, and hold two cylinders in reserve for each collected sample.

3.12.3 Thickness and Consolidation Testing

Drill two random cores between 4 and 6 inches in diameter from the pavement at the frequency shown in Table 7. Drill the cores within 3 days after placement. Fill each core hole with an approved concrete mixture and respray cored areas with curing compound. Record eight measurements of thickness around the circumference of each core and one in the center in accordance with ASTM C174/C174M. Record and submit testing, inspection, and evaluation of each core for mortar-rich surface, 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 showing the core's entire length, rotating the core approximately 120 degrees between photographs. Include a ruler for scale in the photographs that does not obscure the core. Provide plan view of location for each core.

3.12.4 Surface Smoothness Testing

Test the entire surface of the pavement in such a manner as to reveal all surface irregularities exceeding the tolerances specified in paragraph ACCEPTANCE. Begin smoothness testing after the concrete has hardened sufficiently to permit walking thereon, but not later than 48 hours after placement. Test the entire area of the pavement in both a longitudinal and a transverse direction on parallel lines. Perform the transverse lines 5 feet or less apart, as directed. Perform the longitudinal lines at the centerline of each paving lane shown on the drawings, regardless of whether multiple lanes are allowed to be paved at the same time and at the 1/8th point in from each side of the lane. Also perform testing lines across all joints and at other areas having obvious deviations. Retest areas if they are diamond ground. Maintain detailed notes of the testing results and provide a copy to the Government after each day's testing.

3.12.4.1 Straightedge Testing

Use the straightedge method for transverse testing, longitudinal testing, joints, and at the ends of the paving limits for the project. Hold the straightedge in contact with the surface and moved 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 pavement surface and measuring the maximum gap between the straightedge and the pavement surface. Determine measurements along

the entire length of the straight edge and submit all test results to the government prior to placement of adjacent concrete.

3.12.5 Plan Grade Testing

Within 5 days after paving, test the finished surface of the pavement area to reveal all elevations exceeding the tolerances specified in paragraph ACCEPTANCE. Run 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 provide a copy to the Government at the completion of the survey prior to placement of adjacent concrete.

3.12.6 Cementitious Materials Testing

Retest cementitious material that has not been used within 6 months after testing and reject if test results do not meet manufacturer requirements.

3.12.7 Chemical Admixture Testing

Retest chemical admixtures that have been in storage at the project site for longer than 6 months or that have been subjected to freezing and reject if test results do not meet manufacturer requirements.

3.12.8 Testing and Inspection Requirements

Perform CQC sampling, testing, inspection and reporting in accordance with Table 8.

TABLE 8
TESTING AND INSPECTION REQUIREMENTS

Frequency	Test Method	Control Limit	Corrective Action
Fine Aggregate Gradation and Fineness Modulus			
Once per day	ASTM C136/C136M and ASTM C117 sample at belt	Outside limits on any sieve	Retest
		2nd gradation failure	Stop production paving, report to COR, and revise materials and operations to be in compliance prior to restarting production paving
Coarse Aggregate Gradation (each aggregate size)			

TABLE 8
TESTING AND INSPECTION REQUIREMENTS

Frequency	Test Method	Control Limit	Corrective Action
Once per day	ASTM C136/C136M and ASTM C117 sample at belt	Outside limits on any sieve	Retest
		2nd gradation failure	Stop production paving, report to COR, and revise materials and operations to be in compliance prior to restarting production paving
Workability Factor and Coarseness Factor Computation			
Same as C.A. and F.A.	see paragraph AGGREGATES	Use individual C.A. and F.A. gradations. Combine using batch ticket percentages (average of aggregate percentages from 3 before and 3 after sampling). Tolerances: plus or minus 3 points on WF; plus or minus 5 points on CF from approved adjusted mix design values; only the portion of the tolerance box within the parallelogram is available for use	Check batching tolerances, recalibrate scales
		Test result outside limits	Stop production paving, report to COR, and revise materials and operations to be in compliance prior to restarting production paving
Concrete Mixture - Slump			
50 cubic yards and when test specimens prepared	ASTM C143/C143M sample at point of discharge within the paving lane	At maximum allowable slump	Retest
		2nd slump failure	Reject concrete, stop production paving, report to COR, and revise materials and operations to be in compliance prior to restarting production paving

TABLE 8
TESTING AND INSPECTION REQUIREMENTS

Frequency	Test Method	Control Limit	Corrective Action
Concrete Mixture - Air Content			
Same as slump	ASTM C231/C231M sample at point of discharge within the paving lane	Plus or minus 1.5 percent	Retest
		2nd air content failure	Reject concrete, stop production paving, report to COR, and revise materials and operations to be in compliance prior to restarting production paving
Concrete Mixture - Temperature			
Same as slump	ASTM C1064/C1064M sample at point of discharge within the paving lane	See paragraph WEATHER LIMITATIONS	
Concrete Mixture - Strength			
150 cubic yards, minimum one test per day	ASTM C31/C31M sample at point of discharge within the paving lane	See paragraph ACCEPTANCE Perform fabrication of strength specimens and initial cure outside the paving lane and within 1,000 feet of the sampling point.	
Concrete Mixture - Unit Weight and Yield			
Same as concrete strength	ASTM C138/C138M sample at point of discharge within the paving lane	0 or plus 5 percent	Retest
		2nd unit weight and yield failure	Reject concrete, stop production paving, report to COR, and revise materials and operations to be in compliance prior to restarting production paving
Concrete Thickness			
Same as concrete strength	ASTM C174/C174M	See paragraph ACCEPTANCE	

3.12.9 Contractor Quality Control Reports

Report informally and in writing daily the results of all tests and

inspections conducted. Submit Contractor Quality Control reports on a daily basis using a format that is clear and allows for ready determination of compliance with specification. Use testing and inspections for early identification and correction of issues to production. These requirements do not relieve the obligation to report certain failures immediately as required in preceding paragraphs. Confirm such reports of failures and the action taken in writing in the routine reports. The Government has the right to examine all Contractor quality control records.

-- End of Section --

SECTION 32 13 73.19

COMPRESSION CONCRETE PAVING JOINT SEALANT

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 D412	(2016; R 2021) Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
ASTM D2628	(1991; R 2016) Standard Specification for Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements
ASTM D2835	(1989; R 2017) Standard Specification for Lubricant for Installation of Preformed Compression Seals in Concrete Pavements

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 548	(1988) Standard Specification for Jet-Fuel and Heat-Resistant Preformed Polychloroprene Elastomeric Joint Seals for Rigid Pavements

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

Equipment

Manufacturer's Instructions

SD-04, Samples

Compression Seals; G

SD-06 Test Reports

Test Requirements; G

1.3 DELIVERY, STORAGE, AND HANDLING

Inspect materials delivered to the jobsite for defects. Unload and store

materials with a minimum of handling to avoid damage. Provide storage facilities that protect materials from weather and maintain materials within temperatures recommended by the manufacturer.

1.4 ENVIRONMENTAL REQUIREMENTS

Install materials only when the ambient temperature and the pavement temperature within the joint wall is at least 35 degrees F and rising. Do not permit sealant installation if moisture or foreign material is observed in the joint.

PART 2 PRODUCTS

2.1 SYSTEM EQUIPMENT

Provide machines, tools, and equipment, for use in the performance of the work required by this section, approved before the work is started, and maintained in satisfactory condition. Submit list of proposed machines, tools, and equipment to be used in the performance of joint sealing, including descriptive data, 30 days prior to use on the project.

2.1.1 Joint Cleaning Equipment

2.1.1.1 Concrete Saw

Provide a self-propelled power saw with water-cooled diamond saw blades for cutting joints to the depths and widths specified and for removing filler, existing old joint seal, or other material embedded in the joints or adhered to the joint faces.

2.1.1.2 Sandblasting Equipment

Include with the sandblasting equipment an air compressor, hose, and a long-wearing venturi-type nozzle of proper size, shape, and opening. Do not permit the maximum nozzle opening to exceed 1/4 in. Provide a portable air compressor capable of providing not less than 150 cubic ft per minute and maintaining a line pressure of not less than 90 psi at the nozzle while in use. Use a compressor equipped with traps that maintains the compressed air free of oil and water. Use a nozzle with an adjustable guide that holds the nozzle aligned with the joint approximately 1 in above the pavement surface and directs the blast to clean the joint walls. Adjust the height, angle of inclination, and the size of the nozzle to ensure satisfactory results.

2.1.1.3 Waterblasting Equipment

Include with the waterblasting equipment a trailer-mounted water tank, pumps, high-pressure hose, a wand with safety release cutoff controls, nozzle, and auxiliary water resupply equipment. Use a water tank and auxiliary water resupply equipment of sufficient capacity to permit continuous operations. Use pumps, hoses, wand, and nozzle of sufficient capacity to permit the cleaning of both walls of the joint and the pavement surface for a width of at least 1/2 in on either side of the joint. Use a pressure gauge mounted at the pump that shows the pressure in psi at which the equipment is operating.

2.1.2 Sealing Equipment

Install the compression seal by placing the compression seal to the

prescribed depths and within the specified tolerances without cutting, nicking, twisting, or otherwise damaging the seal. Use equipment capable of placing the seal with not more than two percent longitudinal stretch or compression of the seal during installation. Use a machine that is an automatic self-propelled joint seal application equipment and engine powered. Use a machine that includes a reservoir for the lubricant/adhesive, a device for conveying the lubricant/adhesive in the proper quantities to the sides of the compression seal or the sidewalls of the joints, a reel capable of holding one full spool of compression seal, and a power-driven apparatus for feeding the joint seal through a compression device and inserting the seal into the joint. Include a guide with the equipment to maintain the proper course along the joint being sealed. Operate the machine by an experienced operator.

2.1.3 Test Requirements

Sample, identify and test each lot of compression joint seal and lubricant/adhesive for conformance with the material specification.

a. A lot of compression seal consists of 1 day's production or 20,000 linear ft for each cross section, whichever is less. A lot of lubricant/adhesive consists of 1 day's production.

b. Testing of the compression joint seal and lubricant/adhesive material is the responsibility of the Contractor. Perform testing in an approved, independent laboratory, and submit certified copies of the test reports for approval 30 days prior to the use of the materials at the jobsite.

c. Submit samples of each lot of material to be retained by the Government for possible future testing if the materials appear defective during or after application. Provide additional samples of materials, in sufficient quantity to be tested, upon request. Base final acceptance on conformance to the specified test requirements and the performance of the in-place materials with respect to slipping down the joint or material coming out of the joint.

2.2 COMPRESSION SEALS

Regardless of testing responsibility, submit 9 ft long samples of the materials, 30 days prior to use on the project. Provide printed directions from the manufacturer on recommended installation criteria with the samples plus the manufacturer's certification that the selected seal is recommended for the installation on this project. Use compression joint seal materials that are vulcanized elastomeric compound using polychloroprene as the only base polymer. Use material and manufactured seal in accordance with ASTM D2628 or ASTM D2628 and COE CRD-C 548 where jet fuel and/or heat blast resistance is required as tested by ASTM D412. Use a labyrinth seal for the joint seal. The uncompressed depth of the face of the compression seal (that is to be bonded to the joint wall) is greater than the uncompressed width of the seal, except that for seals 1 in or greater in width, the depth need be only 1 in or greater. The actual width of the uncompressed seal for construction and contraction joints is 0.75 or 1 in and for expansion joints is 1.25 in. The tolerance on the seal is plus 1/8 in or minus 1/16 in.

2.3 LUBRICANT/ADHESIVE

Use a lubricant/adhesive for the compression elastomeric joint seal that

is a one-component compound conforming to ASTM D2835.

PART 3 EXECUTION

3.1 PREPARATION OF JOINTS

Immediately before installation of the compression joint seal, clean the joints to remove laitance, filler, existing sealer, foreign material and protrusions of hardened concrete from the sides and upper edges of the joint space to be sealed. Clean by sandblasting or waterblasting and extend along pavement surfaces at least 1/2 in on either side of the joint. After final cleaning and immediately prior to sealing, blow out the joints with compressed air and leave free of debris and water. Demonstrate that the selected cleaning operation meets the cleanliness requirements resulting in joint sidewalls that are clean and dry and exhibit newly exposed concrete. Correct irregularities in the joint face which would prevent uniform contact between the joint seal and the joint face prior to the installation of the joint seal.

3.1.1 Sawing

Clean and open joints to the specified width and depth by sawing. Immediately following the sawing operation, clean the joint faces and opening using a water jet to remove saw cuttings or debris remaining on the faces or in the joint opening. Install compression seal within 3 calendar days of the time the joint cavity is sawed. Provide a depth of the joint cavity in accordance with manufacturer's instructions. Where installation procedures are required in accordance with the manufacturer's recommendations, submit printed copies of manufacturers' instructions, 30 days prior to use on the project. Center the saw cut for the joint seal cavity over the joint line. Provide the nominal width of the sawed joint seal cavity as follows:

a. If a nominal 13/16 in wide compression seal is provided, the nominal width of the saw cut is 1/2 in when the pavement temperature at the time of sawing is between 30 and 110 degrees F. If the pavement temperature at the time of sawing is above this range, decrease the nominal width of the saw cut 1/16 in. If the pavement temperature at the time of sawing is below this range, increase the nominal width of the saw cut 1/16 in.

b. If a nominal 1 in wide compression seal is provided, the nominal width of the saw cut is 9/16 ins when the pavement temperature at the time of sawing is between 30 and 170 degrees F. If the pavement temperature at the time of sawing is above this range, decrease the nominal width of the saw cut 1/16 in. If the pavement temperature at the time of sawing is below this range, increase the nominal width of the saw cut 1/16 in.

c. Measure the pavement temperature in the presence of the Contracting Officer. Make measurement each day before commencing sawing and when the temperature appears to be varying from the allowable sawing range.

Use a tolerance of plus or minus 1/16 in for the actual width.

3.1.2 Sandblast Cleaning

Use a multiple pass sandblasting technique until the joint surfaces are free of dust, dirt, curing compound, or residue that might prevent ready

insertion or uniform contact of the seal and bonding of the lubricant/adhesive to the concrete.

3.1.3 Waterblast Cleaning

Use a multiple pass waterblast technique until the surfaces are free of dust, dirt, curing compound, or residue that might prevent ready insertion or uniform contact of the seal and bonding of the lubricant/adhesive to the concrete. After final cleaning and immediately prior to sealing, blow out the joints with compressed air and leave completely free of debris and water.

3.1.4 Rate of Progress

Limit sandblasting or waterblasting of joint faces to the length of joint that can be sealed during the same workday.

3.2 INSTALLATION OF THE COMPRESSION SEAL

3.2.1 Time of Installation

Seal joints immediately within 3 calendar days of sawing the joint seal cavity and following concrete cure and the final cleaning of the joint walls. Provide open joints, ready for sealing that cannot be sealed under the specified conditions, with an approved temporary seal to prevent infiltration of foreign material. When rain interrupts the sealing operations, wash, clean with air pressure, and allow joints to dry prior to installing the lubricant/adhesive and compression seal.

3.2.2 Sequence of Installation

Seal longitudinal joints first, followed by transverse joints. Install seals in longitudinal joints so that transverse joint seals are intact from edge to edge of the pavement. Make intersections monolithic by use of joint seal adhesive and care in fitting the intersection parts together. Do not permit extender pieces of seal at intersections. Remove and replace seals falling short at the intersection with new seals at no additional cost to the Government. Require a poured sealant at the intersection where seals are required to change direction by more than 20 degrees. Provide poured sealant in accordance with compression seal manufacturer's instructions.

3.3 SEALING OF JOINTS

Cover the sides of the joint seal or the sides of the joint with a coating of lubricant/adhesive and the seal installed as specified. Coat butt joints and seal intersections with liberal applications of lubricant/adhesive. Immediately removed lubricant/adhesive spilled on the pavement to prevent setting on the pavement.

Provide the in-place joint seal will be in an upright position and free from twisting, distortion, and cuts. Adjustments will be made to the installation equipment and procedure, if the stretch exceeds 1 percent. Remove and replace seals exceeding 2 percent stretch. Place the joint seal at a uniform depth within the tolerances specified. Remove and replace in-place joint seals which fail to meet the specified requirements with new joint seal at no cost to the Government.

Place the compression joint seal to a depth of 1/4 in, plus or minus 1/8 in,

below the pavement surface except when the joint is beveled or has a radius at the surface, or unless otherwise directed. For beveled joints or joints with a radius at the surface, install the compression joint seal at a depth of 1/8 in, plus or minus 1/8 in, below the bottom of the edge of the bevel or radius. Do not permit the seal to project above the surface of the pavement or above the edge of the bevel or radius.

Install the seal in the longest practicable lengths in longitudinal joints and cut at the joint intersections to provide continuous installation of the seal in the transverse joints. Permit the lubricant/adhesive in the longitudinal joints to set for 1 hour prior to cutting at the joint intersections to reduce the possibility of shrinkage. For transverse joints, the minimum length of the compression joint seal is the pavement width from edge to edge.

3.4 CLEAN-UP

Upon completion of the project, remove unused materials from the site, remove lubricant/adhesive on the pavement surface, and leave the pavement in clean condition.

3.5 QUALITY CONTROL PROVISIONS

3.5.1 Application Equipment

Inspect the application equipment to assure uniform application of lubricant/adhesive to the sides of the compression joint seal or the walls of the joint. If equipment causes cutting, twisting, nicking, excessive stretching or compressing of the seal, or improper application of the lubricant/adhesive, suspend the operation until causes of the deficiencies are determined and corrected.

3.5.2 Procedures

3.5.2.1 Quality Control Inspection

Provide quality control provisions during the joint cleaning process to prevent or correct improper equipment and cleaning techniques that damage the concrete. Cleaned joints will be approved by the Government prior to installation of the lubricant/adhesive and compression joint seal.

3.5.2.2 Conformance to Stretching and Compression Limitations

Determine conformance to stretching and compression limitations. Mark the top surface of the compression seal at 1 ft intervals in a manner clear and durable to enable length determinations of the seal. After installation, measure the distance between the marks on the seal. If the stretching or compression exceeds 2 percent, remove the seal and replace it with new joint at no additional cost to the Government. Remove the seal up to the last correct measurement. Inspect the seal a minimum of once per 100 ft of seal for compliance to the shrinkage or compression requirements. Make measurements at the same interval to determine conformance with depth and width of installation requirements. Remove and replace compression seal that is not in conformance with specification requirements with new joint seal at no additional cost to the Government.

3.5.2.3 Pavement Temperature

Determine the pavement temperature by placing a thermometer in the initial

saw cut for the joint and record the reading. Permit the thermometer to remain in the joint for an adequate time to provide a stable control reading.

3.5.3 Acceptance

Inspect the joint sealing system (compression seal and lubricant/adhesive) for proper rate of cure and bonding to the concrete, cuts, twists, nicks and other deficiencies. Remove, waste and replace seals exhibiting defects prior to final acceptance of the project from the joint.

-- End of Section --

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SECTION 32 16 19

CONCRETE CURBS, GUTTERS AND SIDEWALKS

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 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	(2024b) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C94/C94M	(2024c) Standard Specification for Ready-Mixed Concrete
ASTM C143/C143M	(2020) Standard Test Method for Slump of Hydraulic-Cement 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) 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 ASTM C94/C94M 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 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

Unless 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 biodegradable and 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 31 00 00 EARTHWORK. 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 31 00 00 EARTHWORK. 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 gutter and curb top. Finish the top surface of gutter to grade with a wood float.

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 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 17 23.16

ROAD AND PARKING LOT PAVEMENT MARKINGS

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 in the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D4414	(1995; R 2020) Standard Practice for Measurement of Wet Film Thickness by Notch Gages

MASTER PAINTERS INSTITUTE (MPI)

MPI 97	(2012) Traffic Marking Paint, Latex

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE AMS-STD-595A	(2017) Colors used in Government Procurement

U.S. FEDERAL HIGHWAY ADMINISTRATION (FHWA)

MUTCD	(2009; Rev 2012) Manual on Uniform Traffic Control Devices

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS TT-P-1952	(2015; Rev F; Notice 1) Paint, Traffic and Airfield Markings, Waterborne

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. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Quality Control Plan; G

Safety Data Sheets For Each Paint Type; G

Safety Data Sheets For Chemicals Used In Surface Preparation; G

Data Sheets For Paint Removal Equipment; G

Surface Preparation Equipment List; G

Marking Applications Equipment List; G

Detour Plans; G

SD-03 Product Data

Manufacturer Data Sheets for all Marking Materials; G

SD-06 Test Reports

Marking Application Wet Film Thickness Test; G

SD-07 Certificates

Manufacturer Certificate of Compliance for Marking Materials; G

Manufacturer Certificate of Conformance for Volatile Organic Compliance; G

SD-08 Manufacturer's Instructions

Marking Materials Storage and Application; G

Reflective Media Storage and Application; G

Chemicals Used in Surface Preparation; G

1.3 QUALITY CONTROL

1.3.1 Quality Control Plan

Within 10 calendar days of project award, submit a quality control plan. The plan must state the means, methods, equipment, and materials to be employed for the performance of the surface preparation, existing markings removal, application of reflective and non-reflective marking, and marking layout. At a minimum, provide descriptive criteria for each of the following activities for review and approval by the Contracting Officer:

a. Describe the means and methods used to layout marking geometry and the location of marking elements.

b. Describe the protocol for determination of the operating pressure and speed of the equipment for surface preparation.

c. Describe the protocol for surface preparation when not using water.

d. Describe the protocol for existing markings removal.

e. Define the protocol for the performance of test stripes for each line width, color, and paint type.

f. Provide equipment details to include speed, pressures and application rate for the minimum wet film thickness.

g. Provide and discuss safety directives for maintaining traffic on roads and parking lots.

h. Define communications procedures when operating on roads and parking

lots.

1.4 DELIVERY, STORAGE, AND HANDLING

Ensure all materials delivered to the storage location are in the original container and clearly marked with the product name, compliance information, batch number, color, manufactured date, instructions for storage, instructions for application, and the name of the manufacturer. All materials are to be stored in conformance with the manufacturer instructions. Provide manufacturer instructions for; marking materials storage and application, reflective media storage and application, and the chemicals used in surface preparation.

1.5 PROJECT/SITE SPECIAL CONDITIONS

1.5.1 Environmental Requirements

Pavement surface must be free of snow, ice, or slush; with a surface temperature of at least 40 degrees F and rising at the beginning of operations, except those involving shot blasting or grinding. Cease operation during thunderstorms, or during rainfall, except for water blasting and removal of previously applied chemicals. Cease water blasting where surface water accumulation alters the effectiveness of material removal.

1.5.1.1 Weather Limitations for Marking Application

Apply pavement markings to clean, dry surfaces and only when the ambient temperature is at least 5 degrees F above the dew point and the pavement surface temperatures are within the limits recommended by the manufacturer of the material being used unless otherwise noted. Allow the pavement surface to dry after the water has been used for surface preparation or after a precipitation event. Do not perform marking applications when the wind carries overspray onto locations adjacent to the marking. Provide wind screens to shroud application equipment.

1.5.1.2 Testing Dry Surfaces

Do not commence marking until the pavement surface is dry. Use the plastic wrap method as described in paragraph PRE-APPLICATION TESTING to test the pavement surface for moisture. Do not proceed with marking until the Contracting Officer has observed the moisture test and has accepted the area prepared for marking.

1.5.1.3 Volatile Organic Compounds Compliance

Submit a manufacturer certificate stating that the proposed pavement marking paint meets the Volatile Organic Compound (VOC) regulations of the local Air Pollution Control District having jurisdiction over the geographical area in which the project is located. Submit manufacturer certificate of conformance for volatile organic compliance.

1.5.2 Traffic Control for Roads and Parking Lots

Place approved signs conforming to MUTCD near the beginning of the worksite and well ahead of the worksite to alert approaching traffic from both directions. Place markers along newly painted lines to control traffic and prevent damage to newly painted surfaces. Mark painting equipment with warning signs that can be read from a distance of 100 feet,

indicating slow-moving painting equipment in operation. Provide all lighting and equipment necessary to light the work area during night operations effectively.

When traffic is rerouted or controlled to accomplish the work, provide necessary warning signs, flag persons, and related equipment for the safe passage of vehicles. Submit detour plans to the Contracting Officer for approval before doing the work.

1.6 APPLICATION EQUIPMENT CALIBRATION

Before performing any marking application, calibrate the paint application equipment at the necessary speed to execute the application. Calibration and application will be performed using paint that is not diluted or thinned. Paint will be used as formulated by the manufacturer. Calibrate paint for each line width and color intended to be applied. Use metal coupons placed in the path of the equipment to capture a test line. Use a wet film gauge in accordance with ASTM D4414, to determine if the wet film thickness is the same at each edge and at the center of the marking. Adjust each paint gun to provide a line of uniform thickness.

PART 2 PRODUCTS

2.1 EQUIPMENT

Submit a surface preparation equipment list by serial number, type, model, and manufacturer. Include descriptive data indicating area of coverage per pass, pressure adjustment range, tank and flow capacities, and safety precautions required for the equipment operation. Mobile equipment must allow for removal of markings without damaging the pavement surface or joint sealant. Maintain machines, tools, and equipment used in the performance of the work in satisfactory operating condition.

2.1.1 Surface Preparation and Paint Removal for Roads and Parking Lots

Submit data sheets for paint removal equipment intended for use in preparation of the pavement surface for marking. In the submittal, include descriptive information on the means for adjusting coverage per each pass, water pressure adjustment range, and tank and flow capacities. The equipment must have a range of adjustments that will provide a clean surface free of dirt, dust, oil, grease, algae, mildew, mold, and loose paint. When preparing new portland cement concrete for marking, provide equipment capable of removing curing compounds without damage to the concrete surface and joint seal materials. Submit safety data sheets for chemicals used in surface preparation. Chemicals must be bio-degradable.

2.1.1.1 Water Blasting Equipment

Use mobile water blasting equipment capable of producing a pressurized stream of water that effectively removes paint from the pavement surface without significantly damaging the pavement. Provide equipment, tools, and machinery which are safe and in good working order.

2.1.1.2 Shot Blasting Equipment

Use mobile self-propelled shot blasting equipment capable of producing an adjustable depth of paint removal and propelling abrasive particles at high velocities on the paint for effective removal. Ensure each unit is self-cleaning and self-contained. Use equipment able to confine the

abrasive, any dust that is produced, and removed paint and is capable of recycling the abrasive for reuse.

2.1.1.3 Grinding or Scarifying Equipment

Use equipment capable of removing surface contaminates, paint build-up, or extraneous markings from the pavement surface without leaving any residue. Clean the surface by a hydro blast to remove surface contaminants, and ash after a weed torch is used to remove paint.

2.1.1.4 Chemical Removal Equipment

Use chemical equipment capable of applying and removing chemicals and paint from the pavement surface, leaving only non-toxic biodegradable residue without scarring or other damage to the pavement or joints and joint seals.

2.1.2 Markings Application Equipment

Submit a marking applications equipment list of equipment appropriate for the material(s) to be used. Include the manufacturer's descriptive data and certification for the planned use that indicates the area of coverage per pass, pressure adjustment range, tank and flow capacities, and all safety precautions required for operating and maintaining the equipment. Provide and maintain machines, tools, and equipment used in the performance of the work in satisfactory operating condition, or remove equipment that is not providing satisfactory performance from the work site. Provide mobile and maneuverable application equipment to the extent that straight lines can be followed and normal curves can be made in a true arc.

2.1.2.1 Airless or Atomizing Equipment

Provide mobile airless or pneumatic air-atomized application equipment that is maneuverable to the extent that straight lines can be followed and normal curves can be made in a true arc. Mount equipment on trucks, skids or tractors. Use equipment suitable for application of the marking material specified. Airless systems are used to apply waterborne and epoxy coatings. Pneumatic systems are used only to apply waterborne and solvent based coatings.

Provide equipment capable of applying a marking from 4 inches to 12 inches wide in a single pass and also capable of applying two single solid or intermittent lines using a minimum of two colors. Provide equipment with tanks or reservoirs equipped with mechanical agitators, pressure regulators, and gages in full view of the equipment operator. Use paint strainers suitable to screen paint flowing in all supply lines.

2.1.2.2 Hand-Operated Machines

Provide a hand-operated push-type applicator machine commonly used for the application of water-based paint or two-component, or chemically curing paint to pavement surfaces for small marking projects, such as legends and cross-walks, parking lots, or surface painted signs. Provide an applicator machine with the necessary tanks and spraying nozzles capable of applying paint uniformly at specified wet film thickness. Provide spray guns for hand application of paint in areas where push-type machines cannot be used.

2.2 ROAD AND PARKING LOT MATERIALS

Submit safety data sheets for each paint type as well as manufacturer data sheets for all marking materials; include with the submittal a manufacturer certificate of compliance for marking materials.

2.2.1 Marking Colors

Provide markings for pavements that conform to SAE AMS-STD-595A color numbers as listed in Table I.

Table I - SAE AMS-STD-595A Color Numbers

Paint Color	SAE AMS-STD-595A Color Number
White	37925
Yellow	33538
Black	37038
Green	34108
Red	33411

2.2.2 Waterborne Paint

Use FS TT-P-1952, Type I or II paint. Use MPI 97 paint.

PART 3 EXECUTION

3.1 TEST SECTIONS

Before the performance of any marking application, demonstrate to the Government, using the equipment, materials, and personnel identified in the approved quality control plan, that the requirements for acceptance of the final product(s) are attainable. Perform demonstrations in a location designated by the Contracting Officer within the project scope of work. Do not perform the test section(s) until the Contracting Officer is present to observe the test. Each test section's result is the standard of performance for the color, width, wet film thickness application rate for each marking element. Submit the color, line width, wet film thickness, and measured reflectivity.

3.1.1 Surface Preparation and Paint Removal Test Section

Prepare an area large enough to determine cleanliness, cleaning rate, and removal rate. Use the means, methods, and equipment identified in the approved quality control plan. Adjust the means, methods, equipment, or equipment settings until the prepared surface is free of dirt, debris, oils and greases, algae, mold, mildew, and loose or flaking paint without damage to the pavement. Remove any equipment that fails to provide an acceptable product during the demonstration and provide new equipment that will produce an acceptable product.

3.1.2 Wet Film Thickness Test Section

Adjust the marking application rate for equipment speed, operating pressure, and line width, to provide a minimum wet film thickness, full coverage, and reflective media anchoring. Minimum and maximum wet film thickness is identified in Table III. Measure the wet film thickness using a wet film gauge at three points along the test section. Wet film thickness is determined using ASTM D4414 as the performance standard. When the average of the three readings is less than the minimum specified in Table III, repeat the test section. Submit the results of the marking application wet film thickness test to the Contracting Officer.

3.2 SURFACE PREPARATION

Clean surfaces before the application of marking materials. Remove all dust, dirt, scaling or loose paint, algae, oils, and grease and mineral deposits such as iron stains by use of water blasting or chemical removal. Follow the cleaning with sweeping, blowing or using water rinse. Do not begin painting in any location prepared for marking until surfaces are dry and clean.

Scrub areas with oil or grease present with applications of trisodium phosphate solution or other approved detergent or degreaser. Rinse thoroughly after each application to prevent staining of the new marking. After cleaning oil-soaked areas, seal with shellac or primer as the manufacturer recommends to prevent bleeding through the new paint.

3.3 PRE-APPLICATION TESTING

Test the pavement surface for moisture before beginning pavement marking after each period of rainfall, fog, high humidity, or cleaning or when the ambient temperature has fallen below the dew point. Do not commence marking until the pavement is sufficiently dry and the Contracting Officer has approved the pavement condition.

Employ the plastic wrap method, described as follows, to test the pavement for moisture:

a. Cover the pavement with a 12 inch by 12 inch section of clear plastic wrap and seal the edges with tape.

b. After 15 minutes, examine the plastic wrap for any visible moisture accumulation. Do not begin marking operations until the test can be performed with no visible moisture accumulation inside the plastic wrap.

c. Re-test surfaces when work has been stopped due to a precipitation event.

3.4 MARKINGS APPLICATION

3.4.1 Marking Materials for Roads and Parking Lots Pavement

3.4.1.1 Waterborne Paint

The dilution or thinning of paint prior to application is not allowed.

Provide FS TT-P-1952waterborne paint. Apply markings in accordance with Table III. Use the paint type as shown.

The paint wet film thickness application rate is provided in Table III. Perform the marking and bead application test section beginning at the minimum value and adjust the application rate up or down until the requirements of WET FILM THICKNESS TEST SECTION and REFLECTIVE TEST SECTION are satisfied. The values of wet film thickness and bead application rate established by the test section will be the standard of performance for the respective marking type and color.

Table III. Paint Wet Film Thickness and Bead Application Rate	
Paint Type	Non-Reflectorized Marking Wet Film Thickness (mil)
Type I	14-16
Type II	14-16
Type III	16-20

3.5 FIELD QUALITY CONTROL AND ACCEPTANCE

3.5.1 Material Inspection

The Contractor is responsible for examining all materials accepted for delivery for compliance with the certificate of compliance.

3.5.2 Dimensional Tolerance

The Contractor applies layout markings. All layout markings are placed before the marking material application. The edges of a line must not vary from a straight line drawn between the beginning and end of the line more than 1/2-inch to 50 feet. Marking dimensions and spacing must be within the tolerances provided in Table IV.

TABLE IV - Dimensional Tolerance for Marking Elements	
Dimension and Spacing	Tolerance
12 inch or less	+/- 1/2 inch
Greater than 36 inch to 6 feet	+/- 1 inch
Greater than 6 feet to 60 feet	+/- 2 inch
Greater than 60 feet	+/- 3 inch

3.5.3 Coating Application Reporting

3.5.3.1 Reporting Wet Film Thickness

Submit documentation on the wet film thickness for each marking element. Provide a reading at the rate of one reading per 1000 linear feet of line marking. A reading is the average of 10 measurements at random locations

within the marking element area. Submit the results of the marking application wet film thickness test to the Contracting Officer before proceeding with work on the project.

3.5.3.2 Wet Film Thickness

Conduct a marking application wet film thickness test. Provide a wet film thickness gauge to measure the wet film thickness using ASTM D4414 at the edge(s) and one interior location of the marking. When more than 3 in 10 consecutive measurements of wet film thickness are outside of the tolerances in Table III, remove and replace areas not meeting the wet film thickness requirement.

3.6 CLEANUP AND WASTE DISPOSAL

The worksite and the material staging area must be free of debris, dirt, and items that will blow away during periods of elevated wind speeds. Dispose of all materials at a site approved by the Contracting Officer. Dispose of waste from cleaning the marking equipment at a facility that is permitted to accept the material.

3.6.1 Cleanup Requirements

Provide a vacuum sweeper after each work area when markings are cured. Vacuum sweep the entire pavement surface to provide a clean pavement without fugitive glass beads and debris.

-- End of Section --

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SECTION 32 92 23

SODDING

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 C602	(2023) Agricultural Liming Materials
ASTM D4427	(2018) Standard Classification of Peat Samples by Laboratory Testing
ASTM D4972	(2018) Standard Test Methods for pH of Soils

TURFGRASS PRODUCERS INTERNATIONAL (TPI)

TPI GSS	(1995) Guideline Specifications to Turfgrass Sodding

U.S. DEPARTMENT OF AGRICULTURE (USDA)

DOA SSIR 42	(2022) Kellogg Soil Survey Laboratory Methods Manual, Soil Survey Investigations Report, No. 42, Version 6.0

1.2 DEFINITIONS

1.2.1 Stand of Turf

100 percent ground cover of the established species.

1.3 RELATED REQUIREMENTS

Section 31 00 00 EARTHWORK applies to this section for pesticide use and plant establishment requirements, with additions and modifications herein.

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. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Fertilizer

Include physical characteristics, and recommendations.

SD-06 Test Reports

Topsoil composition tests (reports and recommendations).

SD-07 Certificates

Sod farm certification for sods. Indicate type of sod in accordance with TPI GSS.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery

1.5.1.1 Sod Protection

Protect from drying out and from contamination during delivery, on-site storage, and handling.

1.5.1.2 Fertilizer Gypsum Sulfur Iron and Lime Delivery

Deliver to the site in original, unopened containers bearing manufacturer's chemical analysis, name, trade name, trademark, and indication of conformance to state and federal laws. Instead of containers, fertilizer gypsum sulphur iron and lime may be furnished in bulk with certificate indicating the above information.

1.5.2 Storage

1.5.2.1 Sod Storage

Lightly sprinkle with water, cover with moist burlap, straw, or other approved covering; and protect from exposure to wind and direct sunlight until planted. Provide covering that will allow air to circulate so that internal heat will not develop. Do not store sod longer than 24 hours. Do not store directly on concrete or bituminous surfaces.

1.5.2.2 Topsoil

Prior to stockpiling topsoil, treat growing vegetation with application of appropriate specified non-selective herbicide. Clear and grub existing vegetation three to four weeks prior to stockpiling topsoil.

1.5.2.3 Handling

Do not drop or dump materials from vehicles.

1.6 TIME RESTRICTIONS AND PLANTING CONDITIONS

1.6.1 Restrictions

Do not plant when the ground is muddy, or when air temperature exceeds 90 degrees Fahrenheit.

1.7 TIME LIMITATIONS

1.7.1 Sod

Place sod a maximum of thirty six hours after initial harvesting, in accordance with TPI GSS as modified herein.

PART 2 PRODUCTS

2.1 SODS

2.1.1 Classification

Nursery grown, certified as classified in the TPI GSS. Machine cut sod at a uniform thickness of 3/4 inch within a tolerance of 1/4 inch, excluding top growth and thatch. Each individual sod piece shall be strong enough to support its own weight when lifted by the ends. Broken pads, irregularly shaped pieces, and torn or uneven ends will be rejected.

2.1.2 Purity

Sod species shall be genetically pure, free of weeds, pests, and disease.

2.1.3 Planting Dates

Lay sod from March 1 to June 1 for warm season spring planting and from September 1 to December 1 for cool season fall planting.

2.1.4 Composition

2.1.4.1 Proportion

Proportion grass species as follows.

Botanical Name	Common Name	Percent
Cynodon dactylon 'T-419'	Bermudagrass	100

2.1.4.2 Sod Farm Overseeding

At the sod farm provide sod with overseeding of type recommended by seed producer.

2.2 TOPSOIL

2.2.1 On-Site Topsoil

Surface soil stripped and stockpiled on site and modified as necessary to meet the requirements specified for topsoil in paragraph COMPOSITION. When available topsoil shall be existing surface soil stripped and stockpiled on-site in accordance with Section 31 00 00 EARTHWORK.

2.2.2 Off-Site Topsoil

Conform to requirements specified in paragraph COMPOSITION. Additional topsoil shall be furnished by the Contractor.

2.2.3 Composition

Containing from 5 to 10 percent organic matter as determined by the topsoil composition tests of the Organic Carbon, 6A, Chemical Analysis Method described in DOA SSIR 42. Maximum particle size, 3/4 inch, with maximum 3 percent retained on 1/4 inch screen. The pH shall be tested in accordance with ASTM D4972. Topsoil shall be free of sticks, stones, roots, and other debris and objectionable materials. Other components shall conform to the following limits:

Silt	25-50 percent
Clay	10-30 percent
Sand	20-35 percent
pH	5.5 to 7.0
Soluble Salts	600 ppm maximum

2.3 SOIL CONDITIONERS

Add conditioners to topsoil as required to bring into compliance with "composition" standard for topsoil as specified herein.

2.3.1 Lime

Commercial grade hydrate limestone containing a calcium carbonate equivalent (C.C.E.) as specified in ASTM C602 of not less than 20 percent.

2.3.2 Aluminum Sulfate

Commercial grade.

2.3.3 Sulfur

100 percent elemental.

2.3.4 Iron

100 percent elemental.

2.3.5 Peat

Natural product of peat moss derived from a freshwater site and conforming to ASTM D4427. Shred and granulate peat to pass a 1/2 inch mesh screen and condition in storage pile for minimum 6 months after excavation.

2.3.6 Sand

Clean and free of materials harmful to plants.

2.3.7 Perlite

Horticultural grade.

2.3.8 Composted Derivatives

Ground bark, nitrolized sawdust, humus or other green wood waste material free of stones, sticks, and soil stabilized with nitrogen and having the following properties:

2.3.8.1 Particle Size

Minimum percent by weight passing:

No. 4 mesh screen	95
No. 8 mesh screen	80

2.3.8.2 Nitrogen Content

Minimum percent based on dry weight:

Fir Sawdust	0.7
Fir or Pine Bark	1.0

2.3.9 Gypsum

Coarsely ground gypsum comprised of calcium sulfate dihydrate 91 percent, calcium 22 percent, sulfur 17 percent; minimum 96 percent passing through 20 mesh screen, 100 percent passing thru 16 mesh screen.

2.3.10 Calcined Clay

Calcined clay shall be granular particles produced from montmorillonite clay calcined to a minimum temperature of 1200 degrees F. Gradation: A minimum 90 percent shall pass a No. 8 sieve; a minimum 99 percent shall be retained on a No. 60 sieve; and a maximum 2 percent shall pass a No. 100 sieve. Bulk density: A maximum 40 pounds per cubic foot.

2.4 FERTILIZER

2.4.1 Granular Fertilizer

Organic, granular controlled release fertilizer as recommended by manufacturer.

2.5 WATER

Source of water shall be approved by Contracting Officer and of suitable quality for irrigation containing no element toxic to plant life.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Extent Of Work

Provide soil preparation (including soil conditioners), fertilizing, and sodding of all newly graded finished earth surfaces, unless indicated otherwise, and at all areas inside or outside the limits of construction that are disturbed by the Contractor's operations.

3.1.2 Soil Preparation

Provide 4 inches of off-site topsoil, or on-site topsoil to meet indicated finish grade. After areas have been brought to indicated finish grade, incorporate fertilizer, pH adjusters, soil conditioners into soil a minimum depth of 4 inches by disking, harrowing, tilling or other method approved by the Contracting Officer. Remove debris and stones larger than 3/4 inch in any dimension remaining on the surface after finish grading. Correct irregularities in finish surfaces to eliminate depressions. Protect finished topsoil areas from damage by vehicular or pedestrian traffic.

3.1.2.1 Soil Conditioner Application Rates

Apply soil conditioners at rates as determined by laboratory soil analysis of the soils at the job site.

3.1.2.2 Fertilizer Application Rates

Apply fertilizer at rates as determined by laboratory soil analysis of the soils at the job site.

3.2 SODDING

3.2.1 Finished Grade and Topsoil

Prior to the commencement of the sodding operation, the Contractor shall verify that finished grades are as indicated on drawings; the placing of topsoil, smooth grading, and compaction requirements have been completed in accordance with Section 31 00 00 EARTHWORK.

The prepared surface shall be a maximum 1 inch below the adjoining grade of any surfaced area. New surfaces shall be blended to existing areas. The prepared surface shall be completed with a light raking to remove from the surface debris and stones over a minimum 5/8 inch in any dimension.

3.2.2 Placing

Place sod a maximum of 36 hours after initial harvesting, in accordance with TPI GSS as modified herein.

3.2.3 Finishing

After completing sodding, blend edges of sodded area smoothly into surrounding area. Air pockets shall be eliminated and a true and even surface shall be provided. Frayed edges shall be trimmed and holes and missing corners shall be patched with sod.

3.2.4 Rolling

Immediately after sodding, firm entire area except for slopes in excess of 3 to 1 with a roller not exceeding 90 pounds for each foot of roller width.

3.2.5 Watering

Start watering areas sodded as required by daily temperature and wind conditions. Apply water at a rate sufficient to ensure thorough wetting of soil to minimum depth of 6 inches. Run-off, puddling, and wilting shall be prevented. Unless otherwise directed, watering trucks shall not be

driven over turf areas. Watering of other adjacent areas or plant material shall be prevented.

3.3 PROTECTION OF TURF AREAS

Immediately after turfing, protect area against traffic and other use.

3.4 RESTORATION

Restore to original condition existing turf areas which have been damaged during turf installation operations. Keep clean at all times at least one paved pedestrian access route and one paved vehicular access route to each building. Clean other paving when work in adjacent areas is complete.

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SECTION 33 05 07.13

UTILITY DIRECTIONAL DRILLING

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	(2017) 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

ASTM INTERNATIONAL (ASTM)

ASTM D3350	(2021) Polyethylene Plastics Pipe and Fittings Materials
ASTM F714	(2024) Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter
ASTM F2620	(2024) Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI Z535.1	(2017) Safety Colors

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

29 CFR 1926.652	Safety and Health Regulations for Construction; Subpart P, Excavations; Requirements for Protective Systems

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. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Statement of Qualifications and Records; G

Horizontal Directional Drilling Plan; G

SD-03 Product Data

Pipe; G

Drilling Fluids; G

Additives; G

Tracer Wire; G

SD-06 Test Reports

Soil Test Data

SD-07 Certificates

Drill Rod

Fusion Technician Qualifications

SD-11 Closeout Submittals

Record Drawings

Complete Work Logs of Guided Directional Drill Operations

1.3 QUALITY CONTROL

1.3.1 Qualifications

Ensure that the field supervisor and workers assigned to this project are experienced in work of this nature and have successfully completed similar projects of similar length, pipe type, pipe size, and soil type using directional drilling in the last three (3) years. As part of the bid submission, submit project descriptions which include, at a minimum, a listing of the location(s), date of project(s), owner, pipe type and material, size installed, length of installation, manufacturer of equipment used, and other information relevant to the successful completion of the project.

1.3.2 Safety

Include in directional drilling equipment machine safety requirements a common grounding system to prevent electrical shock in the event of underground electrical cable strike. Ensure the grounding system connects all pieces of interconnecting machinery; the drill, mud mixing system, drill power unit, drill rod trailer, operator's booth, worker grounding mats, and any other interconnected equipment to a common ground. Equip the drill with an "electrical strike" audible and visual warning system that notifies the system operators of an electrical strike.

1.3.3 Horizontal Directional Drilling Plan

Provide a plan prepared, signed, and sealed by a licensed Professional Engineer. Submit supporting calculations, certifications, and material product data demonstrating the strength of the product pipes for acceptance before the beginning of the installation. Demonstrate that the proposed material satisfies the purpose of the utility and withstands the design and construction stresses and pressures. The HDD Plan will include the following:

1.3.3.1 Layout Plan

Provide a plan location of the operation, including entry and exit points, discussing the relationship of the equipment, pipe assembly, and staging areas.

1.3.3.2 Utility Profile

Provide a profile of the utility plotted at a scale appropriate for the work.

1.3.3.3 Equipment List

Provide a directional drilling equipment list including: Drilling rig, drill bit, back-reamer, mud mixing and pumping systems, down-hole tools, guidance system, and rig safety system. Provide calibration records for guidance system.

1.3.3.4 Drilling Fluid Management Plan

Provide a drilling fluid management plan to include drilling fluid types and specifications, cleaning and recycling equipment, estimated flow rates, procedures for minimizing drilling fluid escape, and the method/location for final disposal of waste drilling fluids. Provide a frac out control plan, including frac control materials that will be onsite and contact information for emergency personnel.

1.3.3.5 Method and Procedures

Provide an outline of the methods and procedures, describing the pilot hole drilling procedure, the reaming operation, and the pullback procedure, including drawings, schedule of operations, specifications, and method of operation. Include pipe storage and handling details and pipeline assembly and installation procedures.

1.3.3.6 Safety Data Sheets

Submit safety data sheets for fluids and additives.

1.3.3.7 Revisions

If site conditions change and require modification to the HDD Plan, submit revised drilling plan to achieve successful installation. Explain, in the revised submittal, the anticipated and encountered conditions that mandated the change in plans.

1.3.4 Fusion Technician Qualifications

The fusion technician must be qualified by the fusion equipment manufacturer to thermally butt-fuse the size of pipe used at the time of fusion performance. Each joint must be datalogged, recorded, and submitted for review.

1.4 DELIVERY, STORAGE, AND HANDLING

Inspect materials delivered to the site for damage. All materials found during inspection or during the progress of work to have cracks, flaws, surface abrasions, or other defects will be rejected. Remove defective

materials from the job site.

Protect stored piping from moisture and dirt and place on level surface. Store plastic piping protected from direct sunlight.

PART 2 PRODUCTS

2.1 EQUIPMENT

2.1.1 Drill Rod

Select the appropriate drill rod to be used. Submit certified statement that the drill rod has been inspected and is in satisfactory condition for its intended use.

2.2 MATERIALS

2.2.1 Pipe

2.2.1.1 HDPE

Install 6-inch diameter high density polyethylene pipe (HDPE) with a standard dimension ratio of 9 (SDR9). Provide pipe conforming to ASTM D3350, ASTM F714.

Use butt fusion jointing method for plain end HDPE pipe. Comply with ASTM F2620 for butt fusion joints.

2.2.2 Drilling Fluids

Use a high quality bentonite drilling fluid to ensure hole stability, cuttings transport, bit and electronics cooling, and hole lubrication to reduce drag on the drill pipe and the product pipe. Use only fluid with a composition which complies with all Federal, State, and local environmental regulations.

2.2.3 Additives

Use admixtures as required to address soil conditions and water conditions such as water hardness, acidity, and alkalinity.

2.2.4 Tracer Wire

Use a continuous sheathed solid conductor copper wire line, minimum #12 AWG. Sheathing must be color coded to match the utility.

PART 3 EXECUTION

3.1 EXAMINATION

a. Soil Test Data.

Provide written documentation of conformance with AASHTO T 180.

3.2 INSTALLATION

Ensure all utilities are located and clearly marked prior to start of excavation or drilling.

3.2.1 Drill Set-Up

Design and construct the drill entrance and exit pits.

3.2.1.1 Drilling Fluids

Mix the bentonite drilling fluid with potable water (of proper pH) to ensure no contamination is introduced into the soil during the drilling, reaming, or pipe installation process. Make any required additive adjustments.

3.2.2 Drill Entrance and Exit Pits

Drill entrance and exit pits are required. Maintain at minimum size to allow only the minimum amount of drilling fluid storage prior to transfer to mud recycling or processing system or removal from the site.

Do not allow drilling mud to flow freely on the site or around the entrance or exit pits. Remove spilled mud and restore ground to original condition. Provide shore pits in compliance with OSHA Standards, 29 CFR 1926.652.

3.2.3 Drill Entrance and Exit Angle

Ensure entrance and exit angles and elevation profile maintains adequate cover to reduce risk of drilling fluid breakouts and ground exit occurs as specified herein. Ensure that entrance and exit angles generate pullback forces that do not exceed 5 percent strain on the high density polyethylene pipe.

3.2.4 Pilot Hole

The type and size of the pilot string cutting head and the diameter of the drill pipe are at the Contractor's discretion.

Drill the pilot hole along the path shown on the plan and profile drawings. Pilot hole tolerances are as follows:

a. Vertical Tolerance: Provide minimum cover below underground utilities as specified on the plans. Pilot hole may go deeper if necessary to prevent breakout.

b. Horizontal Tolerance: Plus or minus - 60 inches from the centerline of the product pipe.

c. Curve Radius: No curve is acceptable with a radius less than manufacturer recommendation.

d. Entry Point Location: Make pilot hole entry point within plus or minus - 60 inches of the location shown on the drawings or as directed by the Contracting Officer in the field.

e. Exit Point Location: Make the exit point location within plus/minus - 60 inches of the location shown on the drawings or as directed by the Contracting Officer in the field.

f. Mandatory pipeline cover requirements are as shown on the drawings or as specified.

3.2.5 Guidance Systems

Use a walkover guidance systemor an electric grid (tru-tracker) system for this project. Ensure proper calibration of all equipment before commencing directional drilling operation.

3.2.6 Reaming

Conduct reaming operations at the Contractor's discretion. Determine the type of back reamer to be utilized by the type of subsurface soil conditions that are encountered during the pilot hole drilling operation. The reamer type is at the Contractor's discretion.

3.2.7 Pull Back

Fully assemble the entire pipeline to be installed via direction drill prior to commencement of pull back operations. Install a continuous length of tracer wire for the full length of each run of nonmetallic pipe in accordance with ANSI Z535.1. Attach wire to top of pipe in such a manner that it will not be displaced during construction operations.

Support the pipeline during pullback operations in a manner to enable it to move freely and prevent damage. Install the pipeline in one continuous pull.

Minimize torsion stress by using a swivel to connect the pull section to the reaming assembly.

Maximum allowable tensile force imposed on the pull section is not to exceed 90 percent of the pipe manufacturer's safe pull (or tensile) strength.

Minimize external pressure during installation of the pullback section in the reamed hole. Replace damaged pipe resulting from external pressure at no cost to the Government. Buoyancy modification is at the discretion of the Contractor.

3.2.8 Drilling Fluids Disposal

Collect drilling fluid returns in the entrance pit, exit pit, or spoils recovery pit. Immediately clean up any drilling fluid spills or overflows from these pits.

Dispose of fluids in a manner that is in compliance with all permits and applicable Federal, State, and local regulations. Disposal of the drilling fluids may occur on approved land owned by the Government subject to written approval from the Contracting Officer. Spread the drilling slurry over the Government-approved disposal area and plow into the soil.

Conduct disposal in compliance with all relative environmental regulations, right-of-way and work space agreements, and permit requirements.

3.2.9 Connection of Product Pipe to Pipeline

After the product pipe has been successfully installed, allow the product pipe to recover for 24 hours prior to connection of the pipeline. Ensure that a sufficient length of the product pipe has been pulled through the hole so that the pull-nose is not pulled back into bore hole due to

stretch recovery of the product pipe.

3.3 FIELD QUALITY CONTROL

3.3.1 Daily Work Log

Maintain a work log of construction events and operations including, but not limited to, the following for each day's work:

a. Hours worked.

b. Log of each drill rod added or withdrawn during drilling, reaming, and pull back.

c. Groundwater control operations.

d. Description of soil conditions encountered.

e. Tools and equipment in use, drilling fluid, fluid pumping rate, and drilling head location.

f. Any unusual conditions or events.

g. Reasons for operational shutdown in event work is halted.

3.3.2 Drill Logs

Maintain drilling logs that accurately provide drill bit location (both horizontally and vertically) at each rod, typically 10 feet along the drill path. In addition, keep logs that record, as a minimum the following, every 15 minutes throughout each drill pass, back ream pass, or pipe installation pass:

a. Drilling Fluid Pressure.

b. Drilling Fluid Flow Rate.

c. Drill Thrust Pressure.

d. Drill Pullback Pressure.

e. Drill Head Torque.

Make all instrumentation, readings, and logs available to the Contracting Officer at all times during operation.

3.3.3 Field Tests

Perform field tests and provide labor, equipment, and incidentals required for testing. Submit test results, identifying any results that do not meet requirements, to the Contracting Officer within four days of test completion. Provide corrective action and retest pipe not meeting requirements. Provide corrective action as recommended by the pipe manufacturer and subject to approval by the Contracting Officer.

3.4 CLOSEOUT ACTIVITIES

Immediately upon completion of work, remove all rubbish and debris from the job site. Remove all construction equipment and implements of service

leaving the entire area involved in a neat condition acceptable to the Contracting Officer.

Immediately clean "blow holes" or "breakouts" of drilling fluid to the surface and return the surface area to its original condition. Dispose of all drilling fluids, soils, and separated materials in compliance with Federal, State, and local environmental regulations.

Provide a post-construction fusion report including the following data for each fusible connection:

a. Pipe Size and Thickness.

b. Machine Size.

c. Fusion Technician Identification.

d. Job Identification.

e. Fusion Joint Number.

f. Fusion, Heating, and Drag Pressure Settings.

g. Heat Plate Temperature.

h. Time Stamp.

i. Heating and Cool Down Time of Fusion.

j. Ambient Temperature.

Submit an electronic copy and three hard copies of the record drawings to the Contracting Officer within five days after completing the pull back. Include in the record drawings a plan, profile, and all information recorded during the progress of the work. Clearly tie the record drawings to the project's survey control. Maintain, and submit upon completion, signed complete work logs of guided directional drill operations.

-- End of Section --

SECTION 33 11 00

WATER UTILITY DISTRIBUTION PIPING

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 B18.2.2	(2022) Nuts for General Applications: Machine Screw Nuts, and Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C104/A21.4	(2022) Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
AWWA C110/A21.10	(2021) Ductile-Iron and Gray-Iron Fittings
AWWA C111/A21.11	(2023) Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C151/A21.51	(2023) Ductile-Iron Pipe, Centrifugally Cast
AWWA C153/A21.53	(2019) Ductile-Iron Compact Fittings for Water Service
AWWA C219	(2023) Bolted Sleeve-Type Couplings for Plain-End Pipe
AWWA C500	(2019) Metal-Seated Gate Valves for Water Supply Service
AWWA C509	(2023) Resilient-Seated Gate Valves for Water Supply Service
AWWA C515	(2020) Reduced-Wall, Resilient-Seated Gate Valves for Water Supply Service
AWWA C600	(2023) Installation of Ductile-Iron Mains and Their Appurtenances
AWWA C651	(2023) Standard for Disinfecting Water Mains
AWWA C655	(2018) Field Dechlorination
AWWA C800	(2021) Underground Service Line Valves and Fittings

AWWA M41	(2009; 3rd Ed) Ductile-Iron Pipe and Fittings

ASTM INTERNATIONAL (ASTM)

ASTM A48/A48M	(2022) Standard Specification for Gray Iron Castings
ASTM A307	(2021) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings
ASTM A563/A563M	(2024) Standard Specification for Carbon and Alloy Steel Nuts (Inch and Metric)
ASTM C94/C94M	(2024c) Standard Specification for Ready-Mixed Concrete
ASTM C1433	(2024) Standard Specification for Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains, and Sewers

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 8678	(1998) Cup Head Square Neck Bolts with Small Head and Short Neck-Product Grade B

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 24	(2022) Standard for the Installation of Private Fire Service Mains and Their Appurtenances

NSF INTERNATIONAL (NSF)

NSF/ANSI/CAN 61	(2024) Drinking Water System Components - Health Effects

UNDERWRITERS LABORATORIES (UL)

UL 262	(2004; Reprint Jul 2023) Gate Valves for Fire-Protection Service

1.2 DEFINITIONS

1.2.1 Water Service Lines

Water service lines include water piping from a water main to a building service connection 5 feet from the perimeter of buildings or structures,

specific materials, methods of joining and any appurtenances deemed necessary for a satisfactory system.

1.2.2 Additional Definitions

For additional definitions refer to the definitions in the applicable referenced standard.

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. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Connections; G

SD-03 Product Data

Pipe, Fittings, Joints and Couplings; G

Valves; G

Precast Concrete Thrust Blocks; G

Disinfection Procedures; G

SD-06 Test Reports

Leakage Test

Hydrostatic Test

SD-07 Certificates

Pipe, Fittings, Joints and Couplings

Lining

SD-08 Manufacturer's Instructions

Ductile-Iron Piping

1.4 QUALITY CONTROL

1.4.1 Regulatory Requirements

Use NSF/ANSI/CAN 61 materials for potable water systems to comply with lead free content requirements as defined by the U.S. Safe Drinking Water Act effective January 2014 and January 2022.

Comply with NFPA 24 for materials, installation, and testing of fire main piping and components.

1.4.2 Qualifications

1.4.2.1 Backflow Preventers

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery and Storage

Inspect materials delivered to site for required pipe markings and damage. Unload and store with minimum handling and in accordance with manufacturer's instructions to prevent cuts, scratches and other damage. Store materials on site in enclosures or under protective covering. Do not store materials directly on the ground. Keep inside of pipes, fittings, valves, and other accessories free of dirt and debris or other contaminates.

1.5.2 Handling

Handle pipe, fittings, valves, and other accessories in accordance with applicable AWWA standard, manufacturer's instructions and in a manner to ensure delivery to the trench in sound undamaged condition. Avoid injury to coatings and linings on pipe and fittings; make repairs if coatings or linings are damaged. Do not place other material, hooks, or pipe inside a pipe or fitting after the coating has been applied. Inspect the pipe for defects before installation. Carry, do not drag pipe to the trench. Use of pinch bars and tongs for aligning or turning pipe will be permitted only on the bare ends of the pipe. Clean the interior of pipe and accessories of foreign matter before being lowered into the trench and keep them clean during laying operations by plugging. Replace defective material without additional expense to the Government. Store rubber gaskets, not immediately installed, under cover or out of direct sunlight.

Handle ductile iron pipe, fittings, and accessories in accordance with AWWA C600 and AWWA M41.

PART 2 PRODUCTS

2.1 MATERIALS

All materials are intended for potable water use unless otherwise indicated. Comply with NSF/ANSI/CAN 61 for all potable water pipe, fittings and other applicable materials.

Provide all materials in accordance with AWWA C800 and as indicated herein. Provide valves and fittings with pressure ratings equivalent to the pressure ratings of the pipe.

2.1.1 Pipe, Fittings, Joints And Couplings

Submit manufacturer's standard drawings or catalog cuts, except submit both drawings and cuts for push-on joints. Include information concerning gaskets with submittal for joints and couplings.

2.1.1.1 Ductile-Iron Piping

2.1.1.1.1 Pipe and Fittings

Pipe, AWWA C151/A21.51, Pressure Class 150. Fittings, AWWA C110/A21.10 or AWWA C153/A21.53. Provide fittings with pressure ratings equivalent to

that of the pipe. Provide compatible pipe ends and fittings for the specified joints. Provide cement-mortar lining, AWWA C104/A21.4, standard thickness on pipe and fittings.

2.1.1.1.2 Joints and Jointing Material

Provide push-on joints or mechanical joints for pipe and fittings unless otherwise indicated. Sleeve-type mechanical couplings in lieu of push-on joints are acceptable, subject to the limitations specified in the paragraph SLEEVE-TYPE MECHANICAL COUPLINGS.

a. Push-On Joints: Shape of pipe ends and fitting ends, gaskets, and lubricant for joint assembly as recommended in AWWA C111/A21.11.

b. Mechanical Joints: Dimensional and material requirements for pipe ends, glands, bolts and nuts, and gaskets as recommended in AWWA C111/A21.11.

c. Sleeve-Type Mechanical Coupled Joints: As specified in the paragraph SLEEVE-TYPE MECHANICAL COUPLINGS.

2.1.2 Valves

2.1.2.1 Gate Valves 3 Inch Size and Larger

AWWA C500, AWWA C509, AWWA C515, or UL 262 and:

a. AWWA C500: Nonrising stem type with double-disc gate and mechanical-joint ends or push-on joint ends compatible for the adjoining pipe.

b. AWWA C509 or AWWA C515: Nonrising stem type with mechanical-joint ends or resilient-seated gate valves 3 to 12 inches in size

c. UL 262: Inside-screw type with operating nut, double-disc or split-wedge type gate, designed for a hydraulic working pressure of 175 psi, and have mechanical-joint ends or push-on joint ends as appropriate for the pipe to which it is joined.

Match materials for UL 262 gate valves to the reference standards specified in AWWA C500. Gate valves open by counterclockwise rotation of the valve stem. Stuffing boxes have 0-ring stem seals. Stuffing boxes are bolted and constructed so as to permit easy removal of parts for repair. Use gate valves with special ends for connection to cement piping or sleeve-type mechanical coupling in lieu of mechanical-joint ends and push-on joint ends. Provide valve ends and gaskets for connection to cement piping or to sleeve-type mechanical couplings that conform to the requirements specified respectively for the joint or coupling. When operating nut depth exceeds 3 feet below finished grade, provide an extension stem with standard 2 inch operating nut. Provide all valves from one manufacturer.

2.1.2.2 Water Service Valves

2.1.2.2.1 Gate Valves Smaller than 3 Inch in Size on Buried Piping

Gate valves smaller than 3 inch size on Buried Piping MSS SP-80, Class 150, solid wedge, nonrising stem, with flanged or threaded end connections, a union on one side of the valve, and a handwheel operator.

2.1.2.3 Valve Boxes

Provide a valve box for each gate valve on buried piping. Construct adjustable valve boxes manufactured from cast iron of a size compatible for the valve on which it is used. Provide cast iron valve boxes with a minimum cover and wall thickness of 3/16 inch and conforming to ASTM A48/A48M, Class 35B. Coat the cast-iron box with a heavy coat of bituminous paint. Cast the word "WATER" on the lid. The minimum diameter of the shaft of the box is 5 1/4 inches. Provide ASTM C1433 precast concrete valve box.

2.2 ACCESSORIES

2.2.1 Pipe Restraint

2.2.1.1 Thrust Blocks

Use ASTM C94/C94M concrete having a minimum compressive strength of 3000 at 28 days.

2.2.1.2 Precast Thrust Blocks

Provide precast concrete thrust blocks.

2.2.1.3 Joint Restraint

Provide restrained joints in accordance with NFPA 24, Chapter 10.

Provide mechanical joint restraint and meeting the requirements of AWWA C110/A21.10.

2.2.2 Sleeve-Type Mechanical Couplings

Use AWWA C219 couplings to join plain-end piping by compression of a ring gasket at each end of the adjoining pipe sections. The coupling consists of one middle ring flared or beveled at each end to provide a gasket seat; two follower rings; two resilient tapered rubber gaskets; and bolts and nuts to draw the follower rings toward each other to compress the gaskets. Provide true circular middle ring and the follower rings sections free from irregularities, flat spots, and surface defects; provide for confinement and compression of the gaskets. For ductile iron pipe, use ASTM A536 ductile iron. Use gaskets for resistance to set after installation and to meet the requirements specified for gaskets for mechanical joint in AWWA C111/A21.11. Provide track-head type bolts ASTM A307, Grade A, with ASTM A563/A563M, Grade A nuts or round-head square-neck type ISO 8678 bolts with ASME B18.2.2 hex nuts. Provide 5/8 inch diameter bolts. Minimum number of bolts for each coupling is 4 for 4 inch pipe, 6 for 8 inch pipe, and 7 for 10 inch pipe. Shape bolt holes in follower rings to hold fast to the necks of the bolts used. Do not use mechanically coupled joints using a sleeve-type mechanical coupling as an optional method of jointing except where pipeline is adequately anchored to resist tension pull across the joint. Provide a tight flexible joint with mechanical couplings under reasonable conditions, such as pipe movements caused by expansion, contraction, slight settling or shifting in the ground, minor variations in trench gradients, and traffic vibrations. Match coupling strength to that of the adjoining pipeline.

2.2.3 Insulating Joints

Provide a rubber-gasketed insulating joint or dielectric coupling between pipe of dissimilar metals which will effectively prevent metal-to-metal contact between adjacent sections of piping.

2.2.4 Dielectric Fittings

Install dielectric fittings between threaded ferrous and nonferrous metallic pipe, fittings and valves, except where corporation stops join mains to prevent metal-to-metal contact of dissimilar metallic piping elements and compatible with the indicated working pressure.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Connections to Existing System

Perform all connections to the existing water system in the presence of the Contracting Officer.

3.1.2 Operation of Existing Valves

Do not operate valves within or directly connected to the existing water system unless expressly directed to do so by the Contracting Officer.

3.1.3 Earthwork

Perform earthwork operations in accordance with Section 31 00 00 EARTHWORK.

3.2 INSTALLATION

Install all materials in accordance with the applicable reference standard, manufacturers instructions and as indicated herein.

3.2.1 Piping

3.2.1.1 General Requirements

Install pipe, fittings, joints and couplings in accordance with the applicable referenced standard, the manufacturer's instructions and as specified herein.

3.2.1.1.1 Termination of Water Lines

Terminate the work covered by this section at a point approximately 5 feet from the building, unless otherwise indicated.

Do not lay water lines in the same trench with gas lines, fuel lines, electric wiring, or any other utility.

3.2.1.1.2 Pipe Laying and Jointing

Remove fins and burrs from pipe and fittings. Before placing in position, clean pipe, fittings, valves, and accessories, and maintain in a clean condition. Provide proper facilities for lowering sections of pipe into trenches. Under no circumstances is it permissible to drop or dump pipe, fittings, valves, or other water line material into trenches. Cut pipe

cleanly, squarely, and accurately to the length established at the site and work into place without springing or forcing. Inspect pipe and fittings prior to backfilling and repair as required. Replace a pipe or fitting that does not allow sufficient space for installation of jointing material. Blocking or wedging between bells and spigots is not permitted. Lay bell-and-spigot pipe with the bell end pointing in the direction of laying. Grade the pipeline in straight lines; avoid the formation of dips and low points. Support pipe at the design elevation and grade. Secure firm, uniform support. Wood support blocking is not permitted. Lay pipe so that the full length of each section of pipe and each fitting rests solidly on the pipe bedding; excavate recesses to accommodate bells, joints, and couplings. Provide anchors and supports for fastening work into place. Make provision for expansion and contraction of pipelines. Keep trenches free of water until joints have been assembled. At the end of each work day, close open ends of pipe temporarily with wood blocks or bulkheads. Do not lay pipe when conditions of trench or weather prevent installation. Provide a minimum of 3 feet depth of cover over top of pipe.

3.2.1.1.3 Connections to Existing Water Lines

Make connections to existing water lines after coordination with the facility and with a minimum interruption of service on the existing line. Make connections to existing lines under pressure in accordance with the recommended procedures of the manufacturer of the pipe being tapped and as indicated.

3.2.1.1.4 Sewer Manholes

No water piping is to pass through or come in contact with any part of a sewer manhole.

3.2.1.1.5 Water Piping Crossing Sewer Piping

Provide at least 24 inches above the top (crown) of the sewer piping and the bottom (invert) of the water piping whenever possible. Measure the distance edge-to-edge. Where water lines cross under gravity sewer lines, construct sewer line of AWWA compliant ductile iron water piping with rubber-gasketed joints and no joint located within 10 feet, horizontally, of the crossing.

a. Normal Conditions: Provide a separation of at least 24 inches between the bottom of the water piping and the top of the sewer piping in cases where water piping crosses above sewer piping.

b. Unusual Conditions: When local conditions prevent a vertical separation described above, construct sewer piping passing over or under water piping of AWWA compliant ductile iron water piping and perform hydrostatic sewer test, without leakage, prior to backfilling. Construct sewer crossing with a minimum 20 feet length of the AWWA compliant ductile iron water piping, centered at the point of the crossing so that joints are equidistant and as far as possible from the water piping. Protect water piping passing under sewer piping by providing a vertical separation of at least 24 inches between the bottom of the sewer piping and the top of the water piping; adequate structural support for the sewer piping to prevent excessive deflection of the joints and the settling on or damage to the water piping.

3.2.1.1.6 Penetrations

Provide ductile-iron or Schedule 40 steel wall sleeves for pipe passing through walls of valve pits and structures. Fill annular space between walls and sleeves with rich cement mortar. Fill annular space between pipe and sleeves with mastic.

3.2.1.2 Ductile-Iron Piping

Unless otherwise specified, install pipe and fittings in accordance with the paragraph GENERAL REQUIREMENTS and with the requirements of AWWA C600 for pipe installation, joint assembly, valve-and-fitting installation, and thrust restraint.

a. Jointing: Make push-on joints with the gaskets and lubricant specified for this type joint; assemble in accordance with the applicable requirements of AWWA C600 and AWWA M41 for joint assembly. Make mechanical joints with the gaskets, glands, bolts, and nuts specified for this type joint; assemble in accordance with the applicable requirements of AWWA C600 and AWWA M41 for joint assembly and the recommendations of Appendix A to AWWA C111/A21.11.

b. Allowable Deflection: Follow AWWA C600 and AWWA M41 for the maximum allowable deflection. If the alignment requires deflection in excess of the above limitations, provide special bends or a sufficient number of shorter lengths of pipe to achieve angular deflections within the limit set forth.

3.2.1.3 Metallic Piping for Service Lines

Install pipe and fittings in accordance with the paragraph GENERAL REQUIREMENTS and with the applicable requirements of AWWA C600 for pipe installation, unless otherwise specified.

3.2.1.3.1 Screwed Joints

Make screwed joints up tight with a stiff mixture of graphite and oil, inert filler and oil, or graphite compound; apply to male threads only or with PTFE Tape, for use with threaded pipe. Threads are to be full cut; do not leave more than three threads on the pipe exposed after assembling the joint.

3.2.1.4 Trenchless Piping

3.2.1.4.1 Installation Ductile Iron Ball and Socket Joint

Install pipe and fittings in accordance with AWWA C600 and AWWA M41 for pipe installation, joint assembly, and thrust restraint.

a. Allowable Deflection: Meet the applicable requirements of AWWA C600, AWWA M41 and in accordance with pipe manufacturer's instructions for the maximum allowable deflection.

3.2.1.5 Fire Protection Service Lines for Sprinkler Supplies

Connect water service lines used to supply building sprinkler systems for fire protection to the water main in accordance with NFPA 24.

3.2.1.6 Water Service Piping

3.2.1.6.1 Location

Connect water service piping to the building service where the building service has been installed. Where building service has not been installed, terminate water service lines approximately 5 feet from the building line at the points indicated; close such water service lines with plugs or caps.

3.2.1.6.2 Water Service Line Connections to Water Mains

Connect water service lines to the main as indicated. Connect water service lines to the main with a rigid connection and install a gate valve on service line below the frostline as indicated. Connect water service lines to ductile-iron water mains in accordance with AWWA C600 for service taps.

3.2.2 Disinfection

Prior to disinfection, provide disinfection procedures, proposed neutralization and disposal methods of waste water from disinfection as part of the disinfection submittal. Disinfect new water piping and existing water piping affected by Contractor's operations in accordance with AWWA C651. Disinfect new water piping using the AWWA C651. Ensure a free chlorine residual of not less than 10 parts per million after 24 hour holding period and prior to performing bacteriological tests.

3.2.3 Flushing

Perform bacteriological tests prior to flushing. Flush solution from the systems with domestic water until maximum residual chlorine content is within the range of 0.2 to 0.5 parts per million, the residual chlorine content of the distribution system, or acceptable for domestic use. Use AWWA C655 neutralizing chemicals.

3.2.4 Pipe Restraint

3.2.4.1 Concrete Thrust Blocks

Install concrete thrust blocks where indicated.

3.2.4.2 Restrained Joints

Install restrained joints in accordance with the manufacturer's instructions NFPA 24 where indicated. For metal harness use tie rods and clamps as shown in NFPA 24. Provide metal harness fabricated by the pipe manufacturer and furnished with the pipe.

3.2.5 Valves

3.2.5.1 Gate Valves

Install gate valves, AWWA C500 and UL 262, in accordance with the requirements of AWWA C600 for valve-and-fitting installation and with the recommendations of the Appendix ("Installation, Operation, and Maintenance of Gate Valves") to AWWA C500. Install gate valves, AWWA C509 or AWWA C515, in accordance with the requirements of AWWA C600 for valve-and-fitting installation and with the recommendations of the Appendix ("Installation,

Operation, and Maintenance of Gate Valves") to AWWA C509 or AWWA C515. Make and assemble joints to gate valves as specified for making and assembling the same type joints between pipe and fittings.

3.3 FIELD QUALITY CONTROL

3.3.1 Tests

Notify the Contracting Officer a minimum of five days in advance of hydrostatic testing. Coordinate the proposed method for disposal of waste water from hydrostatic testing. Perform field tests, and provide labor, equipment, and incidentals required for testing. Provide documentation that all items of work have been constructed in accordance with the Contract documents.

3.3.1.1 Hydrostatic Test

Test the water system in accordance with the applicable AWWA standard specified below. Where water mains provide fire service, test in accordance with the special testing requirements given in the paragraph SPECIAL TESTING REQUIREMENTS FOR FIRE SERVICE. Do not backfill utility trench or begin testing on any section of a pipeline where concrete thrust blocks have been provided until at least 7 days after placing of the concrete.

3.3.1.2 Hydrostatic Sewer Test

The hydrostatic pressure sewer test will be performed in accordance with the applicable AWWA standard for the piping material or AWWA C600.

3.3.1.3 Leakage Test

For leakage test, use a hydrostatic pressure not less than the maximum working pressure of the system. Leakage test may be performed at the same time and at the same test pressure as the pressure test.

3.3.1.4 Bacteriological Testing

Perform bacteriological tests in accordance with AWWA C651 obtain two sets of samples for coliform analysis, each sample being collected at least 16 hours apart. Analyze samples by a certified laboratory, and submit the results of the bacteriological samples.

3.3.1.5 Special Testing Requirements for Fire Service

Test water mains and water service lines providing fire service or water and fire service in accordance with NFPA 24. The additional water added to the system must not exceed the limits given in NFPA 24

3.4 SYSTEM STARTUP

Water mains and appurtenances must be completely installed, disinfected, flushed, and satisfactory bacteriological sample results received prior to permanent connections being made to the active distribution system. Obtain approval by the Contracting Officer prior to the new water piping being placed into service.

3.5 CLEANUP

Upon completion of the installation of water lines and appurtenances, remove all debris and surplus materials resulting from the work.

-- End of Section --

SECTION 33 11 23

NATURAL GAS PIPING

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 GAS ASSOCIATION (AGA)

AGA ANSI B109.4	(2016) Self-Operated Diaphragm-Type Natural Gas Service Regulators for Nominal Pipe Size 1¼ inches (32 mm) and Smaller with Outlet Pressures of 2 psig (13.8 kPa) and Less
AGA XR0603	(2006; 8th Ed) AGA Plastic Pipe Manual for Gas Service

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.15/CSA 9.1	(2021) Manually Operated Gas Valves for Appliances, Appliance Connector Valves and Hose End Valves
ANSI Z21.21/CSA 6.5	(2023) Automatic Valves for Gas Appliances
ANSI Z21.41/CSA 6.9	(2023) Quick-Disconnect Devices for Use with Gas Fuel Appliances
ANSI Z21.45	(1995) Flexible Connectors of Other Than All-Metal Construction for Gas Appliances
ANSI Z21.69/CSA 6.16	(2015; R 2020) Connectors for Movable Gas Appliances
ANSI Z21.80/CSA 6.22	(2019) Line Pressure Regulators

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.1	(2024) Unified Inch Screw Threads (UN, UNR, and UNJ Thread Form)
ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
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	(2018) Factory-Made Wrought Buttwelding

	Fittings
ASME B16.38	(2023) Large Metallic Valves for Gas Distribution Manually Operated, NPS 2 1/2 (DN 65) to NPS 12 (DN 300), 125 psig 8.6 bar) Maximum
ASME B16.39	(2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B18.2.1	(2012; R 2021) Square, Hex, Heavy Hex, and Askew Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws (Inch Series)
ASME B18.2.2	(2022) Nuts for General Applications: Machine Screw Nuts, and Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)
ASME B31.8	(2022; Supplement 2022) Gas Transmission and Distribution Piping Systems
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 A193/A193M	(2024) 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 D2513	(2018a) Standard Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing, and Fittings

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 54	(2024) National Fuel Gas Code

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-101	(2014; Rev C) Color Code for Pipelines and for Compressed Gas Cylinders

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

49 CFR 192	Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards

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. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Valve Box

Pressure Regulator

Gas Equipment Connectors

Valves

Warning and Identification Tape

Risers

Transition Fittings

SD-07 Certificates

PE Welder's Qualifications

SD-08 Manufacturer's Instructions

PE Pipe and Fittings

Submit manufacturer's installation instructions and manufacturer's visual joint appearance chart.

1.3 QUALITY ASSURANCE

1.3.1 PE Welder's Qualifications

Prior to installation, Contractor must have supervising and installing personnel trained by a PE pipe manufacturer's sponsored course of not less than one week duration, or present proof satisfactory to the Contracting Officer that personnel are currently working in the installation of PE gas distribution lines.

1.3.2 Safety Standards

49 CFR 192.

1.4 DELIVERY, STORAGE, AND HANDLING

Handle, transport, and store plastic pipe and fittings carefully. Plug or cap pipe ends during transportation or storage to minimize dirt and moisture entry. Do not subject to abrasion or concentrated external loads. Discard PE pipe sections and fittings that have been damaged.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Conform to NFPA 54 and with requirements specified herein. Supply piping to appliances or equipment must be at least as large as the inlets thereof.

2.2 PIPE AND FITTINGS

2.2.1 Aboveground

a. Pipe: Black steel in accordance with ASTM A53/A53M, Schedule 40, threaded ends for sizes 2 inches and smaller; otherwise, plain end beveled for butt welding.

b. Threaded Fittings: ASME B16.3, black malleable iron.

c. Butt-Welding Fittings: ASME B16.9, with backing rings of compatible material.

d. Unions: ASME B16.39, black malleable iron.

e. Flanges and Flanged Fittings: ASME B16.5 steel flanges or convoluted steel flanges conforming to ASME BPVC SEC VIII D1. Flange faces must have integral grooves of rectangular cross sections which afford containment for self-energizing gasket material.

2.2.2 Underground Polyethylene (PE)

PE pipe and fittings are as follows:

a. Pipe: ASTM D2513, 100 psig working pressure, Standard Dimension Ratio (SDR), the ratio of pipe diameter to wall thickness, 11.5 maximum.

b. Butt-Fusion Fittings: ASTM D2513, molded.

2.2.3 Risers

Manufacturer's standard riser, transition from plastic to steel pipe with 7 to 12 mil thick epoxy coating. Use swaged gas-tight construction with O-ring seals, metal insert, and protective sleeve. Provide wall-mounted riser supports as indicated.

2.2.4 Transition Fittings

a. Steel to Plastic (PE): As specified for "riser" except designed for steel-to-plastic with tapping tee or sleeve. Coat or wrap exposed steel pipe with heavy plastic coating.

2.3 SHUTOFF VALVES, BELOW GROUND

2.3.1 Metallic Ball Valves

ASME B16.38 corrosion-resisting steel, with threaded or flanged ends. Provide polytetrafluoroethylene (PTFE) seats.

2.4 VALVES, ABOVEGROUND

2.4.1 Shutoff Valves, Sizes Larger Than 2 Inches

Cast-iron or steel body ball valve with flanged ends in accordance with ASME B16.38. Provide PTFE seats.

2.4.2 Line Appliance Pressure Regulator and Shutoff Valve

Provide regulators conforming to ANSI Z21.80/CSA 6.22 for line pressure regulators. Provide shutoff valves conforming to ANSI Z21.15/CSA 9.1 for manually controlled gas shutoff valves and ANSI Z21.21/CSA 6.5 for automatic shutoff valves for gas appliances.

2.4.3 Service Regulators

a. Provide ferrous bodied pressure regulators for individual service lines, capable of reducing distribution line pressure to pressures required for users. Provide service regulators conforming to AGA ANSI B109.4 CGA-6.18-M95 with full capacity internal relief and overpressure shutoff. Set pressure relief at a lower pressure than would cause unsafe operation of any connected user.

b. Adjust regulators for liquified petroleum gas to 10 to 12 inches of water column, with pressure relief set a 16 inches of water column.

c. Provide regulator(s) having a single port with orifice diameter no greater than that recommended by the manufacturer for the maximum gas flow rate at the regulator inlet pressure. Provide regulator valve vent of resilient materials designed to withstand flow conditions when pressed against the valve port, capable of regulating downstream pressure within limits of accuracy and limiting the buildup of pressure under no-flow conditions to 50 percent or less of the discharge pressure maintained under flow conditions. Provide a self-contained service regulator, and pipe not exceeding exceed 2 inch size.

2.5 GAS EQUIPMENT CONNECTORS

a. Flexible Connectors: ANSI Z21.45.

b. Quick Disconnect Couplings: ANSI Z21.41/CSA 6.9.

c. Semi-Rigid Tubing and Fittings: ANSI Z21.69/CSA 6.16.

2.6 VALVE BOX

Provide rectangular concrete valve box, sized large enough for removal of valve without removing box. Cast the word "Gas" into the box cover. Use valve box for areas as follows:

a. Roads and Traffic Areas: Heavy duty, cast iron cover.

b. Other Areas: Standard duty, concrete cover.

2.7 BURIED UTILITY WARNING AND IDENTIFICATION TAPE

Provide detectable aluminum-foil plastic-backed tape or detectable magnetic plastic tape manufactured specifically for warning and

identification of buried piping. Tape must be detectable by an electronic detection instrument. Provide tape in rolls, 3 inch minimum width, color-coded yellow for natural gas, with warning and identification imprinted in bold black letters continuously and repeatedly over entire tape length. Warning and identification must be "CAUTION BURIED GAS PIPING BELOW" or similar wording. Use permanent code and letter coloring unaffected by moisture and other substances contained in trench backfill material.

2.8 WELDING FILLER METAL

ASME B31.8.

2.9 PIPE-THREAD TAPE

Antiseize and sealant tape of polytetrafluoroethylene (PTFE).

2.10 BOLTING (BOLTS AND NUTS)

Stainless steel bolting; ASTM A193/A193M, Grade B8M or B8MA, Type 316, for bolts; and ASTM A194/A194M, Grade 8M, Type 316, for nuts. Dimensions of bolts, studs, and nuts must conform with ASME B18.2.1 and ASME B18.2.2 with coarse threads conforming to ASME B1.1, with Class 2A fit for bolts and studs and Class 2B fit for nuts. Bolts or bolt-studs must extend through the nuts and may have reduced shanks of a diameter not less than the diameter at root of threads. Bolts must have American Standard regular square or heavy hexagon heads; nuts must be American Standard heavy semifinished hexagonal.

2.11 GASKETS

Fluorinated elastomer, compatible with flange faces.

2.12 IDENTIFICATION FOR ABOVEGROUND PIPING

MIL-STD-101 for legends and type and size of characters. For pipes 3/4 inch od and larger, provide printed legends to identify contents of pipes and arrows to show direction of flow. Color code label backgrounds to signify levels of hazard. Make labels of plastic sheet with pressure-sensitive adhesive suitable for the intended application. For pipes smaller than 3/4 inch od, provide brass identification tags 1 1/2 inches in diameter with legends in depressed black-filled characters.

PART 3 EXECUTION

3.1 INSTALLATION

Install gas piping, appliances, and equipment in accordance with NFPA 54.

3.1.1 Excavating and Backfilling

Perform excavating and backfilling of pipe trenches as specified in Section 31 00 00 EARTHWORK. Place pipe directly in trench bottom and cover with minimum 3 inches of sand to top of pipe. If trench bottom is rocky, place pipe on a 3 inch bed of sand and cover as above. Provide remaining backfilling. Coordinate provision of utility warning and identification tape with backfill operation. Bury utility warning and identification tape with printed side up at a depth of 12 inches below the top surface of earth or the top surface of the subgrade under pavements.

3.1.2 Piping

Cut pipe to actual dimensions and assemble to prevent residual stress. Provide supply connections entering the buildings as indicated.

3.1.2.1 Cleanliness

Clean inside of pipe and fittings before installation. Blow lines clear using 80 to 100 psig clean dry compressed air. Rap steel lines sharply along entire pipe length before blowing clear. Cap or plug pipe ends to maintain cleanliness throughout installation.

3.1.2.2 Aboveground Steel Piping

Determine and establish measurements for piping at the job site and accurately cut pipe lengths accordingly. For 2 1/2 inch diameter and larger, use flanged or butt-welded joints.

a. Threaded Joints: Where possible use pipe with factory-cut threads, otherwise cut pipe ends square, remove fins and burrs, and cut taper pipe threads in accordance with ASME B1.20.1. Provide threads smooth, clean, and full-cut. Apply anti-seize paste or tape to male threads portion. Work piping into place without springing or forcing. Backing off to permit alignment of threaded joints will not be permitted. Engage threads so that not more than three threads remain exposed. Use unions for connections to valves for which a means of disconnection is not otherwise provided.

b. Welded Joints: Weld by the shielded metal-arc process, using covered electrodes and in accordance with procedures established and qualified in accordance with ASME B31.8.

c. Flanged Joints: Use flanged joints for connecting welded joint pipe and fittings to valves to provide for disconnection. Install joints so that flange faces bear uniformly on gaskets. Engage bolts so that there is complete threading through the nuts and tighten so that bolts are uniformly stressed and equally torqued.

d. Pipe Size Changes: Use reducing fittings for changes in pipe size. Size changes made with bushings will not be accepted.

e. Painting: Paint new ferrous metal piping, including supports, in accordance with Section 09 90 00 PAINTS AND COATINGS. Do not apply paint until piping tests have been completed.

f. Identification of Piping: Identify piping aboveground in accordance with MIL-STD-101, using adhesive-backed or snap-on plastic labels and arrows. In lieu of labels, identification tags may be used. Apply labels or tags to finished paint at intervals of not more than 50 feet. Provide two copies of the piping identification code framed under glass and install where directed.

3.1.2.3 Buried Plastic Lines

Provide totally PE piping. Prior to installation, obtain printed instructions and technical assistance in proper installation techniques from pipe manufacturer. When joining new PE pipe to existing pipe line, ascertain what procedural changes in the fusion process is necessary to

attain optimum bonding.

a. Jointing Procedures: Use jointing procedures conforming to AGA XR0603 and 49 CFR 192 that have been qualified by test in accordance with 49 CFR 192.283 and proven to make satisfactory joints. Personnel make joints in plastic pipe must be qualified in accordance with 49 CFR 192.285, under the submitted and approved procedure by making a satisfactory specimen joint that passes the required inspection and test. Joints in plastic pipe must be inspected by a person qualified by 49 CFR 192.287 under the applicable procedure. Certificates that qualify the applicable procedures, joining personnel, and inspectors must be submitted and approved and must be on file with the Contracting Officer prior to making these joints.

b. PE Piping: Prior to installation, Contractor must have supervising and installing personnel, certified in accordance with paragraph WELDER'S QUALIFICATIONS. Provide fusion-welded joints except where transitions have been specified. Use electrically heated tools, thermostatically controlled and equipped with temperature indication. (Where connection must be made to existing plastic pipe, contractor must be responsible for determination of compatibility of materials and procedural changes in fusion process necessary to attain maximum integrity of bond.)

c. Laying PE Pipe/ Bury pipe 36 inches below finish grade or deeper when indicated. Lay in accordance with manufacturer's printed instructions.

3.1.2.4 Connections to Existing Pipeline

When making connections to live gas mains, use pressure tight installation equipment operated by workmen trained and experienced in making hot taps. For connections to existing underground pipeline or service branch, use transition fittings for dissimilar materials.

3.1.2.5 Wrapping

Where connection to existing steel line is made underground, tape wrap new steel transition fittings and exposed existing pipe having damaged coating. Clean pipe to bare metal. Initially stretch first layer of tape to conform to the surface while spirally half-lapping. Apply a second layer, half-lapped and spiraled as the first layer, but with spirals perpendicular to first wrapping. Use 10 mil minimum thick polyethylene tape. In lieu of tape wrap, heat shrinkable 10 mil minimum thick polyethylene sleeve may be used.

3.1.3 Valves

Install valves approximately at locations indicated. Orient stems vertically, with operators on top, or horizontally. Provide support for valves to resist operating torque applied to PE pipes.

3.1.3.1 Stop Valve and Shutoff Valve

Provide stop valve on service branch at connection to main and shut-off valve on riser outside of building.

3.1.4 Gas Service Installation

Installations must be in accordance with 49 CFR 192 and ASME B31.8.

Contractor must submit and use only tested and approved work procedures. Contractor must use only welders and jointers who have been recently qualified by training and test for joining and installing the gas pipe material used on this job. The finished product must be inspected by a person qualified to inspect joints made by the particular procedures used to make joints.

3.1.5 Pipe Sleeves

Comply with Section 07 84 00 FIRESTOPPING. Where piping penetrates concrete or masonry wall, floor or firewall, provide pipe sleeve poured or grouted in place. Make sleeve of steel or cast-iron pipe of such size to provide 1/4 inch or more annular clearance around pipe. Extend sleeve through wall or slab and terminate flush with both surfaces. Pack annular space with oakum, and caulk at ends with silicone construction sealant.

3.2 FIELD QUALITY CONTROL

3.2.1 Metal Welding Inspection

Inspect for compliance with NFPA 54 and 49 CFR 192. Replace, repair, and then re-inspect defective welds.

3.2.2 PE Fusion Welding Inspection

Visually inspect butt joints by comparing with, manufacturer's visual joint appearance chart. Inspect fusion joints for proper fused connection. Replace defective joints by cutting out defective joints or replacing fittings. Inspect 100 percent of all joints and reinspect all corrections. Arrange with the pipe manufacturer's representative in the presence of the Contracting Officer to make first time inspection.

3.2.3 Pressure Tests

Use test pressure of 1 1/2 times maximum working pressure, but in no case less than 50 psig. Do not test until every joint has set and cooled at least 8 hours at temperatures above 50 degrees F. Conduct testing before backfilling; however, place sufficient backfill material between fittings to hold pipe in place during tests. Test system gas tight in accordance with NFPA 54. Use clean dry air or inert gas, such as nitrogen or carbon dioxide, for testing. Systems which may be contaminated by gas must first be purged as specified. Make tests on entire system or on sections that can be isolated by valves. After pressurization, isolate entire piping system from sources of air during test period. Maintain test pressure for at least 8 hours between times of first and last reading of pressure and temperature. Take first reading at least one hour after test pressure has been applied. Do not take test readings during rapid weather changes. Provide temperature same as actual trench conditions. There must be no reduction in the applied test pressure other than that due to a change in ambient temperature. Allow for ambient temperature change in accordance with the relationship PF + 14.7 = (P1 + 14.7) (T2 + 460) / T1 + 460), in which "T" and "PF" represent Fahrenheit temperature and gage pressure, respectively, subscripts "1" and "2" denote initial and final readings, and "PF" is the calculated final pressure. If "PF" exceeds the measured final pressure (final gage reading) by 1/2 psi or more, isolate sections of the piping system, retest each section individually, and apply a solution of warm soapy water to joints of each section for which a reduction in pressure occurs after allowing for ambient temperature change. Repair leaking joints and repeat test until no reduction in

pressure occurs. In performing tests, use a test gage calibrated in one psi increments and readable to 1/2 psi.

3.2.4 System Purging

After completing pressure tests, and before testing a gas contaminated line, purge line with nitrogen at junction with main line to remove all air and gas. Clear completed line by attaching a test pilot fixture at capped stub-in line at building location and let gas flow until test pilot ignites. Procedures must conform to NFPA 54.

-CAUTION-
Failure to purge may result in explosion within line when air-to-gas is at correct mixture.

-- End of Section --

SECTION 33 30 00

SANITARY SEWERAGE

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 WATER WORKS ASSOCIATION (AWWA)

AWWA C600	(2023) Installation of Ductile-Iron Mains and Their Appurtenances

ASTM INTERNATIONAL (ASTM)

ASTM A48/A48M	(2022) Standard Specification for Gray Iron Castings
ASTM A123/A123M	(2024) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings
ASTM C33/C33M	(2024) Standard Specification for Concrete Aggregates
ASTM C94/C94M	(2024c) Standard Specification for Ready-Mixed Concrete
ASTM C150/C150M	(2022) Standard Specification for Portland Cement
ASTM C270	(2019a; E 2019) Standard Specification for Mortar for Unit Masonry
ASTM C443	(2021) Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
ASTM C478	(2018) Standard Specification for Circular Precast Reinforced Concrete Manhole Sections
ASTM C478M	(2018) Standard Specification for Precast Reinforced Concrete Manhole Sections (Metric)
ASTM C972	(2024) Standard Test Method for Compression-Recovery of Tape Sealant
ASTM C1244	(2020) Standard Test Method for Concrete

	Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill
ASTM C1644	(2006; R 2017) Standard Specification for Resilient Connectors Between Reinforced Concrete On-Site Wastewater Tanks and Pipes
ASTM D412	(2016; R 2021) Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
ASTM D624	(2000; R 2020) Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
ASTM D2321	(2020) Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
ASTM D3034	(2016) Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D3212	(2020) Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
ASTM D3753	(2019) Glass-Fiber-Reinforced Polyester Manholes and Wetwells
ASTM D4101	(2017) Standard Classification System and Basis for Specification for Polypropylene Injection and Extrusion Materials
ASTM F477	(2014; R 2021) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F949	(2020) Standard Specification for Poly(Vinyl Chloride) (PVC) Corrugated Sewer Pipe with a Smooth Interior and Fittings

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

29 CFR 1910.27	(Nov 2016) Scaffolds and Roope Descent Systems

UNI-BELL PVC PIPE ASSOCIATION (UBPPA)

UBPPA UNI-B-6	(1998) Recommended Practice for Low-Pressure Air Testing of Installed Sewer Pipe

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-01 Preconstruction Submittals

Contractor's License; G

SD-02 Shop Drawings

Installation Drawings; G, AE

SD-03 Product Data

Precast Concrete Manholes

Frames, Covers, and Gratings

Gravity Pipe

SD-06 Test Reports

Precast Concrete Sewer Manhole Test; G

Hydrostatic Sewer Test; G

Negative Air Pressure Test; G

Low-Pressure Air Tests; G

SD-07 Certificates

Portland Cement

Pre-Installation Inspection Request; G

Post-Installation Inspection; G

1.3 QUALITY CONTROL

1.3.1 Installer Qualifications

Install specified materials by a licensed underground utility Contractor licensed for such work in the state where the work is to be performed. Verify installing Contractor's License is current and state certified or state registered.

1.4 DELIVERY, STORAGE, AND HANDLING

1.4.1 Delivery and Storage

Check upon arrival; identify and segregate as to types, functions, and sizes. Store off the ground in a manner affording easy accessibility and not causing excessive rusting or coating with grease or other objectionable materials.

1.4.1.1 Piping

Inspect materials delivered to site for damage; store with minimum of handling. Store materials on site in enclosures or under protective coverings. Store plastic piping and jointing materials and rubber gaskets

under cover out of direct sunlight. Do not store materials directly on the ground. Keep inside of pipes and fittings free of dirt and debris.

1.4.2 Handling

Handle pipe, fittings, and other accessories in such manner as to ensure delivery to the trench in sound undamaged condition. Carry, do not drag, pipe to trench. Store solvents, solvent compounds, lubricants, elastomeric gaskets, and any similar materials required to install the plastic pipe in accordance with the manufacturer's recommendation and discard those materials if the storage period exceeds the recommended shelf life. Discard solvents in use when the recommended pot life is exceeded.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

2.1.1 Sanitary Sewer Gravity Pipeline

Provide mains and laterals of polyvinyl chloride (PVC) plastic pipe. Provide building connections of polyvinyl chloride (PVC) plastic pipe. Provide new and modify existing exterior sanitary gravity sewer piping and appurtenances. Provide each system complete and ready for operation. The exterior sanitary gravity sewer system includes equipment, materials, installation, and workmanship as specified herein more than 5 feet outside of building walls.

2.2 MATERIALS

Provide materials conforming to the respective specifications and other requirements specified below. Submit manufacturer's product specification,standard drawings or catalog cuts.

2.2.1 Gravity Pipe

2.2.1.1 PVC Gravity Sewer Piping

2.2.1.1.1 PVC Gravity Pipe and Fittings

ASTM D3034, SDR 35, or ASTM F949 with ends suitable for elastomeric gasket joints.

2.2.1.1.2 PVC Gravity Joints and Jointing Material

Provide joints conforming to ASTM D3212. Gaskets are to conform to ASTM F477.

2.2.2 Cement Mortar

Provide cement mortar conforming to ASTM C270, Type M with Type II cement.

2.2.3 Portland Cement

Submit certificates of compliance stating the type of cement used in manufacture of concrete pipe, fittings, septic tanks, and precast manholes. Provide portland cement conforming to ASTM C150/C150M, Type II for concrete used in concrete pipe, concrete pipe fittings, septic tanks,

and manholes and type optional for cement used in concrete cradle, concrete encasement, and thrust blocking. Use a cement containing less than 0.60 percent alkalies where aggregates are alkali reactive, as determined by Appendix XI of ASTM C33/C33M.

2.2.4 Portland Cement Concrete

Provide portland cement concrete conforming to ASTM C94/C94M, compressive strength of 4000 psi at 28 days, except for concrete cradle and encasement or concrete blocks for manholes. Concrete used for cradle and encasement is to have a compressive strength of 2500 psi minimum at 28 days. Protect concrete in place from freezing and moisture loss for 7 days.

2.2.5 Precast Concrete Manholes

Provide precast concrete manholes, risers, base sections, and tops conforming to ASTM C478.

2.2.6 Glass-Fiber-Reinforced Polyester Manholes

Glass-Fiber-Reinforced Polyester Manholes are to conform to ASTM D3753.

2.2.7 Gaskets and Connectors

Provide gaskets for joints between manhole sections conforming to ASTM C443. Resilient connectors for making joints between manhole and pipes entering manhole are to conform toASTM C1644.

2.2.8 External Preformed Rubber Joint Seals

An external preformed rubber joint seal is an accepted method of sealing cast iron covers to precast concrete sections to prevent ground water infiltration into sewer systems. All finished and sealed manholes constructed in accordance with paragraph entitled "Manhole Construction" are to be tested for leakage in the same manner as pipelines as described in paragraph entitled "Leakage Tests." The seal is to be multi-section with a neoprene rubber top section and all lower sections made of Ethylene Propylene Diene Monomer (EPDM) rubber with a minimum thickness of 60 mils. Each unit is to consist of a top and bottom section and have mastic on the bottom of the bottom section and mastic on the top and bottom of the top section. The mastic is to be a non-hardening butyl rubber sealant and seal to the cone/top slab of the manhole/catch basin and over the lip of the casting. Extension sections are to cover up to two more adjusting rings. Properties and values are listed in the following table:

Properties, Test Methods and Minimum Values for Rubber used in Preformed Joint Seals				
Physical Properties	Test Methods	EPDM	Neoprene	Butyl Mastic
Tensile, psi	ASTM D412	1840	2195	--
Elongation, percent	ASTM D412	553	295	350
Tear Resistance, ppi	ASTM D624 (Die B)	280	160	--

Properties, Test Methods and Minimum Values for Rubber used in Preformed Joint Seals				
Physical Properties	Test Methods	EPDM	Neoprene	Butyl Mastic
Rebound, percent, 5 minutes	ASTM C972 (mod.)	--	--	11
Rebound, percent, 2 hours	ASTM C972	--	--	12

2.2.9 Frames, Covers, and Gratings for Manholes

Submit certification on the ability of frame and cover to carry the imposed live load. Frame and cover are to be cast gray iron, ASTM A48/A48M, Class 35B, cast ductile iron, ASTM A536, Grade 65-45-12, or reinforced concrete, ASTM C478 ASTM C478M. Frames and covers are to be circular with vent holes. Size are to be as indicated on the plans. Stamp or cast the words "Sanitary Sewer" into covers so that it is plainly visible.

2.2.10 Manhole Steps

Zinc-coated steel conforming to 29 CFR 1910.27 with a plastic or rubber coating pressure-molded to the steel is to be used. Provide plastic coating conforming to ASTM D4101, copolymer polypropylene. Rubber is to conform to ASTM C443, except shore A durometer hardness is to be 70 plus or minus 5. Aluminum steps or rungs will not be permitted. Steps are not required in manholes less than 4 feet deep.

2.2.11 Manhole Ladders

Provide a steel ladder where the depth of a manhole exceeds 12 feet. The ladder is not to be less than 16 inches in width, with 3/4 inch diameter rungs spaced 12 inches apart. The two stringers are to be a minimum 3/8 inch thick and 2 inches wide. Galvanize ladders and inserts after fabrication in conformance with ASTM A123/A123M.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Installation Drawings

Submit Installation Drawings showing complete detail, both plan and side view details with proper layout and elevations.

3.2 INSTALLATION

Backfill after inspection by the Contracting Officer. Before, during, and after installation, protect plastic pipe and fittings from any environment that would result in damage or deterioration to the material. Keep a copy of the manufacturer's instructions available at the construction site at all times and follow these instructions unless directed otherwise by the Contracting Officer.

3.2.1 Connections to Existing Lines

Obtain approval from the Contracting Officer before making connection to existing line. Conduct work so that there is minimum interruption of service on existing line.

3.2.2 General Requirements for Installation of Pipelines

These general requirements apply except where specific exception is made in the following paragraphs entitled "Special Requirements."

3.2.2.1 Location

Terminate the work covered by this section at a point approximately 5 feet from the building. Install sewer lines beneath water lines only, with the top of the sewer line being at least 2 feet below bottom of water line. When these separation distances can not be met, contact the Contracting Officer for direction.

3.2.2.1.1 Sanitary Piping Installation Parallel with Water Line

3.2.2.1.1.1 Normal Conditions

Install sanitary piping or manholes at least 10 feet horizontally from a water line whenever possible. Measure the distance from edge-to-edge.

3.2.2.1.1.2 Unusual Conditions

When local conditions prevent a horizontal separation of 10 feet, the sanitary piping or manhole may be laid closer to a water line provided that:

a. The top (crown) of the sanitary piping is to be at least 18 inches below the bottom (invert) of the water main.

b. Where this vertical separation cannot be obtained, construct the sanitary piping with AWWA-approved ductile iron water pipe pressure and conduct a hydrostatic sewer test without leakage prior to backfilling.

c. The sewer manhole is to be of watertight construction and tested in place.

3.2.2.1.2 Installation of Sanitary Piping Crossing a Water Line

3.2.2.1.2.1 Normal Conditions

Lay sanitary sewer piping by crossing under water lines to provide a separation of at least 18 inches between the top of the sanitary piping and the bottom of the water line whenever possible.

3.2.2.1.2.2 Unusual Conditions

When local conditions prevent a vertical separation described above, use the following construction:

a. Construct sanitary piping passing over or under water lines with AWWA-approved ductile iron water pressure piping and conduct a hydrostatic sewer test without leakage prior to backfilling.

b. Protect sanitary piping passing over water lines by providing:

(1) A vertical separation of at least 18 inches between the bottom of the sanitary piping and the top of the water line.

(2) Adequate structural support for the sanitary piping to prevent excessive deflection of the joints and the settling on and breaking of the water line.

(3) That the length, minimum 20 feet, of the sanitary piping be centered at the point of the crossing so that joints are equidistant and as far as possible from the water line.

3.2.2.1.3 Sanitary Sewer Manholes

No water piping must pass through or come in contact with any part of a sanitary sewer manhole.

3.2.2.2 Earthwork

Perform earthwork operations in accordance with Section 31 00 00 EARTHWORK.

3.2.2.3 Pipe Laying and Jointing

Inspect each pipe and fitting before and after installation; replace those found defective and remove from site. Provide proper facilities for lowering sections of pipe into trenches. Lay nonpressure pipe with the bell or groove ends in the upgrade direction. Adjust spigots in bells and tongues in grooves to give a uniform space all around. Blocking or wedging between bells and spigots or tongues and grooves will not be permitted. Replace by one of the proper dimensions, pipe or fittings that do not allow sufficient space for installation of joint material. At the end of each work day, close open ends of pipe temporarily with wood blocks or bulkheads. Provide batterboards not more than 25 feet apart in trenches for checking and ensuring that pipe invert elevations are as indicated. Laser beam method may be used in lieu of batterboards for the same purpose. Construct branch connections by use of regular fittings or solvent cemented saddles as approved. Provide saddles for PVC pipe conforming to Table 4 of ASTM D3034.

3.2.3 Special Requirements

3.2.3.1 Installation of PVC Piping

Install pipe and fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" of this section and with the requirements of ASTM D2321 for laying and joining pipe and fittings. Make joints with the gaskets specified for joints with this piping and assemble in accordance with the requirements of ASTM D2321 for assembly of joints. Make joints to other pipe materials in accordance with the recommendations of the plastic pipe manufacturer.

3.2.4 Concrete Work

Cast-in-place concrete is included in Section 03 30 00 CAST-IN-PLACE CONCRETE. Support the pipe on a concrete cradle, or encased in concrete where indicated or directed.

3.2.5 Manhole Construction

Construct base slab of cast-in-place concrete or use precast concrete base sections. Make inverts in cast-in-place concrete and precast concrete bases with a smooth-surfaced semi-circular bottom conforming to the inside contour of the adjacent sewer sections. For changes in direction of the sewer and entering branches into the manhole, make a circular curve in the manhole invert of as large a radius as manhole size will permit. For cast-in-place concrete construction, either pour bottom slabs and walls integrally or key and bond walls to bottom slab. No parging will be permitted on interior manhole walls. For precast concrete construction, make joints between manhole sections with the gaskets specified for this purpose; install in the manner specified for installing joints in concrete piping. Parging will not be required for precast concrete manholes. Perform cast-in-place concrete work in accordance with the requirements specified under paragraph entitled "Concrete Work" of this section. Make joints between concrete manholes and pipes entering manholes with the resilient connectors specified for this purpose; install in accordance with the recommendations of the connector manufacturer. Where a new manhole is constructed on an existing line, remove existing pipe as necessary to construct the manhole. Cut existing pipe so that pipe ends are approximately flush with the interior face of manhole wall, but not protruding into the manhole. Use resilient connectors as previously specified for pipe connectors to concrete manholes.

3.2.6 Miscellaneous Construction and Installation

3.2.6.1 Connecting to Existing Manholes

Connect pipe to existing manholes such that finish work will conform as nearly as practicable to the applicable requirements specified for new manholes, including all necessary concrete work, cutting, and shaping. Center the connection on the manhole. Holes for the new pipe are be of sufficient diameter to allow packing cement mortar around the entire periphery of the pipe but no larger than 1.5 times the diameter of the pipe. Cut the manhole in a manner that will cause the least damage to the walls.

3.2.6.2 Metal Work

3.2.6.2.1 Workmanship and Finish

Perform metal work so that workmanship and finish will be equal to the best practice in modern structural shops and foundries. Form iron to shape and size with sharp lines and angles. Do shearing and punching so that clean true lines and surfaces are produced. Make castings sound and free from warp, cold shuts, and blow holes that may impair their strength or appearance. Give exposed surfaces a smooth finish with sharp well-defined lines and arises. Provide necessary rabbets, lugs, and brackets wherever necessary for fitting and support.

3.2.6.2.2 Field Painting

After installation, clean cast-iron frames, covers, gratings, and steps not buried in concrete to bare metal, remove mortar, rust, grease, dirt, and other deleterious materials and apply a coat of bituminous paint. Do not paint surfaces subject to abrasion.

3.2.7 Installations of Wye Branches

Install wye branches in an existing sewer using a method which does not damage the integrity of the existing sewer. Do not cut into piping for connections except when approved by the Contracting Officer. When the connecting pipe cannot be adequately supported on undisturbed earth or tamped backfill, support on a concrete cradle as directed by the Contracting Officer. Provide and install concrete required because of conditions resulting from faulty construction methods or negligence without any additional cost to the Government. Do not damage the existing sewer when installing wye branches in an existing sewer.

3.3 FIELD QUALITY CONTROL

The Contracting Officer will conduct field inspections and witness field tests specified in this section. Be able to produce evidence, when required, that each item of work has been constructed in accordance with the drawings and specifications.

3.3.1 Tests

Perform field tests and provide labor, equipment, and incidentals required for testing.

3.3.1.1 Hydrostatic Sewer Test

When unusual conflicts are encountered between sanitary sewer and waterlines a hydrostatic pressure sewer test will be performed in accordance with the applicable AWWA standard for the piping material or AWWA C600.

3.3.1.2 Leakage Tests for Nonpressure Lines

Test lines for leakage by either negative air pressure tests or by low-pressure air tests. When necessary to prevent pipeline movement during testing, place additional backfill around pipe sufficient to prevent movement, but leaving joints uncovered to permit inspection. When leakage or pressure drop exceeds the allowable amount specified, make satisfactory correction and retest pipeline section in the same manner. Correct visible leaks regardless of leakage test results.

3.3.1.2.1 Negative Air Pressure Test

3.3.1.2.1.1 Precast Concrete Manholes

Test precast concrete sewer manhole test in accordance with ASTM C1244. The allowable vacuum drop is located in ASTM C1244 Make calculations in accordance with the Appendix to ASTM C1244.

3.3.1.2.2 Low-Pressure Air Tests

3.3.1.2.2.1 PVC Pipelines

Test PVC pipe in accordance with UBPPA UNI-B-6. The allowable pressure drop is located in UBPPA UNI-B-6. Make calculations in accordance with the Appendix to UBPPA UNI-B-6.

3.3.2 Field Tests for Cast-In-Place Concrete

Field testing requirements are covered in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.3.3 Inspection

Check each straight run of pipeline for gross deficiencies by holding a light in a manhole; the light must show a practically full circle of light through the pipeline when viewed from the adjoining end of line.

3.3.3.1 Pre-Installation Inspection

Prior to connecting the new service, perform pre-installation inspection after trenching and layout is complete. Submit pre-installation inspection request for field support at least 14 days in advance. The Installation's Utilities Field Support personnel will perform the pre-installation inspection.

3.3.3.2 Post-Installation Inspection

Perform a post-installation inspection after connection has been made and before the connection is buried. Submit post-installation inspection request for field support at least 14 days in advance. The Installation's Utilities Field Support personnel will perform the post-connection inspection.

-- End of Section --

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SECTION 33 71 02

UNDERGROUND ELECTRICAL DISTRIBUTION

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 WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2020; Errata 1 2021) Structural Welding Code - Steel

ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)

AEIC CS8	(2013) Specification for Extruded Dielectric Shielded Power Cables Rated 5 Through 46 kV

ASTM INTERNATIONAL (ASTM)

ASTM B1	(2013) Standard Specification for Hard-Drawn Copper Wire
ASTM B3	(2013) 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 B496	(2016; R 2021) Standard Specification for Compact Round Concentric-Lay-Stranded Copper Conductors

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 48	(2020) Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV
IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE 400.2	(2013) Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF)

IEEE 404	(2012) Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500,000 V
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
ANSI/NEMA WC 71/ICEA S-96-659	(2014; R 2022) Standard for Nonshielded Cables Rated 2001-5000 Volts for use in the Distribution of Electric Energy
NEMA RN 1	(2005; R 2013) 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 9	(2020) Standard for Fittings for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installation
NEMA WC 74/ICEA S-93-639	(2022) 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023) National Electrical Code

SOCIETY OF CABLE TELECOMMUNICATIONS ENGINEERS (SCTE)

ANSI/SCTE 77	(2013) Specification for Underground Enclosure Integrity

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

UNDERWRITERS LABORATORIES (UL)

UL 6	(2022) UL Standard for Safety Electrical Rigid Metal Conduit-Steel
UL 44	(2018; Reprint May 2021) UL Standard for Safety Thermoset-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 May 2021) UL Standard for Safety Wire Connectors
UL 510	(2020; Dec 2022) UL Standard for Safety Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 514B	(2012; Reprint Mar 2024) 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 Nov 2023) Standard for Service-Entrance Cables
UL 1072	(2006; Reprint Apr 2020) Medium-Voltage Power Cables
UL 1242	(2006; Reprint Apr 2022) UL Standard for Safety Electrical Intermediate Metal Conduit -- Steel

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-03 Product Data

Medium Voltage Cable; G

Medium Voltage Cable Joints; G

Medium Voltage Cable Terminations; G

Handhole Frames and Covers; G

Frames and Covers for Airfield Facilities; G

Composite/Fiberglass Handholes; G

SD-06 Test Reports

Medium Voltage Cable Qualification and Production Tests; G

Field Acceptance Checks and Tests; G

Arc-proofing Test for cable fireproofing tape; G

Cable Installation Plan and Procedure; G

Six copies of the information described below in 8-1/2 by 11 inch binders having a minimum of three rings from which material may readily be removed and replaced, including a separate section for each cable pull. Separate sections by heavy plastic dividers with tabs, with all data sheets signed and dated by the person supervising the pull.

a. Site layout drawing with cable pulls numerically identified.

b. A list of equipment used, with calibration certifications. The manufacturer and quantity of lubricant used on pull.

c. The cable manufacturer and type of cable.

d. The dates of cable pulls, time of day, and ambient temperature.

e. The length of cable pull and calculated cable pulling tensions.

f. The actual cable pulling tensions encountered during pull.

SD-07 Certificates

Cable splicer/terminator; G

Cable Installer Qualifications; G

1.5 QUALITY ASSURANCE

1.5.1 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.

1.5.2 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.

1.5.3 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 IEEE C2 and NFPA 70 unless more stringent requirements are specified or indicated.

1.5.4 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.

1.5.4.1 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 furnished.

1.5.4.2 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 Intermediate Metal Conduit

UL 1242.

2.1.2.1 Intermediate Metal 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.

2.1.3 Plastic Conduit for Direct Burial and Riser Applications

UL 651 and NEMA TC 2, EPC-80.

2.1.4 Plastic Duct for Concrete Encasement

Provide Type EPC-40 per UL 651 and NEMA TC 2.

2.1.5 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.

2.1.6 Fittings

2.1.6.1 Metal Fittings

UL 514B.

2.1.6.2 PVC Conduit Fittings

UL 514B and UL 651.

2.1.6.3 PVC Duct Fittings

NEMA TC 9.

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 12 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 XHHW 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 XHHW conforming to UL 44. Copper conductors must be annealed copper complying with ASTM B3 and ASTM B8.

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 MEDIUM VOLTAGE CABLE

Cable (conductor) sizes are designated by American Wire Gauge (AWG) and Thousand Circular Mils (Kcmil). Conductor and conduit sizes indicated are for copper conductors unless otherwise noted. Insulated conductors must have the date of manufacture and other identification imprinted on the outer surface of each cable at regular intervals throughout cable length. Wires and cables manufactured more than 12 months prior to date of delivery to the site are not acceptable. Provide single conductor type cables unless otherwise indicated.

2.5.1 Cable Configuration

Provide Type MV cable, conforming to NEMA WC 74/ICEA S-93-639 and UL 1072. Provide cables manufactured for use in duct applications. Cable must be rated 15 kV with 133 percent insulation level.

2.5.2 Conductor Material

Provide concentric-lay-stranded, Class B conductors. Provide soft drawn copper cables complying with ASTM B3 and ASTM B8 for regular concentric and compressed stranding or ASTM B496 for compact stranding.

2.5.3 Insulation

Provide ethylene-propylene-rubber (EPR) insulation conforming to the requirements of ANSI/NEMA WC 71/ICEA S-96-659.

2.5.4 Shielding

Cables rated for 2 kV and above must have a semiconducting conductor shield, a semiconducting insulation shield, and an overall copper tape shield for each phase.

2.5.5 Neutrals

Neutral conductors must be copper, employing the same insulation and jacket materials as phase conductors, except that a 600-volt insulation rating is acceptable. For high impedance grounded neutral systems, the neutral conductors from the neutral point of the transformer or generator to the connection point at the impedance must utilize copper conductors, employing the same insulation level and construction as the phase conductors.

2.5.6 Jackets

Provide cables with a PVC jacket. Provide PVC jackets with a separator that prevents contact with underlying semiconducting insulating shield.

2.6 MEDIUM VOLTAGE CABLE TERMINATIONS

IEEE 48 Class 1; of the molded elastomer, prestretched elastomer, or heat-shrinkable elastomer. Acceptable elastomers are track-resistant silicone rubber or track-resistant ethylene propylene compounds, such as ethylene propylene rubber or ethylene propylene diene monomer. Separable insulated connectors may be used for apparatus terminations, when such apparatus is provided with suitable bushings. Provide terminations, where required, with mounting brackets suitable for the intended installation and with grounding provisions for the cable shielding, metallic sheath, or armor. Provide terminations in a kit, including: Skirts, stress control terminator, ground clamp, connectors, lugs, and complete instructions for assembly and installation. Terminations must be the product of one manufacturer, suitable for the type, diameter, insulation class and level, and materials of the cable terminated. Do not use separate parts of copper or copper alloy in contact with aluminum alloy parts in the construction or installation of the terminator.

2.6.1 Cold-Shrink Type

Terminator must be a one-piece design, utilizing the manufacturer's latest technology, where high-dielectric constant (capacitive) stress control is integrated within a skirted insulator made of silicone rubber. Termination must not require heat or flame for installation. Termination kit must contain all necessary materials (except for the lugs). Design termination for installation in low or highly contaminated indoor and outdoor locations and must resist ultraviolet rays and oxidative

decomposition.

2.6.2 Heat Shrinkable Type

Terminator must consist of a uniform cross section heat shrinkable polymeric construction stress relief tubing and environmentally sealed outer covering that is nontracking, resists heavy atmospheric contaminants, ultra violet rays and oxidative decomposition. Provide heat shrinkable sheds or skirts of the same material. Design termination for installation in low or highly contaminated indoor or outdoor locations.

2.7 MEDIUM VOLTAGE CABLE JOINTS

Provide joints (splices) in accordance with IEEE 404 suitable for the rated voltage, insulation level, insulation type, and construction of the cable. Joints must be certified by the manufacturer for waterproof, submersible applications. Upon request, supply manufacturer's design qualification test report in accordance with IEEE 404. Connectors for joint must be tin-plated electrolytic copper, having ends tapered and having center stops to equalize cable insertion.

2.7.1 Heat-Shrinkable Joint

Consists of a uniform cross-section heat-shrinkable polymeric construction with a linear stress relief system, a high dielectric strength insulating material, and an integrally bonded outer conductor layer for shielding. Replace original cable jacket with a heavy-wall heat-shrinkable sleeve with hot-melt adhesive coating.

2.7.2 Cold-Shrink Rubber-Type Joint

Joint must be of a cold shrink design that does not require any heat source for its installation. Splice insulation and jacket must be of a one-piece factory formed cold shrink sleeve made of black EPDM rubber. Splice should be packaged three splices per kit, including complete installation instructions.

2.8 TAPE

2.8.1 Insulating Tape

UL 510, plastic insulating tape, capable of performing in a continuous temperature environment of 80 degrees C.

2.8.2 Buried Warning and Identification Tape

Provide detectable tape in accordance with Section 31 00 00 EARTHWORK.

2.8.3 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.

2.9 PULL ROPE

Plastic or flat pull line (bull line) having a minimum tensile strength of

200 pounds.

2.10 GROUNDING AND BONDING

2.10.1 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.

2.10.2 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.

2.11 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.

2.12 UNDERGROUND STRUCTURES

Covers must fit the frames without undue play. Castings must be free from warp and blow holes that may impair strength or appearance. Provide necessary lugs, rabbets, and brackets.

2.12.1 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.

2.12.2 Frames and Covers for Airfield Facilities

Fabricate frames and covers for airfield use of standard commercial grade steel welded by qualified welders in accordance with AWS D1.1/D1.1M. Provide rolled steel floor plate covers having an approved anti-slip surface. Steel frames and covers must be hot dipped galvanized after fabrication.

2.12.3 Composite/Fiberglass Handholes and Covers

ANSI/SCTE 77. Provide handholes and covers of polymer concrete, reinforced with heavy weave fiberglass with a design load (Tier rating) appropriate for or greater than the intended use. All covers are required to have the Tier level rating embossed on the surface which must not

exceed the design load of the box.

2.13 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.

2.13.1 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.

2.14 PROTECTIVE DEVICES AND COORDINATION

Provide protective devices and coordination as specified in Section 26 05 73 POWER SYSTEM STUDIES.

2.15 SOURCE QUALITY CONTROL

2.15.1 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.

2.15.2 Medium Voltage Cable Qualification and Production Tests

Results of AEIC CS8 qualification and production tests as applicable for each type of medium voltage cable.

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 IEEE C2 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. Perform pulling calculations and prepare a pulling plan and submit along with the manufacturer's instructions in accordance with SUBMITTALS. Install cable strictly in accordance with the cable manufacturer's recommendations and the approved installation plan.

Calculations and pulling plan must include:

a. Site layout drawing with cable pulls identified in numeric order of expected pulling sequence and direction of cable pull.

b. List of cable installation equipment.

c. Lubricant manufacturer's application instructions.

d. Procedure for resealing cable ends to prevent moisture from entering cable.

e. Cable pulling tension calculations of all cable pulls.

f. Cable percentage conduit fill.

g. Cable sidewall bearing pressure.

h. Cable minimum bend radius and minimum diameter of pulling wheels used.

i. Cable jam ratio.

j. Maximum allowable pulling tension on each different type and size of conductor.

k. Maximum allowable pulling tension on pulling device.

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 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. Bond bare copper grounding conductor to ground rings (loops) in all manholes and to ground rings (loops) at all equipment slabs (pads). Route grounding conductor into manholes with the duct bank (sleeving is not required). Ducts must have a continuous slope downward toward underground structures and away from buildings, laid with a minimum slope of 4 inches per 100 feet. Depending on the contour of the finished grade, the high-point may be at a terminal, a manhole, a handhole, or between manholes or 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 manholes and 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. Hydraulic jet method must not be used.

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. Provide steel reinforcing in the concrete envelope as indicated. Provide color, type and depth of warning tape as specified in Section 31 00 00 EARTHWORK.

3.6.9.1 Connections to Manholes

Duct bank envelopes connecting to underground structures must be flared to have enlarged cross-section at the manhole entrance to provide additional shear strength. Dimensions of the flared cross-section must be larger than the corresponding manhole opening dimensions by no less than 12 inches in each direction. Perimeter of the duct bank opening in the underground structure must be flared toward the inside or keyed to provide a positive interlock between the duct bank and the wall of the structure. Use vibrators when this portion of the encasement is poured to assure a seal between the envelope and the wall of the structure.

3.6.9.2 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.

3.6.9.3 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 bend out to tie into the reinforcing of the duct bank envelope. Chip out the opening in the pad to form a key for the duct bank envelope.

3.6.9.4 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.

3.6.9.5 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.

3.6.9.6 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 manhole or buildings of the highest elevation. Use flexible cable feeds to convey cables through manhole 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 manhole 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 manholes.

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 LOW VOLTAGE CABLE SPLICING AND TERMINATING

Make terminations and splices with materials and methods as indicated or specified herein and as designated by the written instructions of the manufacturer. Do not allow the cables to be moved until after the splicing material has completely set. Make splices in underground distribution systems only in accessible locations such as manholes, handholes, or aboveground termination pedestals.

3.11 MEDIUM VOLTAGE CABLE TERMINATIONS

Make terminations in accordance with the written instruction of the termination kit manufacturer.

3.12 MEDIUM VOLTAGE CABLE JOINTS

Provide power cable joints (splices) suitable for continuous immersion in water. Make joints only in accessible locations in manholes or handholes by using materials and methods in accordance with the written instructions of the joint kit manufacturer.

3.12.1 Joints in Shielded Cables

Cover the joined area with metallic tape, or material like the original cable shield and connect it to the cable shield on each side of the splice. Provide a bare copper ground connection brought out in a watertight manner and grounded to the manhole grounding loop as part of the splice installation. Ground conductors, connections, and rods must be

as specified elsewhere in this section. Wire must be trained to the sides of the enclosure to prevent interference with the working area.

3.13 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.

3.14 FIREPROOFING OF CABLES IN UNDERGROUND STRUCTURES

Fireproof (arc proof) wire and cables which will carry current at 2200 volts or more in underground structures.

3.14.1 Fireproofing Tape

Tightly wrap strips of fireproofing tape around each cable spirally in half-lapped wrapping. Install tape in accordance with manufacturer's instructions.

3.14.2 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.

3.15 GROUNDING SYSTEMS

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

3.15.1 Grounding Electrodes

Provide cone pointed driven ground rods driven full depth plus 12 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.

3.15.2 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.

3.15.3 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. Provide direct connections to the grounding conductor with 600 v insulated, full-size conductor for each grounded neutral of each feeder circuit, which is spliced within the manhole.

3.15.4 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.

3.16 EXCAVATING, BACKFILLING, AND COMPACTING

Provide in accordance with NFPA 70 and Section 31 00 00 EARTHWORK.

3.16.1 Reconditioning of Surfaces

3.16.1.1 Unpaved Surfaces

Restore to their original elevation and condition unpaved surfaces disturbed during installation of duct. 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.

3.16.1.2 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.

3.17 CAST-IN-PLACE CONCRETE

Provide concrete in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.17.1 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.

3.17.2 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.

3.18 FIELD QUALITY CONTROL

3.18.1 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.

3.18.1.1 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)

3.18.1.2 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.

3.18.1.3 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.

3.18.2 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 --

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Appendix C

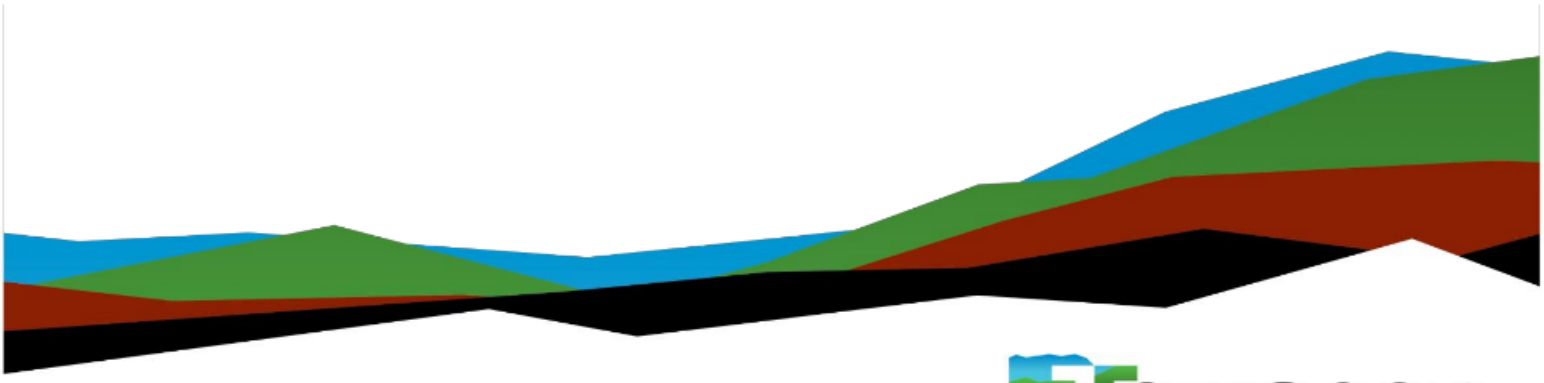
Building 110 Renovation - Revised

Geotechnical Engineering Report

November 20, 2024 | Terracon Project No. HN235221

Prepared for:

Burns and McDonnell Engineering Company, Inc.
3 Ravina Drive, Suite 1800
Atlanta, GA 30346



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November 20, 2024

Burns and McDonnell Engineering Company, Inc.
3 Ravina Drive, Suite 1800
Atlanta, GA 30346

Attn: Ketul Patel
E: kppatel@burnsmcd.com

Re: Geotechnical Engineering Report
Building 110 Renovation - Revised
Warner Robins, Georgia
Terracon Project No. HN235221

Dear Mr. Patel:

We have completed the scope of Geotechnical Engineering services for the above referenced project in general accordance with Terracon Proposal No. PHN235221 dated June 30, 2024. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork, pavement, and the design and construction of foundations for the proposed project.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or if we may be of further service, please contact us.

Sincerely,

Terracon

John P. Mastrion
Field Engineer

Thomas E. Driver, P.E.
Regional Manager

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Note: This report was originally delivered in a web-based format. **Blue Bold** text in the report indicates a referenced section heading. The PDF version also includes hyperlinks which direct the reader to that section and clicking on the Terracon logo will bring you back to this page. For more interactive features, please view your project online at **client.terracon.com**.

Refer to each individual Attachment for a listing of contents.

Report Summary

Topic [1]	Overview Statement [2]
Project Description	The project entails the renovation of Building 110 at Robins Air Force Base, specifically focusing on the geotechnical evaluation needed for the planned elevator addition. This evaluation will support the design and construction of the elevator's foundation and related infrastructure.
Geotechnical Characterization	The borings typically encountered 7.5 feet of fill materials underlain by Coastal Plain soils extending to the depths explored. Groundwater was observed in all four borings during our exploration, with depths ranging from 13.5 to 14 feet below the surface. Additionally, groundwater was noted after 24 hours of drilling at depths between 8.6 and 12.2 feet below the surface. At each boring location, we aimed to collect undisturbed samples for tri-axial shear and unit weight testing. However, due to the cohesionless nature of the soil, we achieved only 60% recovery of a single undisturbed sample from boring B-3, taken at a depth of 2.5 to 4 feet below the surface. Because of this limited recovery, a tri-axial shear test could not be performed. Nonetheless, we successfully conducted one unit weight test, the results of which are detailed in the **Exploration Results** section.
Earthwork	We recommend proof rolling the structure pads after site stripping and before placing structural fill. Replace any loose and unstable areas with engineered fill.
Shallow Foundations	Shallow foundations are recommended for building support. Allowable bearing pressure = 2,500 psf at depths 18 inches to 5 feet below the existing surface and 3,000 psf at depths of greater than 5 feet below the existing ground surface. It is our understanding that the exact depth of the elevator foundation is not known currently. Once excavation of the shaft begins, the elevator foundation depth may be matched to the depths of the existing foundations. Groundwater was encountered at a depth range of 8.6 to 14 feet below the existing ground surface. Should excavations depths approach within two feet of the known groundwater depth, we recommend implementing groundwater control measures.

	Expected settlements: < 1-inch total, < 1/2-inch differential (may vary depending on final load information). Remove overburden in some areas of the building pad to densify underlying soils. Undercut and remove any very loose to loose soils in foundation and floor slab areas to a point 10 feet outside of the edge of the foundation.
General Comments	This section contains important information about the limitations of this geotechnical engineering report.

1. If the reader is reviewing this report as a pdf, the topics above can be used to access the appropriate section of the report by simply clicking on the topic itself.
2. This summary is for convenience only. It should be used in conjunction with the entire report for design purposes.

Introduction

This report presents the results of our subsurface exploration and Geotechnical Engineering services performed for the proposed renovation to be located at Building 110 in Warner Robins, Georgia. The purpose of these services was to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil conditions
- Groundwater conditions
- Seismic site classification
- Site preparation and earthwork
- Excavation considerations
- Foundation design and construction
- Lateral earth pressure
- Pavement considerations
- Environmental testing

The geotechnical engineering Scope of Services for this project included the advancement of test borings, laboratory testing, engineering analysis, and preparation of this report.

Drawings showing the site and boring locations are shown on the **Site Location** and **Exploration Plan**, respectively. The results of the laboratory testing performed on soil samples obtained from the site during our field exploration are included on the boring logs and separate graphs in the **Exploration Results** section.

Project Description

Our initial understanding of the project was provided in our proposal and was discussed during project planning. A period of collaboration has transpired since the project was initiated, and our final understanding of the project conditions is as follows:

Item	Description
Information Provided	We received a request for proposal from Vincent Bredickas with Burns & McDonnell on November 28, 2023. A subsequent email with a link to RFP documents was sent. An email was sent to Ketul Patel on September 19, 2024 with a notification of the offsets with attached maps of the updated locations. The original boring locations requested were offset to the nearest locations that were free of underground utility concerns. The offset distances are noted on the individual boring logs.

Item	Description
Project Description	The project entails the renovation of Building 110 at Robins Air Force Base, specifically focusing on the geotechnical evaluation needed for the planned elevator addition. This evaluation will support the design and construction of the elevator's foundation and related infrastructure.
Maximum Loads	We were provided with an elevator shaft load of 133 kips.
Grading/Slopes	Based on the proposed development, we anticipate cuts and fill to be on the order of 3 feet or less.
Building Code	IBC 2018 with Georgia Amendments

Terracon should be notified if any of the above information is inconsistent with the planned construction, especially the grading limits, as modifications to our recommendations may be necessary.

Site Conditions

The following description of site conditions is derived from our site visit in association with the field exploration and our review of publicly available geologic and topographic maps.

Item	Description
Parcel Information	The project is located at Building 110 at RAFB in Warner Robins, Georgia. Latitude/Longitude (approximate): 32° 37' 39.73" N / 83° 35' 37.41" W. See **Site Location**
Existing Improvements	The site includes Building 110, which is surrounded by a combination of paved surfaces and grassed areas. The location is adjacent to the flight line, with patches of grass primarily found to the west and south of the building.
Existing Topography	The site appears relatively flat.

Environmental Sampling

Terracon collected four (4) soil samples (B-1 through B-4) at Building 110 from the interval ground surface to five (5) feet below ground surface (BGS) on October 10, 2024. The samples were submitted to Eurofins analytical laboratory in Atlanta, Georgia, for hazardous/non-hazardous waste classification. The samples were prepared according to the Toxicity Characteristic Leaching Procedure (TCLP) methodology, followed by analysis

for volatile organic compounds (VOCs) per Method 8260D; semi-volatile organic compounds (SVOCs) using Method 8270E; organochlorine pesticides according to Method 8081B; and Resource, Conservation, and Recovery Act (RCRA) metals per Method 6010D and 7470A. Additionally, the samples were analyzed for ignitability, corrosivity by pH, free liquid, and polynuclear aromatic hydrocarbons (PAHs) per Method 8270E-SIM.

Concentrations of VOCs, SVOCs, and pesticides for the samples B-1 through B-4 were reported as below the applicable laboratory reporting limits. The analytical results also reported the following:

- The cadmium and lead concentrations detected in sample B-3 were below the applicable Environmental Protection Agency TCLP regulatory levels;
- Testing determined the samples to not be ignitable;
- pH was within the acceptable range of 2-12.5 Standard Units (S.U.); and,
- The sample tested negative as a free liquid

Based on these results, soil samples B-1 through B-4 collected at Building 110 are classified as a solid, non-hazardous waste.

The PAH concentrations in soil were compared to the Georgia Environmental Protection Division (EPD) Notification Concentrations (NCs). Several PAH compounds were detected above the applicable laboratory reporting limits but were below the applicable NCs. The PAH concentrations and applicable NCs are summarized in **Detected PAHs and Metals Concentrations in Soil** (see **Exploration Results**). Based on the PAHs results, there are no release notification requirements to EPD.

Geotechnical Characterization

We have developed a general characterization of the subsurface conditions based upon our review of the subsurface exploration, geologic setting, and our understanding of the project. This characterization, termed GeoModel, forms the basis of our geotechnical calculations and evaluation of the site. Conditions observed at each exploration point are indicated on the individual logs. The individual logs can be found in the **Exploration Results** and the GeoModel can be found in the **Figures** attachment of this report.

As part of our analyses, we identified the following models for this site within the subsurface profile. For a more detailed view of the model layer depths at each boring location, refer to the GeoModel.

Model Layer	Layer Name	General Description
1	Surface Cover	5.5 to 8 inch concrete slab at B-1, B-2, and B-4. 4 inches of topsoil at B-3.
2	Fill	7.5 feet of fill on all borings, consisting of Clayey Sand (SC) and Silty Sand (SM).
3	Coastal Plain Sediments	Well Graded Sand with Silt (SW-SM), Poorly Graded Sand with Silt (SP-SM), Sandy Elastic Silt (MH), and Clayey Sand (SC).

Groundwater observations were made both during drilling and 24 hours after drilling was completed. Groundwater was encountered in all boreholes at the time of drilling. Initial groundwater levels ranged from 13.5 to 14 feet below the surface, corresponding to approximate elevations of 259.5 to 260 feet. After 24 hours, groundwater levels were measured between 8.6 and 12.2 feet below the surface, with approximate elevations of 260.8 to 265.4 feet. For detailed groundwater depths, please refer to the individual borehole logs.

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. In addition, perched water can develop over low permeability soil or rock strata. Therefore, groundwater levels during construction or at other times in the life of the structure may be higher or lower than the levels indicated on the boring logs. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

Site Geology

The site is located in the Coastal Plain Physiographic Province of Georgia. Soils in the Coastal Plain are the result of the deposition of sediments in a former marine environment. Coastal Plain sedimentary deposits make up about 60 percent of Georgia's surface area, and consist of a southwardly thickening wedge of sediments, which are bordered on the north by the parent rocks of the Piedmont Physiographic Province. The border between these provinces is known as the "Fall-Line." The Coastal Plain sediments range in age from the Cretaceous to the recent, with the oldest exposed along the "Fall-Line" and the youngest along the coast. Typically, the surface soils consist of complexly interbedded sands, silts, and clays of various mixtures. Sandstones, shales, and limestones comprise the characteristic lithology of the Coastal Plain. These formations are usually found at depths greater than fifty feet but can also be found at or near the ground surface. They are not known to occur near the surface in the site area. Topography in this region of the Coastal Plain is generally flat to gently rolling.

Seismic Site Class

Terracon performed a seismic survey at the site of the proposed renovation to obtain shear wave velocity values of the soil within the upper 100 feet. The goal of this survey was to refine the seismic site classification in general accordance with procedures outlined in ASCE 7-16 and IBC 2018. Terracon completed a limited geophysical survey consisting of one Multi-Channel Analysis of Surface Waves (MASW) array on the site. The line location is presented below as **Figure 1**.

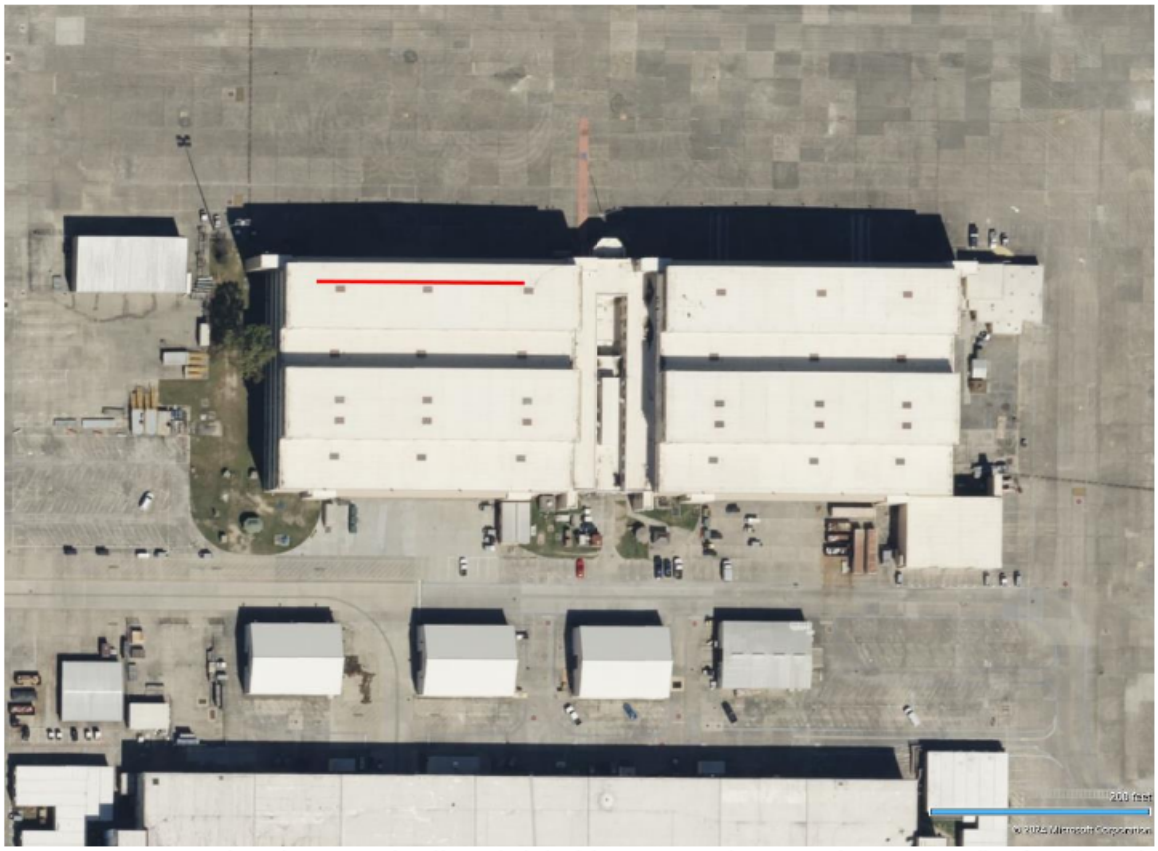


Figure 1 – MASW line location (red) with label location indicating the start or "0-foot" mark of the array.

Terracon performed geophysical exploration services consisting of a seismic survey using both active and passive MASW testing at one line location. Our method of investigation utilized a standard fixed-array set of MASW geophones. The arrays consisted of 24 4.5Hz geophones spaced approximately 8 feet apart along a sensor cable.

For the passive survey, ambient noise (such as nearby traffic or construction) on the site was recorded by a seismograph. For the active survey, a source strike was completed with a sledgehammer against a rubber plate at every geophone from one to eighteen and at one and two geophone spacings off the start of the line.

The data was returned to our office and processed using dispersion analysis software (SurfSeis, engineered by the Kansas Geological Survey) that extracts the fundamental-mode dispersion curve(s). The active and passive survey performed were combined to produce a broader-band overtone image to better identify the dispersion trend. The resulting curve was inverted and modeled to yield a 1D shear-wave velocity profile along the array for a corresponding depth and is presented on **Exhibit 1**.

Geophysical Testing Limitations - All geophysical testing methods rely on instrument signals to indicate physical conditions in the field. Signal information can be affected by on-site conditions beyond the control of the operator, such as, but not limited to, cultural features, standing water, high subsurface moisture content, and other buried objects. Interpretation of those signals is based on a combination of known factors combined with the experience of the operator and geophysical scientist evaluating the results. The provided depth measurements are estimations based on an estimation of the density and seismic properties of the subsurface material.

The resulting Average Shear Wave Velocity Profile is attached in the **Exploration Results**. The average shear wave velocity for the array and recommended Site Class is as follows:

Shear Wave Velocity Results and Recommended Site Class

Array Number	Average Shear Wave Velocity (feet/second)	Recommended Site Class[1]
A-1	1,145	D

The ground motion values and site coefficients were determined using the ASCE 7 hazard tool and are presented below. The ASCE 7 Hazards Report is also included in the **Exploration Results** for reference.

Period (sec)	Mapped MCE Spectral Response Acceleration (g)[1]		Site Coefficients[1]		Adjusted MCE Spectral Response Acceleration (g)[1]		Design Spectral Response Acceleration (g)[1]	
0.2	S_s	0.17	F_a	1.6	S_{MS}	0.273	S_{DS}	0.182
1.0	S_1	0.075	F_v	2.4	S_{M1}	0.18	S_{D1}	0.12

1. Seismic Design Category is B.

At the near surface, typically loose to medium dense Clayey Sand (SC) and Silty Sand (SM) were observed in the borings during this subsurface investigation. Beneath the near surface soils, typically loose to dense Poorly Graded Sand with Silt (SP-SM), medium dense Clayey Sand (SC), stiff Sandy Elastic Silt (MH), and dense Well Graded Sand with Silt (SW-SM) were observed. It is our opinion that the risk of liquefaction settlement is low.

Corrosivity

The table below lists the results of laboratory corrosion suite testing. These tests include the following: pH, soluble sulfates, sulfides, chlorides, RedOx, total salts, and resistivity. The values may be used to estimate potential corrosive characteristics of the on-site soils with respect to contact with the various underground materials which will be used for project construction.

Corrosivity Test Results Summary

Boring	Sample Depth (inches)	Soil Description	pH	Soluble Sulfate (mg/kg)	Sulfides (mg/kg)	Chlorides (mg/kg)	RedOx (mV)	Total Salts (mg/kg)	Electrical Resistivity (Ω-cm)
B-3	3 - 6	Fill	7.5	6	Nil	38	+494	354	8,363
B-4	3 - 6	Fill	6.4	11	Nil	31	+461	109	22,715

Results of soluble sulfate testing can be classified in accordance with ACI 318 – Building Code Requirements for Structural Concrete. Numerous sources are available to characterize corrosion potential to buried metals using the parameters above. ANSI/AWWA is commonly used for ductile iron, while threshold values for evaluating the effect on steel can be specific to the buried feature (e.g., piling, culverts, welded wire reinforcement, etc.) or agency for which the work is performed. Imported fill materials may have significantly different properties than the site materials noted above and should be evaluated if expected to be in contact with metals used for construction. Consultation with a NACE certified corrosion professional is recommended for buried metals on the site.

Mapping by the NRCS includes qualitative severity of corrosion to concrete and steel. Based on this source, the near-surface materials are rated "Moderate" for corrosion to concrete and "Moderate" for corrosion of steel in the test locations.

Geotechnical Overview

The site appears suitable for the proposed construction based upon geotechnical conditions encountered in the test borings, provided that the recommendations presented in this report are implemented in the design and construction phases of this project.

The subsurface material generally consisted of fill underlain by Coastal Plain soils to the maximum depths explored. The fill consisted of loose to medium dense Clayey Sand (SC) and Silty Sand (SM) extending up to 7.5 feet. The Standard Penetration Test (SPT) N-

values in these soils ranged from 6 blows per foot (bpf) to 12 bpf. The Coastal Plain soils encountered include loose to dense Poorly Graded Sand with Silt (SP-SM), medium dense Clayey Sand (SC), stiff Sandy Elastic Silt (MH), and dense Well Graded Sand with Silt (SW-SM). The SPT N-values in these soils ranged from 7 bpf to 39 bpf.

Support of pavements on or above existing fill materials is discussed in this report. However, even with the recommended construction procedures, an inherent risk remains for the owner that compressible fill or unsuitable material, within or buried by the fill, will not be discovered. This risk of unforeseen conditions cannot be eliminated without completely removing the existing fill but can be reduced by following the recommendations contained in this report. To take advantage of the cost benefit of not removing the entire amount of undocumented fill, the owner must be willing to accept the risk of increased differential performance which can result in increased cracking and abrupt differential settlement. Should this risk be acceptable, pavements can be supported above the fill.

Our opinion of pavement section thickness design has been developed based on our understanding of the intended use, assumed traffic, and subgrade preparation recommended herein using methodology contained in ACI 330 "Guide to Design and Construction of Concrete Parking Lots" / NAPA IS-109 "Design of Hot Mix Asphalt Pavements" and adjusted with consideration to local practice. The **Pavements** section includes minimum pavement component thickness.

Based on the conditions encountered and estimated load-settlement relationships, the proposed elevator structure can be supported on shallow foundations.

The **Shallow Foundations** section addresses support of the structure directly bearing on native soils, existing fill, or engineered fill.

The recommendations contained in this report are based upon the results of field testing (presented in the **Exploration Results**), engineering analyses, and our current understanding of the proposed project. The **General Comments** section provides an understanding of the report limitations.

Earthwork

Earthwork is anticipated to include clearing, excavations, and engineered fill placement. The following sections provide recommendations for use in the preparation of specifications for the work. Recommendations include critical quality criteria, as necessary, to render the site in the state considered in our geotechnical engineering evaluation for foundations and pavements.

Earthwork on the project should be observed and evaluated by Terracon Consultants Inc. The evaluation of earthwork should include observation and testing of engineered fill,

subgrade preparation, foundation bearing soils, and other geotechnical conditions exposed during the construction of the project and identified in this report.

Site Preparation

Prior to placing fill or removing soil in cut areas, existing concrete, vegetation, topsoil, and root mats should be removed. Complete stripping of the topsoil should be performed in the proposed foundation areas.

Any expansive soils (Elastic Silt – MH & Fat Clay - CH) encountered (not anticipated but is present at Robins Air Force Base) should be undercut and replaced with suitable fill to create separation of at least 18 inches below structures and at least 12 inches below pavement sections to mitigate potential issues related to volume changes, settlement, and insufficient bearing capacity.

Where fill is placed on existing slopes or slopes generated during site undercutting steeper than 5H:1V, benches should be cut into the existing slopes prior to fill placement. The benches should have a minimum vertical face height of 1 foot and a maximum vertical face height of 3 feet and should be cut wide enough to accommodate the compaction equipment. This benching will help provide a positive bond between the fill and natural soils and reduce the possibility of failure along the fill/natural soil interface.

Although no evidence of underground facilities (such as septic tanks, cesspools, basements, and utilities) was observed during the exploration and site reconnaissance, such features could be encountered during construction. If unexpected fills or underground facilities are encountered, such features should be removed, and the excavation thoroughly cleaned prior to backfill placement and/or construction.

Subgrade Preparation

If expansive soils (Elastic Silt – MH & Fat Clay - CH) are encountered at subgrade elevation, we recommend that the soils within the footprint of the proposed structures be removed to a minimum depth of 18 inches below the bottom of footings, or 12 inches below proposed pavements. Structural fill placed beneath the entire footprint of the foundations should extend horizontally a minimum distance of 10 feet beyond the outside edge of footings. Portions of the near-surface materials anticipated to be developed as excavation spoils are not considered suitable for use as structural fill.

The subgrade should be proof rolled with an adequately loaded vehicle such as a fully-loaded tandem-axle dump truck. The proof rolling should be performed under the observation of the Geotechnical Engineer or representative. Areas excessively deflecting under the proof roll should be delineated and subsequently addressed by the Geotechnical Engineer. Excessively wet or dry material should either be removed, or moisture conditioned and recompacted. We anticipate that, based on the SPT values in the soil borings, some undercutting or reworking of the near surface soils may be required.

Undercut soils may be reused for fill after moisture conditioning. All exposed areas which will receive fill, once properly cleared and benched where necessary, should be scarified to a minimum depth of 10 inches, moisture conditioned as necessary, and compacted per the compaction requirements in this report. Compacted structural fill soils should then be placed to the proposed design grade and the moisture content and compaction of subgrade soils should be maintained until foundation or pavement construction.

Based upon the subsurface conditions determined from the geotechnical exploration, subgrade soils exposed during construction are anticipated to be relatively workable; however, the workability of the subgrade may be affected by precipitation, repetitive construction traffic or other factors. If unworkable conditions develop, workability may be improved by scarifying and drying.

Excavation

We anticipate that excavations for the proposed construction can be accomplished with conventional earthmoving equipment. The bottom of excavations should be thoroughly cleaned of loose soils and disturbed materials prior to backfill placement and/or construction.

Soil Stabilization

If the exposed subgrade is unstable during proof rolling operations, it could be stabilized using one of the methods outlined below.

- **Scarification and Recompaction** - It may be feasible to scarify, dry, and recompact the exposed soils. The success of this procedure would depend primarily upon favorable weather and sufficient time to dry the soils. Stable subgrades likely would not be achievable if the thickness of the unstable soil is greater than about 1 foot, if the unstable soil is at or near groundwater levels, or if construction is performed during a period of wet or cool weather when drying is difficult.
- **Crushed Stone** - The use of crushed stone or crushed gravel is a common procedure to improve subgrade stability. Typical undercut depths would be expected to range from about 12 to 18 inches below finished subgrade elevation. The use of high modulus geotextiles (i.e., engineering fabric or geogrid) could also be considered after underground work such as utility construction is completed. Prior to placing the fabric or geogrid, we recommend that all below grade construction, such as utility line installation, be completed to avoid damaging the fabric or geogrid. Equipment should not be operated above the fabric or geogrid until one full lift of crushed stone fill is placed above it. The maximum particle size of granular material placed over geotextile fabric or geogrid should not exceed 1-1/2 inches.

Further evaluation of the need and recommendations for subgrade stabilization can be provided during construction as the geotechnical conditions are exposed.

Fill Material Types

Fill required to achieve design grade should be classified as structural fill and general fill. Structural fill is material used below, or within 10 feet of structures, pavements or constructed slopes. General fill is material used to achieve grade outside of these areas. Soils used for structural and general fill should meet the following material property requirements:

Reuse of On-Site Soil: Excavated on-site soil may be selectively reused as fill based on the subsurface exploration. Actual material suitability should be determined in the field at time of construction. Moisture conditioning will likely be required prior to reuse as fill.

Imported Fill Materials: Imported fill materials should meet the following material property requirements. Regardless of its source, compacted fill should consist of approved materials that are free of organic matter and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade.

Soil Type [1,2,3]	USCS Classification	Acceptable Parameters (for Structural Fill)
Low Plasticity Cohesive	CL, CL-ML ML, SM, SC	Liquid Limit less than 45, Plasticity index less than 25 Less than 25% retained on No. 200 sieve
Granular	SP, SM, SC, and SW	Less than 50% passing No. 200 sieve
On-Site Soils[4]	SM, SC and SP-SC	Liquid Limit less than 45, Plasticity index less than 25

1. Structural and general fill should consist of approved materials free of organic matter and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade. A sample of each material type should be submitted to the Geotechnical Engineer for evaluation prior to use on this site.
2. All fill should have a maximum dry density of at least 100 pounds per cubic foot (pcf) as determined by the modified Proctor test (ASTM D 1557).
3. Any materials proposed as fill from off-site sources should be tested for compliance with these criteria before being hauled to the site.
4. Re-use of existing fill should meet the requirements noted above.

Fill Placement and Compaction Requirements

Structural and general fill should meet the following compaction requirements.

Item	Structural Fill	General Fill
Maximum Lift Thickness	8 inches or less in loose thickness when heavy, self-propelled compaction equipment is used 4 to 6 inches in loose thickness when hand-guided equipment (i.e. jumping jack or plate compactor) is used	Same as structural fill
Minimum Compaction Requirements[1,2]	95% of max. dry density below foundations and within 1 foot of finished pavement subgrade 95% of max. dry density above foundations, below floor slabs, and more than 1 foot below finished pavement subgrade	92% of max. dry density
Water Content Range[1,2,3]	-2% to +3% of optimum	As required to achieve min. compaction requirements

1. Maximum dry density and optimum water content as determined by the modified Proctor test (ASTM D 1557).
2. Fill should be tested for compaction and moisture content during placement. Should the results of the in-place density tests indicate that the specified moisture or compaction requirements have not been met, the area represented by the test should be reworked and retested as required until the specified moisture and compaction requirements are achieved.
3. Moisture levels should be maintained low enough to allow for satisfactory compaction to be achieved without pumping when proofrolled.

Utility Trench Backfill

Any soft or unsuitable materials encountered at the bottom of utility trench excavations should be removed and replaced with structural fill or bedding material in accordance with public works specifications for the utility being supported. This recommendation is particularly applicable to utility work requiring grade control and/or in areas where subsequent grade raising could cause settlement in the subgrade supporting the utility. Trench excavation should not be conducted below a downward 1:1 projection from existing foundations without engineering review of shoring requirements and geotechnical observation during construction.

Trench backfill should be mechanically placed and compacted as discussed earlier in this report. Compaction of initial lifts should be accomplished with hand-operated tampers or other lightweight compactors. Where trenches are placed beneath slabs or footings, the backfill should satisfy the gradation and expansion index requirements of engineered fill discussed in this report. Flooding or jetting for placement and compaction of backfill is not recommended.

For low permeability subgrades, utility trenches are a common source of water infiltration and migration. Utility trenches penetrating beneath the building should be effectively sealed to restrict water intrusion and flow through the trenches, which could migrate below the building. The trench should provide an effective trench plug that extends at least 5 feet from the face of the building exterior. The plug material should consist of cementitious flowable fill or low permeability clay. The trench plug material should be placed to surround the utility line. If used, the clay trench plug material should be placed and compacted to comply with the water content and compaction recommendations for structural fill stated previously in this report.

Grading and Drainage

Adequate positive drainage should be provided during construction and maintained throughout the life of the development to prevent an increase in moisture content of the foundation, pavement and backfill materials. Surface water drainage should be controlled to prevent undermining of fill slopes and structures during and after construction.

Gutters and downspouts that drain water a minimum of 10 feet beyond the footprint of the proposed structures are recommended. This can be accomplished through the use of splash-blocks, downspout extensions, and flexible pipes that are designed to attach to the end of the downspout. Flexible pipe should only be used if it is daylighted in such a manner that it gravity-drains collected water. Splash-blocks should also be considered below hose bibs and water spigots.

It is recommended that all exposed earth slopes be seeded to provide protection against erosion as soon as possible after completion. Seeded slopes should be protected until the vegetation is established. Sprinkler systems should not be installed behind or in front of walls or near slopes.

Groundwater Considerations

Groundwater was encountered in all of the borings during our exploration. If groundwater is encountered during construction or if excavations approach the depth at which water was encountered in our borings, some form of temporary or permanent dewatering may be required. Conventional dewatering methods, such as pumping from sumps, should likely be adequate for temporary removal of any groundwater encountered during

excavation at the site. Well points would likely be required for significant groundwater flow, or where excavations penetrate groundwater.

The groundwater table could affect overexcavation efforts, especially for overexcavation and replacement of lower strength soils. A temporary dewatering system consisting of sumps with pumps may be necessary to achieve the recommended depth of overexcavation depending on groundwater conditions at the time of construction.

Earthwork Construction Considerations

Shallow excavations for the proposed structures are anticipated to be accomplished with conventional construction equipment. Upon completion of filling and grading, care should be taken to maintain the subgrade water content prior to construction of grade-supported improvements such as floor slabs and pavements. Construction traffic over the completed subgrades should be avoided. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. Water collecting over or adjacent to construction areas should be removed. If the subgrade freezes, desiccates, saturates, or is disturbed, the affected material should be removed, or the materials should be scarified, moisture conditioned, and recompacted prior to floor slab construction.

As a minimum, excavations should be performed in accordance with OSHA 29 CFR, Part 1926, Subpart P, "Excavations" and its appendices, and in accordance with any applicable local and/or state regulations.

Construction site safety is the sole responsibility of the contractor who controls the means, methods, and sequencing of construction operations. Under no circumstances shall the information provided herein be interpreted to mean Terracon is assuming responsibility for construction site safety or the contractor's activities; such responsibility shall neither be implied nor inferred.

Excavations or other activities resulting in ground disturbance have the potential to affect adjoining properties and structures. Our scope of services does not include review of available final grading information or consider potential temporary grading performed by the contractor for potential effects such as ground movement beyond the project limits. A preconstruction/ precondition survey should be conducted to document nearby property/infrastructure prior to any site development activity. Excavation or ground disturbance activities adjacent or near property lines should be monitored or instrumented for potential ground movements that could negatively affect adjoining property and/or structures.

Construction Observation and Testing

The earthwork efforts should be observed by the Geotechnical Engineer (or others under their direction). Observation should include documentation of adequate removal of surficial materials (vegetation, topsoil, and pavements), evaluation and remediation of

existing fill materials, as well as proof rolling and mitigation of unsuitable areas delineated by the proof roll.

Each lift of compacted fill should be tested, evaluated, and reworked, as necessary, as recommended by the Geotechnical Engineer prior to placement of additional lifts. Each lift of fill should be tested for density and water content at a frequency of at least one test for every 2,500 square feet of compacted fill in the building areas and 5,000 square feet in pavement areas. Where not specified by local ordinance, one density and water content test should be performed for every 100 linear feet of compacted utility trench backfill and a minimum of one test performed for every 12 vertical inches of compacted backfill.

In areas of foundation excavations, the bearing subgrade should be evaluated by the Geotechnical Engineer. If unanticipated conditions are observed, the Geotechnical Engineer should prescribe mitigation options.

In addition to the documentation of the essential parameters necessary for construction, the continuation of the Geotechnical Engineer into the construction phase of the project provides the continuity to maintain the Geotechnical Engineer's evaluation of subsurface conditions, including assessing variations and associated design changes.

In areas of foundation excavations, the bearing subgrade should be evaluated by the Geotechnical Engineer (or his representative). If unanticipated conditions are observed, the Geotechnical Engineer should prescribe mitigation options.

In addition to the documentation of the essential parameters necessary for construction, the continuation of the Geotechnical Engineer into the construction phase of the project provides the continuity to maintain the Geotechnical Engineer's evaluation of subsurface conditions, including assessing variations and associated design changes.

Shallow Foundations

If the site has been prepared in accordance with the requirements noted in **Earthwork**, the following design parameters are applicable for shallow foundations.

Design Parameters – Compressive Loads

Item	Description
Maximum Net Allowable Bearing Pressure [1, 2]	2,500 psf at depths of 18" to 5' below subgrade. 3,000 psf at depths greater than 5' below subgrade.
Required Bearing Stratum [3]	Residual soils or suitable structural fill
Minimum Foundation Dimensions	Columns: 24 inches

	Continuous: 16 inches
Sliding Resistance [4]	0.35
Minimum Embedment below Finished Grade [5]	Exterior footings: 18 inches Interior footings: 12 inches
Estimated Total Settlement from Structural Loads [2]	Less than about 1 inch
Estimated Differential Settlement [2, 6]	About 1/2 inch of total settlement

1. The maximum net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. Values assume that exterior grades are no steeper than **5% within 10 feet** of structure.
2. Values provided are for maximum loads noted in **Project Description**. Additional geotechnical consultation will be necessary if higher loads are anticipated.
3. Unsuitable or soft soils should be over excavated and replaced per the recommendations presented in **Earthwork**.
4. Can be used to compute sliding resistance where foundations are placed on suitable soil/materials. Frictional resistance for granular materials is dependent on the bearing pressure which may vary due to load combinations. For fine-grained materials, lateral resistance using cohesion should not exceed ½ the dead load.
5. Embedment necessary to minimize the effects of frost and/or seasonal water content variations. For sloping ground, maintain depth below the lowest adjacent exterior grade within 5 horizontal feet of the structure.
6. Differential settlements are noted for equivalent-loaded foundations and bearing elevation as measured over a span of **40** feet.

The allowable foundation bearing pressures apply to dead loads plus design live load conditions. The weight of the foundation concrete below grade may be neglected in dead load computations. Interior footings should bear a minimum of 12 inches below finished grade. Finished grade is the lowest adjacent grade for perimeter footings and floor level for interior footings.

Footings, foundations, and masonry walls should be reinforced as necessary to reduce the potential for distress caused by differential foundation movement. The use of joints at openings or other discontinuities in masonry walls is recommended. Foundation excavations should be observed by the geotechnical engineer. If the soil conditions encountered differ from those presented in this report, supplemental recommendations will be required.

Design Parameters – Overturning and Uplift Loads

Shallow foundations subjected to overturning loads should be proportioned such that the resultant eccentricity is maintained in the center-third of the foundation (e.g., $e < b/6$, where b is the foundation width). This requirement is intended to keep the entire foundation area in compression during the extreme lateral/overturning load event. Foundation oversizing may be required to satisfy this condition.

Uplift resistance of spread footings can be developed from the effective weight of the footing and the overlying soils with consideration to the IBC basic load combinations.

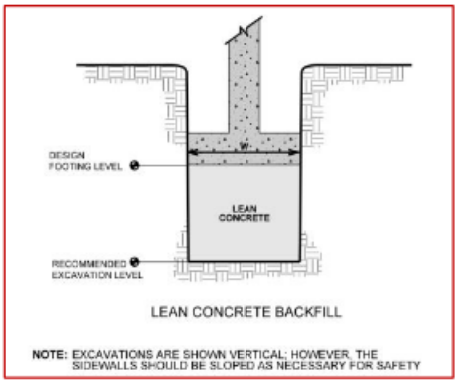
Item	Description
Soil Moist Unit Weight	100 pcf
Soil weight included in uplift resistance	Soil included within the prism extending up from the top perimeter of the footing at an angle of 20 degrees from vertical to ground surface

Foundation Construction Considerations

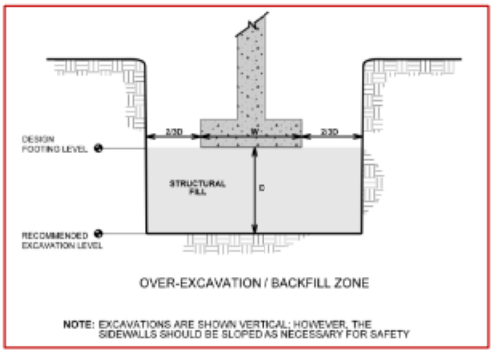
As noted in **Earthwork**, the footing excavations should be evaluated under the observation of the Geotechnical Engineer. The base of all foundation excavations should be free of water and loose soil, prior to placing concrete. Concrete should be placed soon after excavating to reduce bearing soil disturbance. Care should be taken to prevent wetting or drying of the bearing materials during construction. Excessively wet or dry material or any loose/disturbed material in the bottom of the footing excavations should be removed/reconditioned before foundation concrete is placed.

Sensitive soils exposed at the surface of footing excavations may require surficial compaction with hand-held dynamic compaction equipment prior to placing structural fill, steel, and/or concrete. Should surficial compaction not be adequate, construction of a working surface consisting of either crushed stone or a lean concrete mud mat may be required prior to the placement of reinforcing steel and construction of foundations.

If unsuitable bearing soils are observed at the base of the planned footing excavation, the excavation should be extended deeper to suitable soils, and the footings could bear directly on these soils at the lower level or on lean concrete backfill placed in the excavations. The lean concrete replacement zone is illustrated on the sketch below.



Overexcavation for structural fill placement below footings should be conducted as shown below. The overexcavation should be backfilled up to the footing base elevation, with describe soil type placed, as recommended in the **Earthwork** section.



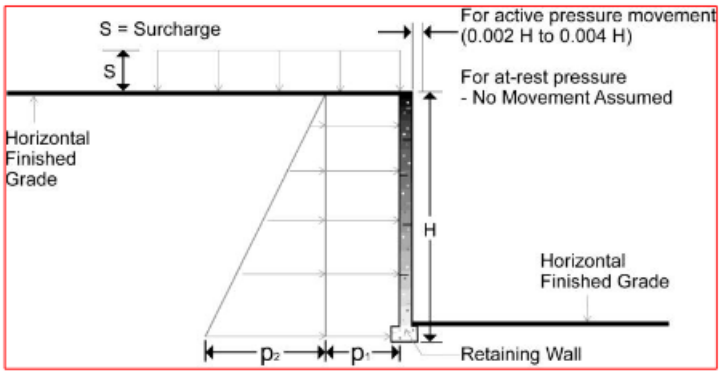
For foundations adjacent to slopes, a minimum horizontal setback of 10 feet should be maintained between the foundation base and slope face. In addition, the setback should be at a location where an imaginary line extending downward at 45 degrees from the nearest edge of the foundation does not intersect the slope face.

Lateral Earth Pressures

Design Parameters

The lateral earth pressure recommendations herein are applicable to the design of rigid retaining walls subject to slight rotation, such as cantilever, or gravity type concrete walls. These recommendations are not applicable to the design of modular block - geogrid reinforced backfill walls. Recommendations covering these types of wall systems are beyond the scope of services for this assignment. However, we would be pleased to develop recommendations for the design of such wall systems upon request.

Structures with unbalanced backfill levels on opposite sides should be designed for earth pressures at least equal to values indicated in the following table. Earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction, and/or compaction and the strength of the materials being restrained. Two wall restraint conditions are shown in the diagram below. Active earth pressure is commonly used for design of free-standing cantilever retaining walls and assumes wall movement. The "at-rest" condition assumes no wall movement and is commonly used for basement walls, loading dock walls, or other walls restrained at the top. The recommended design lateral earth pressures do not include a factor of safety and do not provide for possible hydrostatic pressure on the walls (unless stated).



Lateral Earth Pressure Design Parameters

Earth Pressure Condition	Coefficient for Backfill Type[4]	Surcharge Pressure[5,6,7] p_1 (psf)	Equivalent Fluid Pressures (psf)[4,6,7,8,9]	
			Unsaturated[5]	Submerged[5]
Active (Ka)[1]	On-site soils consisting of SC, SP-SM, and SM - 0.33	(0.33)S	(41)H	(83)H
At-Rest (Ko)	On-site soils consisting of SC, SP-SM, and SM - 0.5	(0.5)S	(63)H	(94)H
Passive (Kp)[2,3]	On-site soils consisting of SC, SP-SM, and SM – 3.0	--	--	--

1. For active earth pressure, wall must rotate about base, with top lateral movements 0.002 H to 0.004 H, where H is wall height.
2. For passive earth pressure, wall must move horizontally to mobilize resistance. Therefore, the total calculated passive pressure should be reduced by one-half to two-thirds for design purposes.
3. Ignore passive pressure in frost zone.
4. Uniform, horizontal backfill compacted to at least 95% of the ASTM D 698 maximum dry density, rendering a maximum unit weight of 125.5 pcf.
5. Uniform surcharge, where S is surcharge pressure.
6. Loading from heavy compaction equipment and dynamic loading are not included.
7. No safety factor is included in these values.
8. To achieve "Unsaturated" conditions, follow guidelines in **Subsurface Drainage for Below-Grade Walls** below. "Submerged" conditions are recommended when drainage behind walls is not incorporated into the design.
9. No hydrostatic pressure acting on wall.

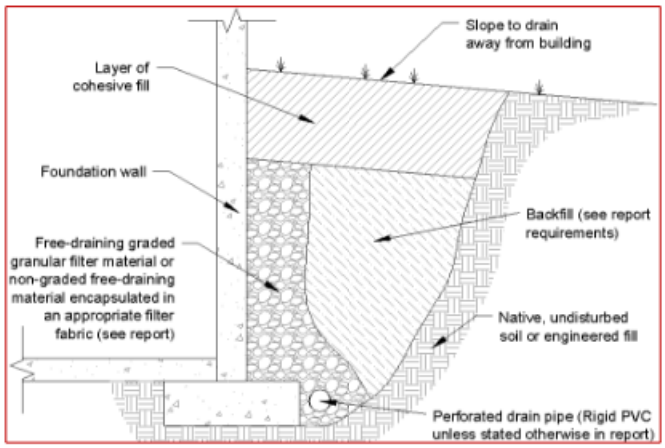
Backfill placed against structures should consist of granular soils or low plasticity cohesive soils. To calculate the resistance to sliding, a value of 0.35 should be used as the ultimate coefficient of friction between the footing and the underlying soil.

Heavy equipment should not operate within a distance closer than the exposed height of retaining walls to prevent lateral pressures more than those provided.

Footings, floor slabs or other loads bearing on backfill behind walls may have a significant influence on the lateral earth pressure. Placing footings within wall backfill and in the zone of active soil influence on the wall should be avoided unless structural analyses indicate the wall can safely withstand the increased pressure.

Subsurface Drainage for Below-Grade Walls

A perforated rigid plastic drain line installed behind the base of walls and extending below adjacent grade is recommended to prevent hydrostatic loading on the walls. The invert of a drain line around a below-grade building area or exterior retaining wall should be placed near foundation bearing level. The drain line should be sloped to provide positive gravity drainage to daylight or to a sump pit and pump. The drain line should be surrounded by clean, free-draining granular material having less than 5% passing the No. 200 sieve, such as No. 57 aggregate. The free-draining aggregate should be encapsulated in a filter fabric. The granular fill should extend to within 2 feet of final grade, where it should be capped with compacted cohesive fill to reduce infiltration of surface water into the drain system.



As an alternative to free-draining granular fill, a prefabricated drainage structure may be used. A prefabricated drainage structure is a plastic drainage core or mesh which is covered with filter fabric to prevent soil intrusion and is fastened to the wall prior to placing backfill.

General Comments

Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration. Variations will occur between exploration point locations or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. Terracon should be retained as the Geotechnical Engineer, where noted in this report, to provide observation and testing services during pertinent construction phases. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our Scope of Services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

Our services and any correspondence are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third-party beneficiaries intended. Any third-party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client. Reliance upon the services and any work product is limited to our client and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly effect excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety and cost estimating including excavation support and dewatering requirements/design are the responsibility of others. Construction and site development have the potential to affect adjacent properties. Such impacts can include damages due to vibration, modification of groundwater/surface water flow during construction, foundation movement due to undermining or subsidence from excavation, as well as noise or air quality concerns. Evaluation of these items on nearby properties are commonly associated with contractor means and methods and are not addressed in this report. The owner and contractor should consider a preconstruction/precondition survey of surrounding development. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

This Seismic Site Classification section of the geotechnical report has been prepared for the application discussed and in accordance with generally accepted geophysical practices. No warranties, express or implied, are intended or made. The findings presented in this report are based upon the data obtained from the geophysical surveys and from other information discussed in this report. This report does not reflect variations that may occur in areas not tested or inaccessible to the geophysical equipment, across the site, or due to the modifying effects of construction or weather.

Figures

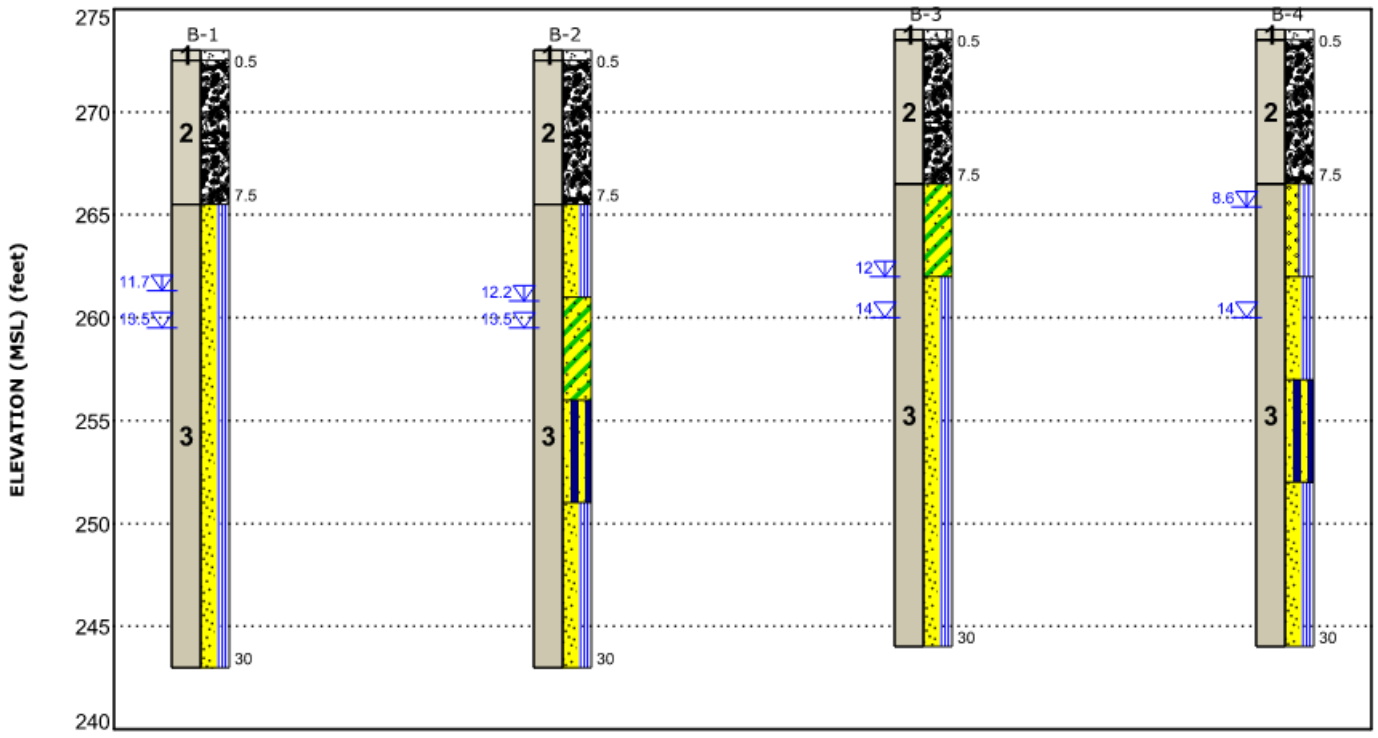
Contents:

GeoModel

RAFB B110 Renovation
RAFB | Warner Robins, GA
Terracon Project No. HN235221

514 Hillcrest Indust. Blvd
Macon, GA

GeoModel



This is not a cross section. This is intended to display the Geotechnical Model only. See individual logs for more detailed conditions.

Model Layer	Layer Name	General Description
1	Surface Cover	4 to 8 inch concrete slab.
2	Fill	7 to 8 inches of fill on all borings, consisting of Clayey Sand (SC) and Silty Sand (SM).
3	Coastal Plain Sediments	Well Graded Sand with Silt (SW-SM), Poorly Graded Sand with Silt (SP-SM), Sandy Elastic Silt (MH), and Clayey Sand (SC).

Legend

- Concrete
- Fill
- Poorly-graded Sand with Silt
- Clayey Sand
- Sandy Elastic Silt
- Topsoil
- Well-graded Sand with Silt

▽ First Water Observation
▽ Second Water Observation

Groundwater levels are temporal. The levels shown are representative of the date and time of our exploration. Significant changes are possible over time.
Water levels shown are as measured during and/or after drilling. In some cases, boring advancement methods mask the presence/absence of groundwater. See individual logs for details.

NOTES:
Layering shown on this figure has been developed by the geotechnical engineer for purposes of modeling the subsurface conditions as required for the subsequent geotechnical engineering for this project.
Numbers adjacent to soil column indicate depth below ground surface.

Attachments

Exploration and Testing Procedures

Field Exploration

Number of Borings	Approximate Boring Depth (feet)	Location
4	30	Sides of Building 110

Boring Layout and Elevations: Terracon personnel provided the boring layout using handheld GPS equipment (estimated horizontal accuracy of about ±20 feet) and referencing existing site features. If elevations and a more precise boring layout are desired, we recommend borings be surveyed following completion of fieldwork. Three borings were offset due to utility and access concerns. The offset distances are noted on the individual boring logs.

Subsurface Exploration Procedures: We advanced the borings with a truck-mounted rotary drill rig using continuous flight augers. Four samples were obtained in the upper 10 feet of each boring and at intervals of 5 feet thereafter. In the split-barrel sampling procedure, a standard 2-inch outer diameter split-barrel sampling spoon was driven into the ground by a 140-pound automatic hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration is recorded as the Standard Penetration Test (SPT) resistance value. The SPT resistance values, also referred to as N-values, are indicated on the boring logs at the test depths. We observed and recorded groundwater levels during drilling and sampling, as well as after 24 hours. For safety purposes, all borings were backfilled with grout after their completion and the surface was capped with concrete (except B-3, which was capped with soil material).

The sampling depths, penetration distances, and other sampling information was recorded on the field boring logs. The samples were placed in appropriate containers and taken to our soil laboratory for testing and classification by a Geotechnical Engineer. Our exploration team prepared field boring logs as part of the drilling operations. These field logs included visual classifications of the materials observed during drilling and our interpretation of the subsurface conditions between samples. Final boring logs were prepared from the field logs. The final boring logs represent the Geotechnical Engineer's interpretation of the field logs and include modifications based on observations and tests of the samples in our laboratory.

Laboratory Testing

The project engineer reviewed the field data and assigned laboratory tests. The laboratory testing program included the following types of tests:

- Moisture Content
- Grain Size Distribution
- Atterberg Limits

The laboratory testing program often included examination of soil samples by an engineer. Based on the results of our field and laboratory programs, we described and classified the soil samples in accordance with the Unified Soil Classification System.

Site Location and Exploration Plans

Contents:

Site Location Plan
Exploration Plan

Note: All attachments are one page unless noted above.

Site Location

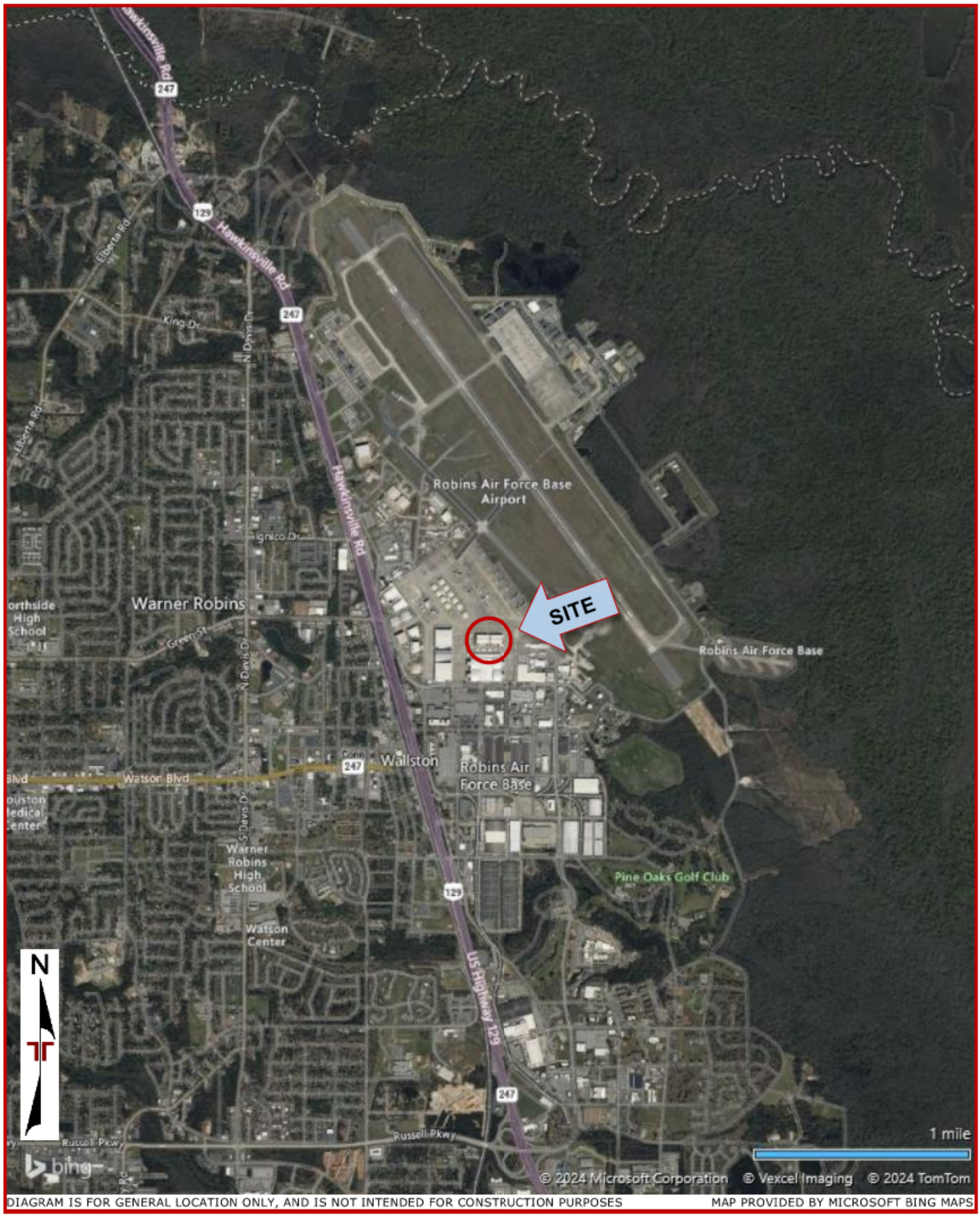


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES MAP PROVIDED BY MICROSOFT BING MAPS

Exploration Plan

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

Exploration and Laboratory Results

Contents:

Boring Logs (4 pages)
Atterberg Limits
Grain Size Distribution (2 pages)
Water Content & Unit Weight
Average Shear Wave Velocity Profile
ASCE Hazards Report (3 pages)
Chemical Laboratory Test Report – Corrosivity (2 pages)
Eurofins Environmental Testing (30 pages)
Detected PAHs Concentrations in Soil

Note: All attachments are one page unless noted above.

RAFB B110 Renovation
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Terracon Project No. HN235221

Terracon
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Macon, GA

Boring Log No. B-1

Location: See Exploration Plan

Latitude: 32.6280° Longitude: -83.5939°

Depth (Ft.) Elevation.: 273 (Ft.)

Depth (Ft.)	Description	Elevation (Ft.)	Field Test Results	PID (ppm)	Water Content (%)	Atterberg Limits LL-PL-PI
0.5	**CONCRETE**, 5.5 inches	272.5				
	FILL - CLAYEY SAND (SC), with gravel, fine to coarse grained, brown tan, loose to medium dense		5-5-7 N=12	0.7	1.8	19-9-10
			2-3-4 N=7	0.5		
4.5		268.5				
	SILTY SAND (SM), with gravel, fine to coarse grained, tan, loose		4-5-5 N=10		2.6	NP
7.5		265.5				
	COASTAL PLAIN SEDIMENTS - POORLY GRADED SAND WITH SILT (SP-SM), trace gravel, fine to coarse grained, reddish tan and gray, moist, medium dense		3-6-9 N=15			
	fine to medium grained, grayish tan, wet		3-5-8 N=13			
	tan		10-6-8 N=14			
	grayish tan		8-7-9 N=16			
30.0		243	6-7-8 N=15			
	Boring Terminated at 30 Feet					

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevation Reference: Elevation taken fromGoogle Earth

Water Level Observations
While drilling
After 24 hours
Cave-In Depth After 24 Hours

Drill Rig
B-46 Truck Rig

Hammer Type
Automatic

Driller
UES

Notes
20' Offset from Original Location

Advancement Method
HSA 2.25"

Abandonment Method
Boring backfilled with grout and capped with concrete.

Logged by
CA

Boring Started

Boring Completed
10-10-2024

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Terracon
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Macon, GA

Boring Log No. B-2

Location: See Exploration Plan

Latitude: 32.6277° Longitude: -83.5925°

Depth (Ft.) | Elevation.: 273 (Ft.)

Depth (Ft.)	Elevation	Description	Field Test Results	PID (ppm)	Water Content (%)	Atterberg Limits LL-PL-PI
0.5	272.5	**CONCRETE**, 8 inches				
		FILL - SILTY SAND (SM), with gravel, fine to coarse grained, brown tan, loose	2-3-4 N=7	0.8	5.3	NP
			1-3-5 N=8	0.7		
		tan	3-3-5 N=8		5.7	NP
7.5	265.5					
		COASTAL PLAIN SEDIMENTS - POORLY GRADED SAND WITH SILT (SP-SM), fine to coarse grained, brownish gray, medium dense	5-12-14 N=26			
12.0	261					
		CLAYEY SAND (SC), fine to coarse grained, gray and tan, moist, medium dense	6-8-10 N=18			
17.0	256					
		SANDY ELASTIC SILT (MH), gray, moist, stiff	3-4-5 N=9			
22.0	251					
		POORLY GRADED SAND WITH SILT (SP-SM), fine to medium grained, grayish tan, moist, medium dense to dense	6-12-11 N=23			
			7-16-19 N=35			
30.0	243					
		Boring Terminated at 30 Feet				

Depth (Ft.): 5, 10, 15, 20, 25, 30

Water Level Observations: ▽ While drilling; ▽ After 24 hours; ▩ Cave-In Depth After 24 Hours

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevation Reference: Elevation taken fromGoogle Earth

Water Level Observations
While drilling
After 24 hours
Cave-In Depth After 24 Hours

Drill Rig
B-46 Truck Rig

Hammer Type
Automatic

Driller
UES

Notes
80' Offset from Original Location

Advancement Method
HSA 2.25"

Abandonment Method
Boring backfilled with grout and capped with concrete.

Logged by
CA

Boring Started

Boring Completed
10-10-2024

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Macon, GA

Boring Log No. B-3

Location: See Exploration Plan

Latitude: 32.6274° Longitude: -83.5934°

Depth (Ft.) Elevation.: 274 (Ft.)

Depth (Ft.)	Description	Elevation (Ft.)	Field Test Results	PID (ppm)	Water Content (%)	Atterberg Limits LL-PL-PI
0.5	**TOPSOIL**, 4 inches	273.5				
	FILL - CLAYEY SAND (SC), fine to coarse grained, brown tan, loose to medium dense		3-4-4 N=8	9.2	3.0	20-10-10
			18-5-7 N=12	7.5	7.3	
4.5		269.5				
	FILL - SILTY SAND (SM), with gravel, fine to coarse grained, tan, loose		1-3-3 N=6		5.3	NP
7.5		266.5				
	COASTAL PLAIN SEDIMENTS - CLAYEY SAND (SC), trace gravel, fine to coarse grained, dark gray, medium dense		7-13-14 N=27			
12.0		262				
	POORLY GRADED SAND WITH SILT (SP-SM), fine to medium grained, grayish tan, moist, loose		4-4-6 N=10			
	tan, wet, medium dense to dense		4-8-15 N=23			
	fine to coarse grained, grayish tan		3-7-9 N=16			
30.0		244	18-18-21 N=39			
	Boring Terminated at 30 Feet					

Water Level Observations: ▽ While drilling; ▽ After 24 hours; Cave-In Depth After 24 Hours

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevation Reference: Elevation taken fromGoogle Earth

Notes

Advancement Method
HSA 2.25"

Abandonment Method
Boring backfilled with grout and capped with soil.

Drill Rig
B-46 Truck Rig

Hammer Type
Automatic

Driller
UES

Logged by
CA

Boring Started

Boring Completed
10-10-2024

RAFB B110 Renovation
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Macon, GA

Boring Log No. B-4

Location: See Exploration Plan

Latitude: 32.6277° Longitude: -83.5949°

Depth (Ft.)	Elevation.: 274 (Ft.)	Field Test Results	PID (ppm)	Water Content (%)	Atterberg Limits LL-PL-PI
0.5	**CONCRETE**, 7 inches 273.5				
	FILL - SILTY SAND (SM), with gravel, fine to coarse grained, tan, loose to medium dense	6-6-6 N=12	6.6		
		3-2-4 N=6	27.1		
		1-3-5 N=8		3.7	NP
7.5	266.5				
	COASTAL PLAIN SEDIMENTS - WELL GRADED SAND WITH SILT (SW-SM), gravelly, fine to coarse grained, light gray, dense	6-12-19 N=31		10.9	NP
12.0	262				
	POORLY GRADED SAND WITH SILT (SP-SM), fine to medium grained, tan, moist, medium dense	4-5-6 N=11			
17.0	257				
	SANDY ELASTIC SILT (MH), gray, wet, stiff	3-6-7 N=13			
22.0	252				
	POORLY GRADED SAND WITH SILT (SP-SM), fine to medium grained, grayish tan, moist, medium dense	6-12-13 N=25			
30.0	244	3-8-10 N=18			
	Boring Terminated at 30 Feet				

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevation Reference: Elevation taken fromGoogle Earth

Water Level Observations
While drilling
After 24 hours
Cave-In Depth After 24 Hours

Drill Rig
B-46 Truck Rig

Hammer Type
Automatic

Driller
UES

Notes
40' Offset from Original Location

Advancement Method
HSA 2.25"

Abandonment Method
Boring backfilled with grout and capped with concrete.

Logged by
CA

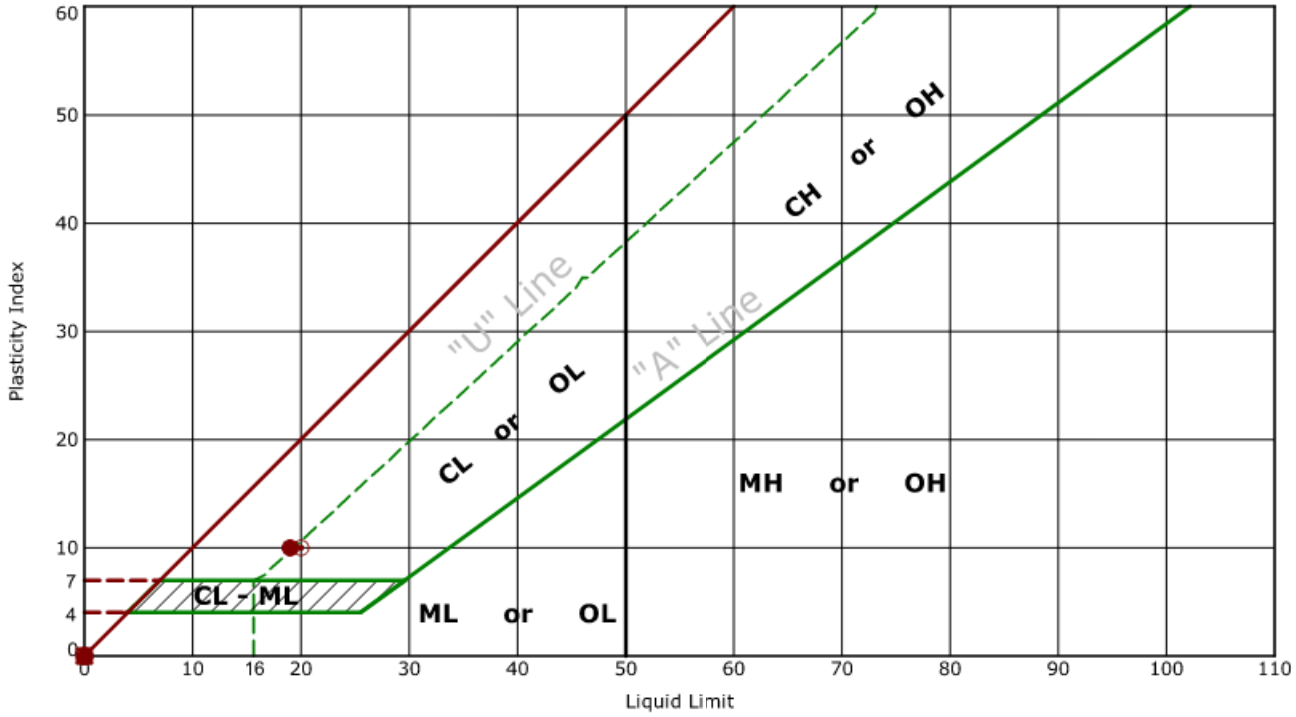
Boring Started

Boring Completed
10-10-2024

Terracon
514 Hillcrest Indust. Blvd
Macon, GA

Atterberg Limit Results

ASTM D4318



	Boring ID	Depth (Ft)	LL	PL	PI	Fines	USCS	Description
●	B-1	0.5 - 2	19	9	10	20.2	SC	Brown tan CLAYEY C-F SAND with GRAVEL
⊠	B-1	5 - 6.5	NP	NP	NP	12.2	SM	Tan SILTY C-F SAND with GRAVEL
▲	B-2	0.5 - 2	NP	NP	NP	13.4	SM	Brown Tan SILTY C-F SAND with GRAVEL
★	B-2	5 - 6.5	NP	NP	NP	13.8	SM	Tan C-F SAND WITH SILT with GRAVEL
⊙	B-3	0.5 - 2	20	10	10	24.7	SC	Brown Tan CLAYEY C-F SAND
✿	B-3	5 - 6.5	NP	NP	NP	16.1	SM	Tan SILTY C-F SAND with GRAVEL
○	B-4	5 - 6.5	NP	NP	NP	14.4	SM	Tan SILTY C-F SAND with GRAVEL
△	B-4	8.5 - 10	NP	NP	NP	11.2	SW-SM	Light Gray GRAVELY C-F SAND with SILT

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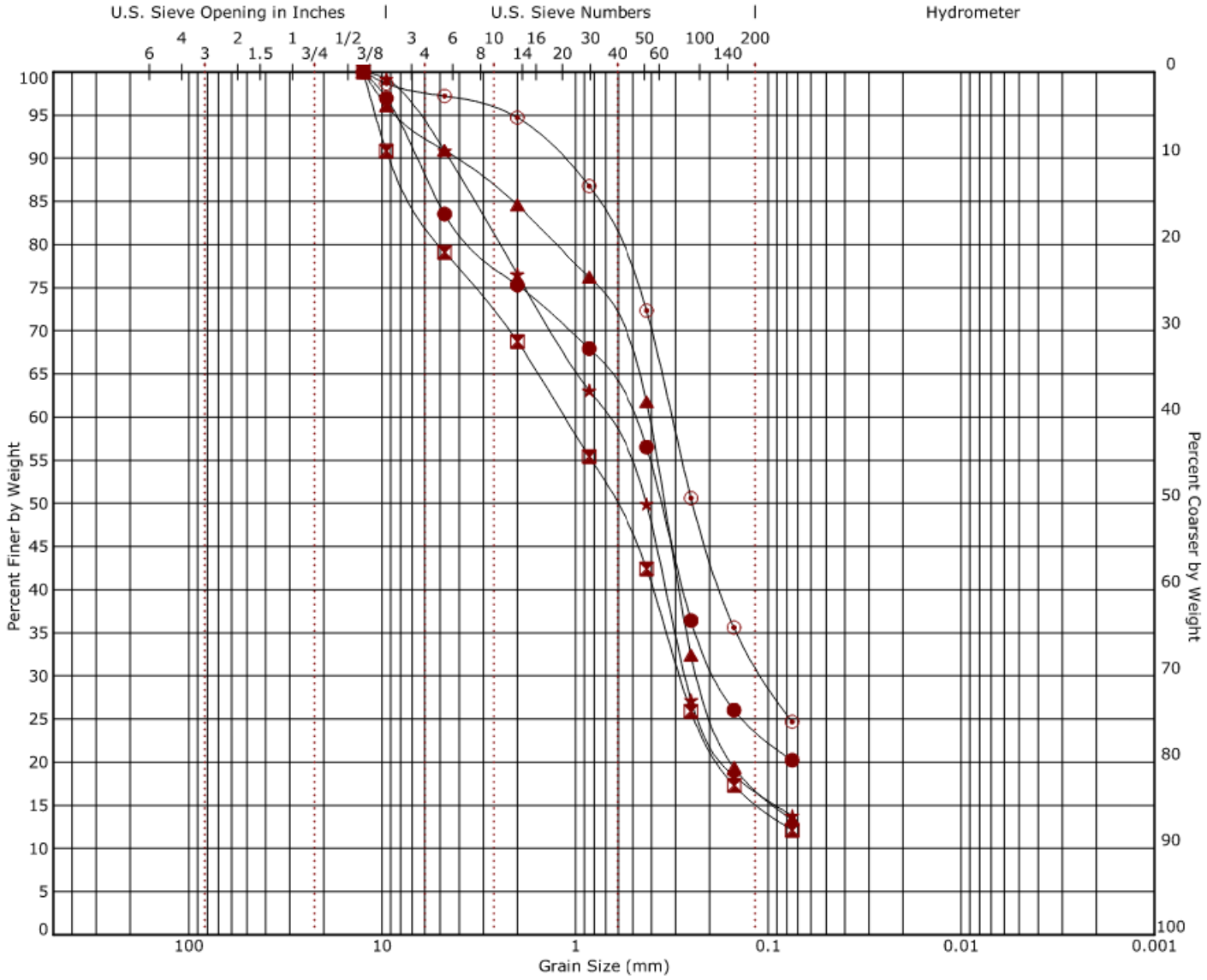
Grain Size Distribution

ASTM D422 / ASTM C136



Cobbles	Gravel		Sand			Silt or Clay
	coarse	fine	coarse	medium	fine	

Boring ID		Depth (Ft)	Description	USCS	LL	PL	PI	Cc	Cu
●	B-1	0.5 - 2	Brown tan CLAYEY C-F SAND with GRAVEL	SC	19	9	10		
⊠	B-1	5 - 6.5	Tan SILTY C-F SAND with GRAVEL	SM	NP	NP	NP	1.27	20.29
▲	B-2	0.5 - 2	Brown Tan SILTY C-F SAND with GRAVEL	SM	NP	NP	NP		
★	B-2	5 - 6.5	Tan C-F SAND WITH SILT with GRAVEL	SM	NP	NP	NP		
⊙	B-3	0.5 - 2	Brown Tan CLAYEY C-F SAND	SC	20	10	10		

Boring ID		Depth (Ft)	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Fines	%Silt	%Clay
●	B-1	0.5 - 2	12.5	0.524	0.182		0.0	16.5	63.3	20.2		
⊠	B-1	5 - 6.5	12.5	1.14	0.285		0.0	20.9	67.0	12.2		
▲	B-2	0.5 - 2	12.5	0.412	0.227		0.0	9.1	77.5	13.4		
★	B-2	5 - 6.5	12.5	0.722	0.267		0.0	9.1	77.1	13.8		
⊙	B-3	0.5 - 2	12.5	0.314	0.105		0.0	2.8	72.5	24.7		

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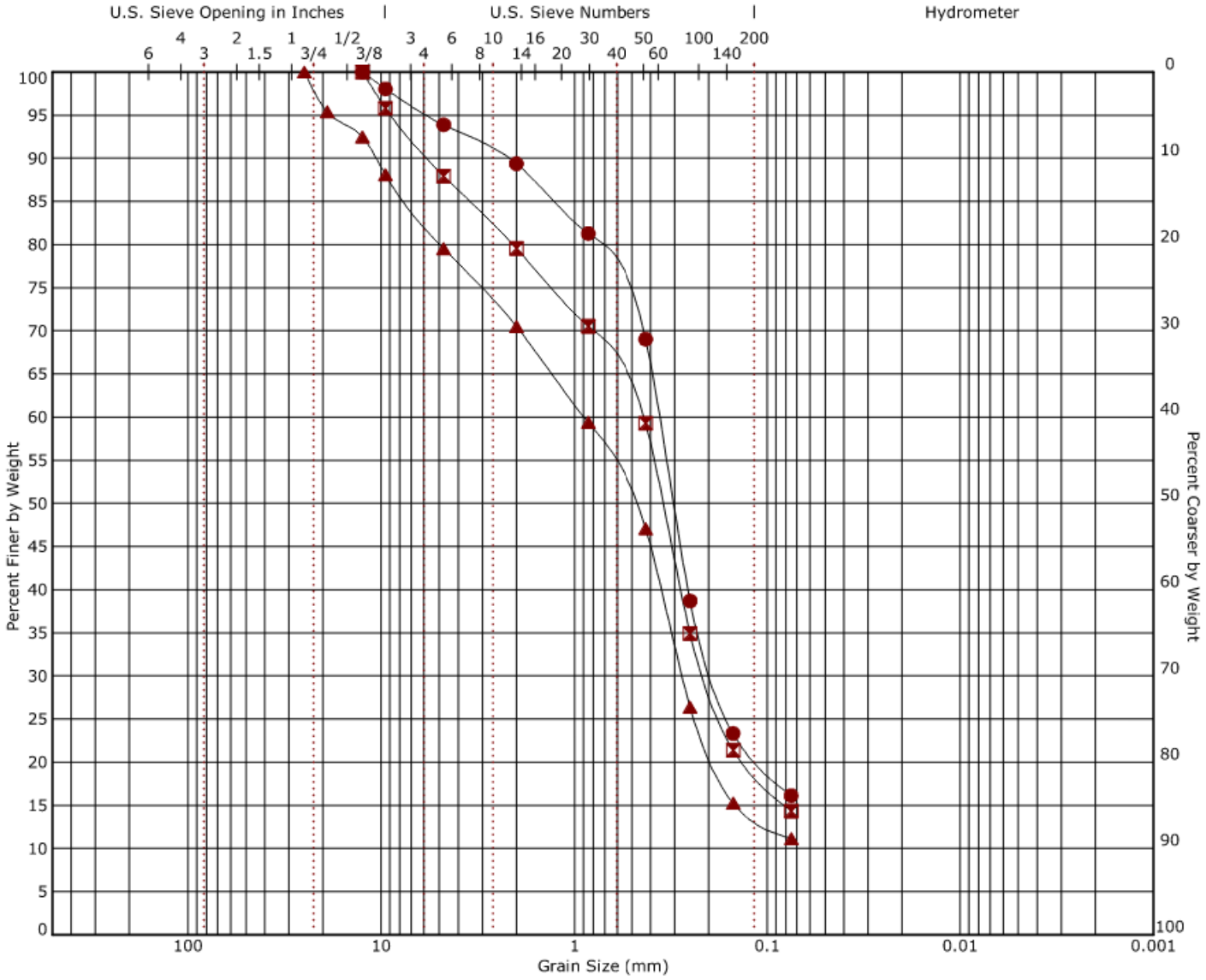
Terracon
514 Hillcrest Indust. Blvd
Macon, GA

Grain Size Distribution

ASTM D422 / ASTM C136



Cobbles	Gravel		Sand			Silt or Clay
	coarse	fine	coarse	medium	fine	

Boring ID		Depth (Ft)	Description	USCS	LL	PL	PI	Cc	Cu
●	B-3	5 - 6.5	Tan SILTY C-F SAND with GRAVEL	SM	NP	NP	NP		
⊠	B-4	5 - 6.5	Tan SILTY C-F SAND with GRAVEL	SM	NP	NP	NP		
▲	B-4	8.5 - 10	Light Gray GRAVELY C-F SAND with SILT	SW-SM	NP	NP	NP	1.37	14.47

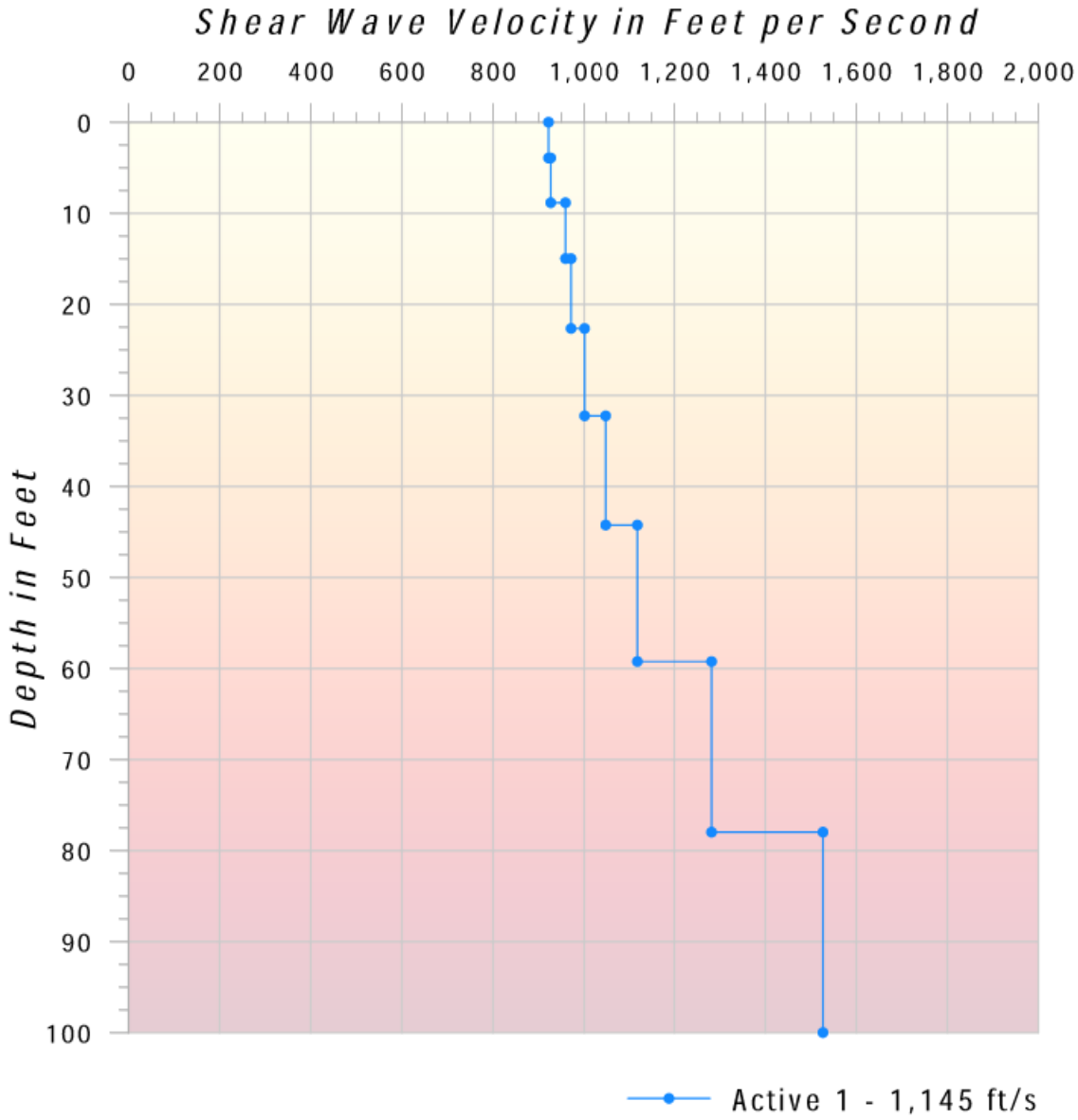
Boring ID		Depth (Ft)	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Fines	%Silt	%Clay
●	B-3	5 - 6.5	12.5	0.363	0.187		0.0	6.1	77.7	16.1		
⊠	B-4	5 - 6.5	12.5	0.444	0.208		0.0	12.0	73.6	14.4		
▲	B-4	8.5 - 10	25	0.891	0.274		0.0	20.5	68.4	11.2		

Terracon
514 Hillcrest Indust. Blvd
Macon, GA

Summary of Laboratory Results

BORING ID	Depth (Ft.)	Unit Weight Wet Density (pcf)	Unit Weight Dry Density (pcf)	Water Content (%)
B-1	0.5-2			1.8
B-1	5-6.5			2.6
B-2	0.5-2			5.3
B-2	5-6.5			5.7
B-3	0.5-2			3.0
B-3	2.5-4	125.5	116.9	7.3
B-3	5-6.5			5.3
B-4	5-6.5			3.7
B-4	8.5-10			10.9

Vs100' Model
Robins AFB B110 Renovation



Notes:

1) Seismic testing was conducted by Terracon on October 24, 2024.
2) Shear wave velocity testing and calculations were conducted in general accordance with ASCE 7-16 and IBC 2018.
3) A seismic site classification of D has been determined for this site.

PROJECT MANAGER:	JPM
DRAWN BY:	AGW
CHECKED BY:	NBR
APPROVED BY:	TED
PROJECT NUMBER:	HN235221
PROJECT TASK:	0
FILE NAME:	Vs100.gpj
DATE:	11/5/2024

Terracon
514 Hillcrest Indust. Blvd
Macon, GA 31204

Site Classification Data

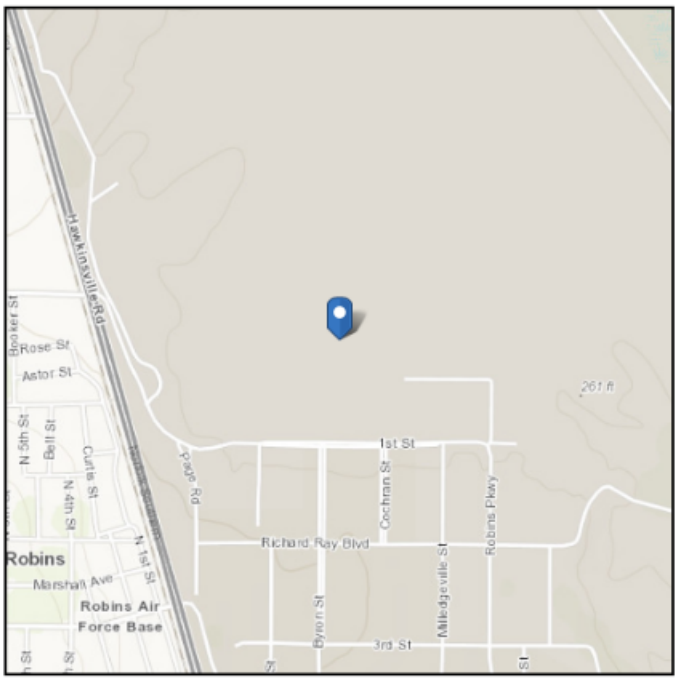
RAFB B110 Renovation
Warner Robins, Georgia

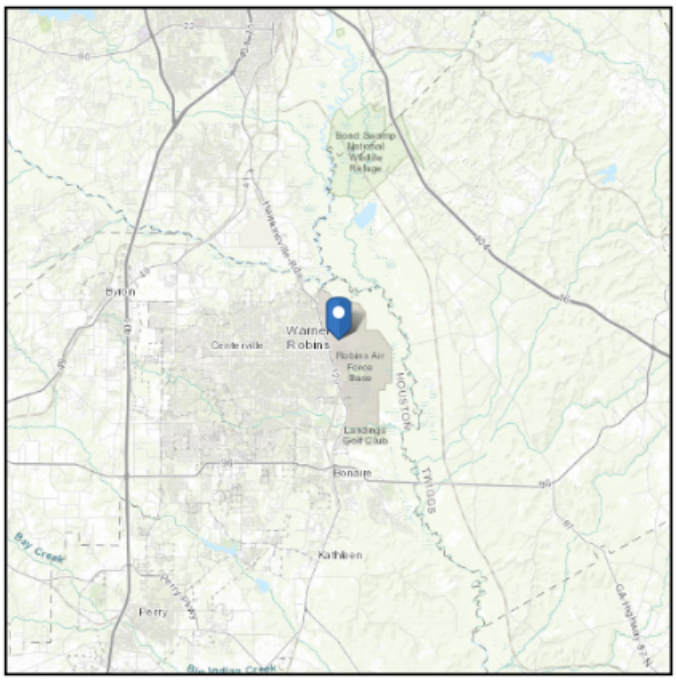
EXHIBIT 1

ASCE Hazards Report

Address:
No Address at This Location

Standard:	ASCE/SEI 7-16	**Latitude:**	32.627655
Risk Category:	III	**Longitude:**	-83.593737
Soil Class:	D - Stiff Soil	**Elevation:**	273.2429191341931 ft (NAVD 88)





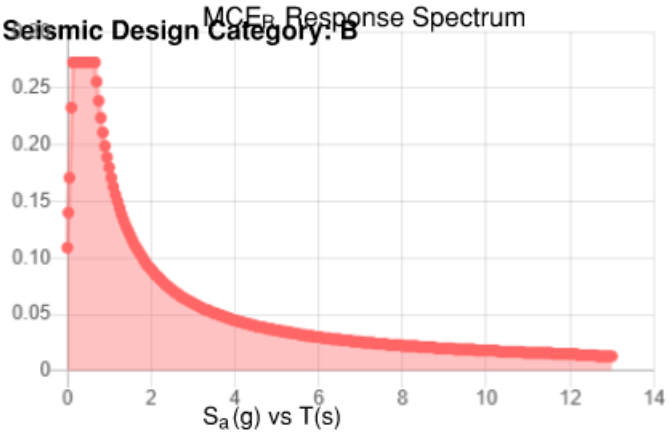
Seismic

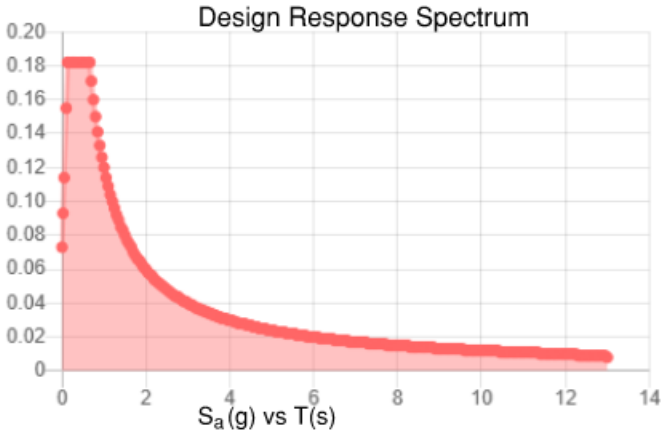
Site Soil Class: D - Stiff Soil

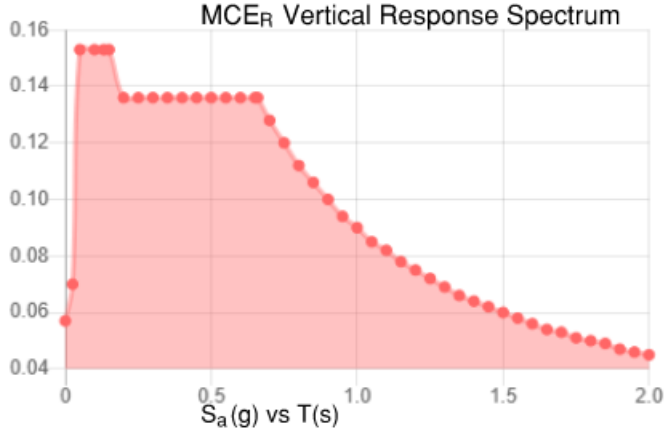
Results:

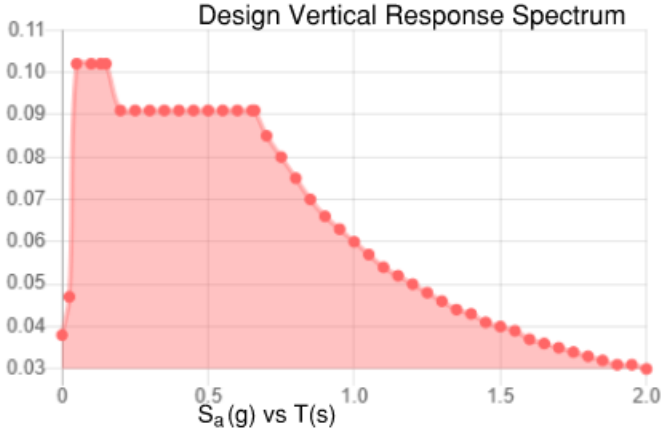
S_S :	0.17	S_{D1} :	0.12
S_1 :	0.075	T_L :	12
F_a :	1.6	PGA :	0.087
F_v :	2.4	PGA_M :	0.14
S_{MS} :	0.273	F_{PGA} :	1.6
S_{M1} :	0.18	I_e :	1.25
S_{DS} :	0.182	C_v :	0.7

Seismic Design Category: B









Data Accessed: Wed Nov 20 2024

Date Source:
USGS Seismic Design Maps based on ASCE/SEI 7-16 and ASCE/SEI 7-16 Table 1.5-2. Additional data for site-specific ground motion procedures in accordance with ASCE/SEI 7-16 Ch. 21 are available from USGS.

The ASCE Hazard Tool is provided for your convenience, for informational purposes only, and is provided “as is” and without warranties of any kind. The location data included herein has been obtained from information developed, produced, and maintained by third party providers; or has been extrapolated from maps incorporated in the ASCE standard. While ASCE has made every effort to use data obtained from reliable sources or methodologies, ASCE does not make any representations or warranties as to the accuracy, completeness, reliability, currency, or quality of any data provided herein. Any third-party links provided by this Tool should not be construed as an endorsement, affiliation, relationship, or sponsorship of such third-party content by or from ASCE.

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CHEMICAL LABORATORY TEST REPORT

Project Number: HN235221
Service Date: 10/16/24
Report Date: 10/18/24

Terracon
10400 State Highway 191
Midland, Texas 79707
432-684-9600

Client

Burns & McDonnell Engineering Company, Incorporated
4004 Summit Blvd., Suite 1200
Atlanta, Georgia 30319

Project

RAFB B110 Renovation
RAFB
Warner Robins, Georgia

Sample Location	B-3
Sample Depth (ft.)	3"-6"
pH Analysis, ASTM G51-18	7.5
Water Soluble Sulfate (SO4), ASTM C1580 (mg/kg)	6
Sulfides, AWWA 4500-S D, (mg/kg)	nil
Chlorides, ASTM D512, (mg/kg)	38
RedOx, ASTM D1498, (mV)	+494
Total Salts, ASTM D1125-14, (mg/kg)	354
Resistivity, ASTM G187, (ohm-cm)	8,363

Analyzed By: *Melissa Flores*
Melissa Flores
Engineering Technician II

The tests were performed in general accordance with applicable ASTM, AASHTO, or DOT test methods. This report is exclusively for the use of the client indicated above and shall not be reproduced except in full without the written consent of our company. Test results transmitted herein are only applicable to the actual samples tested at the location(s) referenced and are not necessarily indicative of the properties of other apparently similar or identical materials.

CHEMICAL LABORATORY TEST REPORT

Project Number: HN235221
Service Date: 11/05/24
Report Date: 11/07/24

Terracon
10400 State Highway 191
Midland, Texas 79707
432-684-9600

Client

Burns & McDonnell Engineering Company Inc
4004 Summit Blvd., Suite 1200
Atlanta, GA 30319

Project

RAFB B110 Renovation
RAFB
Warner Robins, Georgia

Sample Location	B-4
Sample Depth (ft.)	3"-6"
pH Analysis, ASTM G51-18	6.4
Water Soluble Sulfate (SO4), ASTM C1580 (mg/kg)	11
Sulfides, AWWA 4500-S D, (mg/kg)	nil
Chlorides, ASTM D512, (mg/kg)	31
RedOx, ASTM D1498, (mV)	+461
Total Salts, ASTM D1125-14, (mg/kg)	109
Resistivity, ASTM G57, (ohm-cm)	22,715

Analyzed By: Melissa Flores
Melissa Flores
Engineering Technician II

The tests were performed in general accordance with applicable ASTM, AASHTO, or DOT test methods. This report is exclusively for the use of the client indicated above and shall not be reproduced except in full without the written consent of our company. Test results transmitted herein are only applicable to the actual samples tested at the location(s) referenced and are not necessarily indicative of the properties of other apparently similar or identical materials.

eurofins | Environment Testing

1 2 3 4 5 6 7 8 9 10 11

ANALYTICAL REPORT

PREPARED FOR

Attn: Cole Angelo
Terracon Consultants Inc
514 Hillcrest Industrial Blvd.
Macon, Georgia 31204

Generated 10/24/2024 3:24:09 PM

JOB DESCRIPTION

RAFB B110

JOB NUMBER

705-9904-1

Eurofins Atlanta
3080 Presidential Dr
Atlanta GA 30340

See page two for job notes and contact information.

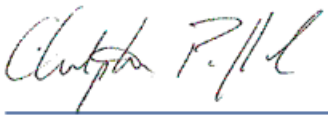
my EOL

Eurofins Atlanta

Job Notes

The test results in this report relate only to the samples as received by the laboratory and will meet all requirements of the methodology, with any exceptions noted. This report shall not be reproduced except in full, without the express written approval of the laboratory. All questions should be directed to the Eurofins Environment Testing Southeast, LLC Project Manager.

Authorization



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10/24/2024 3:24:09 PM

Authorized for release by
Christopher Pafford, Customer Service Manager
christopher.pafford@et.eurofinsus.com
(770)457-8177

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Qualifiers

GC/MS VOA

Qualifier	Qualifier Description
J	Result is less than the RL but greater than or equal to the MDL and the concentration is an approximate value.

GC/MS Semi VOA

Qualifier	Qualifier Description
F1	MS and/or MSD recovery exceeds control limits.

GC Semi VOA

Qualifier	Qualifier Description
S1+	Surrogate recovery exceeds control limits, high biased.

Metals

Qualifier	Qualifier Description
^+	Continuing Calibration Verification (CCV) is outside acceptance limits, high biased.

General Chemistry

Qualifier	Qualifier Description
HF	Parameter with a holding time of 15 minutes. Test performed by laboratory at client's request. Sample was analyzed outside of hold time.

Glossary

Abbreviation	These commonly used abbreviations may or may not be present in this report.
☼	Listed under the "D" column to designate that the result is reported on a dry weight basis
%R	Percent Recovery
CFL	Contains Free Liquid
CFU	Colony Forming Unit
CNF	Contains No Free Liquid
DER	Duplicate Error Ratio (normalized absolute difference)
Dil Fac	Dilution Factor
DL	Detection Limit (DoD/DOE)
DL, RA, RE, IN	Indicates a Dilution, Re-analysis, Re-extraction, or additional Initial metals/anion analysis of the sample
DLC	Decision Level Concentration (Radiochemistry)
EDL	Estimated Detection Limit (Dioxin)
LOD	Limit of Detection (DoD/DOE)
LOQ	Limit of Quantitation (DoD/DOE)
MCL	EPA recommended "Maximum Contaminant Level"
MDA	Minimum Detectable Activity (Radiochemistry)
MDC	Minimum Detectable Concentration (Radiochemistry)
MDL	Method Detection Limit
ML	Minimum Level (Dioxin)
MPN	Most Probable Number
MQL	Method Quantitation Limit
NC	Not Calculated
ND	Not Detected at the reporting limit (or MDL or EDL if shown)
NEG	Negative / Absent
POS	Positive / Present
PQL	Practical Quantitation Limit
PRES	Presumptive
QC	Quality Control
RER	Relative Error Ratio (Radiochemistry)
RL	Reporting Limit or Requested Limit (Radiochemistry)
RPD	Relative Percent Difference, a measure of the relative difference between two points
TEF	Toxicity Equivalent Factor (Dioxin)
TEQ	Toxicity Equivalent Quotient (Dioxin)
TNTC	Too Numerous To Count

AES ENVIRONMENTAL SERVICES, INC.

3080 Presidential Drive, Atlanta, GA 30340 Phone: (770)-457-8177

CHAIN OF CUSTODY

Work Order: _____

Page 1 of 1

COMPANY:	ADDRESS:
Terracon	514 Hillcrest Industrial Macon, GA 31204
PHONE: 478-757-1606	EMAIL: cole.angelo@terracon.com
SAMPLED BY: C Angelo	SIGNATURE:

#	SAMPLE ID	SAMPLED: DATE	SAMPLED: TIME	GRAB	COMPOSITE	MATRIX (see codes)	ANALYSIS REQUESTED: Flashpoint	Pit	TCLP 8 RCRA Metals	TCLP VOCs	TCLP SVOCs	TCLP Pest	Lowlevel PAH	Paint Filter	PRESERVATION (see codes)	REMARKS	Number of Containers
1	B-1 0-5'	10-10-24	1600		✓	Soil	✓	✓	✓	✓	✓	✓	✓	✓			1
2	B-2 0-5'	10-10-24	14:54		✓	Soil	✓	✓	✓	✓	✓	✓	✓	✓			1
3	B-3 0-5'	10-10-24	13:29		✓	Soil	✓	✓	✓	✓	✓	✓	✓	✓			1
4	B-4 0-5'	10-10-24	10:45		✓	Soil	✓	✓	✓	✓	✓	✓	✓	✓			1
5																	
6																	
7																	
8																	
9																	
10																	
11																	
12																	
13																	
14																	

Visit our website www.aesatlanta.com for downloadable COCs and to log in to your AESAccess account.

705-9904 COC

RELINQUISHED BY:	DATE/TIME:	RECEIVED BY:	DATE/TIME:
1.	10/14/2024 10:00	1.	10-14 1124
2.	10-14 1705	2.	10 14 24 1305
3.		3.	

SPECIAL INSTRUCTIONS/COMMENTS:

SHIPMENT METHOD 2.3d

OUT: / / VIA:

IN: / / VIA: #0665

Client FedEx UPS US mail courier

other: _____

PROJECT INFORMATION

PROJECT NAME: RAFB B110

PROJECT #: HN23522

SITE ADDRESS:

SEND REPORT TO: Cole Angelo

INVOICE TO (IF DIFFERENT FROM ABOVE):

QUOTE #: _____ PO#: _____

RECEIPT

Total # of Containers: 4

Turnaround Time (TAT) Request

☒ Standard

☐ 2 Business Day Rush

☐ Next Business Day Rush

☐ Same-Day Rush (auth req.)

☐ Other _____

REGULATORY PROGRAM (if any):

DATA PACKAGE: I ○ II ○ III ○ IV ○

Submission of samples to the laboratory constitutes acceptance of AES's Terms & Conditions. Client assumes sole responsibility for damage or loss of samples before we accept them. Samples received after 3PM or on Saturday are considered as received the following business day. If no TAT is marked on COC, AES will proceed with standard TAT. Samples are disposed of 30 days after completion of report unless other arrangements are made.

Matrix Codes: A = Air GW = Groundwater SE = Sediment SO = Soil SW = Surface Water ST=Stormwater WW = Waste Water W = Water (Blanks) DW = Drinking Water (Blanks) O = Other (specify)

Preservative Codes: H+I = Hydrochloric acid + ice I = Ice only N = Nitric acid S+I = Sulfuric acid + ice S/M+I = Sodium Bisulfate/Methanol + ice O = Other (specify) NA = None

4.30.20_COC

Job Narrative
705-9904-1

Analytical test results meet all requirements of the associated regulatory program listed on the Accreditation/Certification Summary Page unless otherwise noted under the individual analysis. Data qualifiers and/or narrative comments are included to explain any exceptions, if applicable.

- Matrix QC may not be reported if insufficient sample is provided or site-specific QC samples were not submitted. In these situations, to demonstrate precision and accuracy at a batch level, a LCS/LCSD may be performed, unless otherwise specified in the method.
- Surrogate and/or isotope dilution analyte recoveries (if applicable) which are outside of the QC window are confirmed unless attributed to a dilution or otherwise noted in the narrative.

Regulated compliance samples (e.g. SDWA, NPDES) must comply with the associated agency requirements/permits.

Receipt
The samples were received on 10/14/2024 1:05 PM. Unless otherwise noted below, the samples arrived in good condition, and, where required, properly preserved and on ice. The temperature of the cooler at receipt time was 2.3°C.

GC/MS VOA
No additional analytical or quality issues were noted, other than those described above or in the Definitions/ Glossary page.

GC/MS Semi VOA
Method 8270E - TCLP: The matrix spike / matrix spike duplicate (MS/MSD) recoveries for preparation batch 705-17234 and 705-17160 and analytical batch 705-17832 were outside control limits for one or more analytes. See QC Sample Results for detail. Sample matrix interference and/or non-homogeneity are suspected because the associated laboratory control sample (LCS) recovery is within acceptance limits.

No additional analytical or quality issues were noted, other than those described above or in the Definitions/ Glossary page.

Pesticides
Method 8081B - TCLP: Surrogate DCB Decachlorobiphenyl (Surr) and Tetrachloro-m-xylene (Surr) recovery for the following samples were outside the upper control limit: B-2 0-5' (705-9904-2) and B-4 0-5' (705-9904-4).

No additional analytical or quality issues were noted, other than those described above or in the Definitions/ Glossary page.

Metals
No additional analytical or quality issues were noted, other than those described above or in the Definitions/ Glossary page.

General Chemistry
Method 9045D: This analysis is normally performed in the field and has a method-defined holding time of 15 minutes. The following samples has been qualified with the "HF" flag to indicate analysis was performed in the laboratory outside the 15 minute timeframe: B-1 0-5' (705-9904-1), B-2 0-5' (705-9904-2), B-3 0-5' (705-9904-3), B-4 0-5' (705-9904-4), (705-9718-A-1), (705-9718-A-1 DU), (705-9975-A-1) and (705-9975-A-1 DU).

No additional analytical or quality issues were noted, other than those described above or in the Definitions/ Glossary page.

Client: Terracon Consultants Inc
Project/Site: RAFB B110

Job ID: 705-9904-1

Client Sample ID: B-1 0-5'
Date Collected: 10/10/24 16:00
Date Received: 10/14/24 13:05

Lab Sample ID: 705-9904-1
Matrix: Solid

Method: SW846 8260D - Volatile Organic Compounds by GC/MS - TCLP

Analyte	Result	Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
Benzene	ND		100		ug/L			10/17/24 14:35	20
Carbon tetrachloride	ND		100		ug/L			10/17/24 14:35	20
Chlorobenzene	ND		100		ug/L			10/17/24 14:35	20
Chloroform	ND		100		ug/L			10/17/24 14:35	20
1,2-Dichloroethane	ND		100		ug/L			10/17/24 14:35	20
1,1-Dichloroethene	ND		100		ug/L			10/17/24 14:35	20
2-Butanone	ND		1000		ug/L			10/17/24 14:35	20
Tetrachloroethene	ND		100		ug/L			10/17/24 14:35	20
Vinyl chloride	ND		100		ug/L			10/17/24 14:35	20
Trichloroethene	ND		100		ug/L			10/17/24 14:35	20

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
4-Bromofluorobenzene	*94*		*70 - 126*		*10/17/24 14:35*	*20*
Dibromofluoromethane (Surr)	*105*		*77 - 121*		*10/17/24 14:35*	*20*
Toluene-d8 (Surr)	*99*		*79 - 119*		*10/17/24 14:35*	*20*

Method: SW846 8270E - Semivolatile Organic Compounds (GC/MS) - TCLP

Analyte	Result	Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
2-Methylphenol	ND		0.10		mg/L		10/18/24 11:39	10/18/24 21:35	1
3 & 4 Methylphenol	ND		0.10		mg/L		10/18/24 11:39	10/18/24 21:35	1
2,4-Dinitrotoluene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 21:35	1
Hexachlorobenzene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 21:35	1
Hexachlorobutadiene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 21:35	1
Hexachloroethane	ND		0.10		mg/L		10/18/24 11:39	10/18/24 21:35	1
Nitrobenzene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 21:35	1
Pentachlorophenol	ND		0.25		mg/L		10/18/24 11:39	10/18/24 21:35	1
Pyridine	ND		0.10		mg/L		10/18/24 11:39	10/18/24 21:35	1
2,4,5-Trichlorophenol	ND		0.25		mg/L		10/18/24 11:39	10/18/24 21:35	1
2,4,6-Trichlorophenol	ND		0.10		mg/L		10/18/24 11:39	10/18/24 21:35	1
1,4-Dichlorobenzene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 21:35	1

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
2,4,6-Tribromophenol (Surr)	*62*		*53 - 132*	*10/18/24 11:39*	*10/18/24 21:35*	*1*
2-Fluorophenol (Surr)	*62*		*29 - 120*	*10/18/24 11:39*	*10/18/24 21:35*	*1*
Nitrobenzene-d5 (Surr)	*72*		*41 - 129*	*10/18/24 11:39*	*10/18/24 21:35*	*1*
Phenol-d5 (Surr)				*10/18/24 11:39*	*10/18/24 21:35*	*1*
2-Fluorobiphenyl (Surr)	*72*		*48 - 126*	*10/18/24 11:39*	*10/18/24 21:35*	*1*
p-Terphenyl-d14 (Surr)	*78*		*48 - 130*	*10/18/24 11:39*	*10/18/24 21:35*	*1*

Method: SW846 8081B - Organochlorine Pesticides (GC) - TCLP

Analyte	Result	Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
Chlordane (technical)	ND		0.00050		mg/L		10/23/24 10:27	10/23/24 17:38	1
Endrin	ND		0.00010		mg/L		10/23/24 10:27	10/23/24 17:38	1
gamma-BHC (Lindane)	ND		0.000050		mg/L		10/23/24 10:27	10/23/24 17:38	1
Heptachlor	ND		0.000050		mg/L		10/23/24 10:27	10/23/24 17:38	1
Heptachlor epoxide	ND		0.000050		mg/L		10/23/24 10:27	10/23/24 17:38	1
Methoxychlor	ND		0.00050		mg/L		10/23/24 10:27	10/23/24 17:38	1
Toxaphene	ND		0.0050		mg/L		10/23/24 10:27	10/23/24 17:38	1

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
DCB Decachlorobiphenyl (Surr)	*122*		*50 - 130*	*10/23/24 10:27*	*10/23/24 17:38*	*1*

Client Sample ID: B-1 0-5'
Date Collected: 10/10/24 16:00
Date Received: 10/14/24 13:05

Lab Sample ID: 705-9904-1
Matrix: Solid

Method: SW846 8081B - Organochlorine Pesticides (GC) - TCLP (Continued)

Surrogate	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
Tetrachloro-m-xylene (Surr)	*115*		*46 - 120*	*10/23/24 10:27*	*10/23/24 17:38*	*1*

Method: SW846 6010D - Metals (ICP) - TCLP

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	ND		0.25	mg/L		10/18/24 14:32	10/18/24 16:55	1
Barium	ND		0.50	mg/L		10/18/24 14:32	10/18/24 16:55	1
Cadmium	ND		0.025	mg/L		10/18/24 14:32	10/18/24 16:55	1
Chromium	ND		0.050	mg/L		10/18/24 14:32	10/18/24 16:55	1
Lead	ND		0.050	mg/L		10/18/24 14:32	10/18/24 16:55	1
Selenium	ND		0.10	mg/L		10/18/24 14:32	10/18/24 16:55	1
Silver	ND		0.025	mg/L		10/18/24 14:32	10/18/24 16:55	1

Method: SW846 7470A - Mercury (CVAA) - TCLP

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	ND	^+	0.0050	mg/L		10/18/24 14:11	10/18/24 18:32	1

General Chemistry

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Ignitability (SW846 1030)	N			NONE			10/18/24 10:35	1
corrosivity by pH (SW846 9045D)	5.4	HF	0.01	SU			10/17/24 10:50	1
Temperature (SW846 9045D)	22.1	HF	0.01	Degrees C			10/17/24 10:50	1
Free Liquid (SW846 9095B)	NEGATIVE			NONE			10/16/24 13:02	1

Client Sample ID: B-1 0-5'
Date Collected: 10/10/24 16:00
Date Received: 10/14/24 13:05

Lab Sample ID: 705-9904-1
Matrix: Solid
Percent Solids: 94.0

Method: SW846 8270E SIM - Semivolatile Organic Compounds (GC/MS SIM)

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
1-Methylnaphthalene	ND		0.018	mg/Kg	☼	10/18/24 11:24	10/18/24 18:04	1
2-Methylnaphthalene	ND		0.018	mg/Kg	☼	10/18/24 11:24	10/18/24 18:04	1
Acenaphthene	ND		0.018	mg/Kg	☼	10/18/24 11:24	10/18/24 18:04	1
Acenaphthylene	ND		0.035	mg/Kg	☼	10/18/24 11:24	10/18/24 18:04	1
Anthracene	ND		0.0018	mg/Kg	☼	10/18/24 11:24	10/18/24 18:04	1
Benzo[a]anthracene	ND		0.0018	mg/Kg	☼	10/18/24 11:24	10/18/24 18:04	1
Benzo[a]pyrene	ND		0.0018	mg/Kg	☼	10/18/24 11:24	10/18/24 18:04	1
Benzo[b]fluoranthene	ND		0.0035	mg/Kg	☼	10/18/24 11:24	10/18/24 18:04	1
Benzo[g,h,i]perylene	ND		0.0035	mg/Kg	☼	10/18/24 11:24	10/18/24 18:04	1
Benzo[k]fluoranthene	ND		0.0018	mg/Kg	☼	10/18/24 11:24	10/18/24 18:04	1
Chrysene	ND		0.0018	mg/Kg	☼	10/18/24 11:24	10/18/24 18:04	1
Dibenz(a,h)anthracene	ND		0.0035	mg/Kg	☼	10/18/24 11:24	10/18/24 18:04	1
Fluoranthene	ND		0.0035	mg/Kg	☼	10/18/24 11:24	10/18/24 18:04	1
Fluorene	ND		0.0035	mg/Kg	☼	10/18/24 11:24	10/18/24 18:04	1
Indeno[1,2,3-cd]pyrene	ND		0.0018	mg/Kg	☼	10/18/24 11:24	10/18/24 18:04	1
Naphthalene	ND		0.018	mg/Kg	☼	10/18/24 11:24	10/18/24 18:04	1
Phenanthrene	ND		0.0018	mg/Kg	☼	10/18/24 11:24	10/18/24 18:04	1
Pyrene	ND		0.0018	mg/Kg	☼	10/18/24 11:24	10/18/24 18:04	1

Surrogate	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
p-Terphenyl-d14 (Surr)	*107*		*59 - 129*	*10/18/24 11:24*	*10/18/24 18:04*	*1*

Client: Terracon Consultants Inc
Project/Site: RAFB B110

Job ID: 705-9904-1

Client Sample ID: B-2 0-5'
Date Collected: 10/10/24 14:54
Date Received: 10/14/24 13:05

Lab Sample ID: 705-9904-2
Matrix: Solid

Method: SW846 8260D - Volatile Organic Compounds by GC/MS - TCLP

Analyte	Result	Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
Benzene	ND		100		ug/L			10/17/24 13:24	20
Carbon tetrachloride	ND		100		ug/L			10/17/24 13:24	20
Chlorobenzene	ND		100		ug/L			10/17/24 13:24	20
Chloroform	ND		100		ug/L			10/17/24 13:24	20
1,2-Dichloroethane	ND		100		ug/L			10/17/24 13:24	20
1,1-Dichloroethene	ND		100		ug/L			10/17/24 13:24	20
2-Butanone	ND		1000		ug/L			10/17/24 13:24	20
Tetrachloroethene	ND		100		ug/L			10/17/24 13:24	20
Vinyl chloride	ND		100		ug/L			10/17/24 13:24	20
Trichloroethene	ND		100		ug/L			10/17/24 13:24	20

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
4-Bromofluorobenzene	*96*		*70 - 126*		*10/17/24 13:24*	*20*
Dibromofluoromethane (Surr)	*101*		*77 - 121*		*10/17/24 13:24*	*20*
Toluene-d8 (Surr)	*97*		*79 - 119*		*10/17/24 13:24*	*20*

Method: SW846 8270E - Semivolatile Organic Compounds (GC/MS) - TCLP

Analyte	Result	Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
2-Methylphenol	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:02	1
3 & 4 Methylphenol	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:02	1
2,4-Dinitrotoluene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:02	1
Hexachlorobenzene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:02	1
Hexachlorobutadiene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:02	1
Hexachloroethane	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:02	1
Nitrobenzene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:02	1
Pentachlorophenol	ND		0.25		mg/L		10/18/24 11:39	10/18/24 22:02	1
Pyridine	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:02	1
2,4,5-Trichlorophenol	ND		0.25		mg/L		10/18/24 11:39	10/18/24 22:02	1
2,4,6-Trichlorophenol	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:02	1
1,4-Dichlorobenzene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:02	1

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
2,4,6-Tribromophenol (Surr)	*63*		*53 - 132*	*10/18/24 11:39*	*10/18/24 22:02*	*1*
2-Fluorophenol (Surr)	*60*		*29 - 120*	*10/18/24 11:39*	*10/18/24 22:02*	*1*
Nitrobenzene-d5 (Surr)	*67*		*41 - 129*	*10/18/24 11:39*	*10/18/24 22:02*	*1*
Phenol-d5 (Surr)				*10/18/24 11:39*	*10/18/24 22:02*	*1*
2-Fluorobiphenyl (Surr)	*70*		*48 - 126*	*10/18/24 11:39*	*10/18/24 22:02*	*1*
p-Terphenyl-d14 (Surr)	*79*		*48 - 130*	*10/18/24 11:39*	*10/18/24 22:02*	*1*

Method: SW846 8081B - Organochlorine Pesticides (GC) - TCLP

Analyte	Result	Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
Chlordane (technical)	ND		0.00050		mg/L		10/23/24 10:27	10/23/24 17:50	1
Endrin	ND		0.00010		mg/L		10/23/24 10:27	10/23/24 17:50	1
gamma-BHC (Lindane)	ND		0.000050		mg/L		10/23/24 10:27	10/23/24 17:50	1
Heptachlor	ND		0.000050		mg/L		10/23/24 10:27	10/23/24 17:50	1
Heptachlor epoxide	ND		0.000050		mg/L		10/23/24 10:27	10/23/24 17:50	1
Methoxychlor	ND		0.00050		mg/L		10/23/24 10:27	10/23/24 17:50	1
Toxaphene	ND		0.0050		mg/L		10/23/24 10:27	10/23/24 17:50	1

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
DCB Decachlorobiphenyl (Surr)	*130*		*50 - 130*	*10/23/24 10:27*	*10/23/24 17:50*	*1*

Client Sample ID: B-2 0-5'

Lab Sample ID: 705-9904-2

Date Collected: 10/10/24 14:54

Matrix: Solid

Date Received: 10/14/24 13:05

Method: SW846 8081B - Organochlorine Pesticides (GC) - TCLP (Continued)

Surrogate	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
Tetrachloro-m-xylene (Surr)	*123*	*S1+*	*46 - 120*	*10/23/24 10:27*	*10/23/24 17:50*	*1*

Method: SW846 6010D - Metals (ICP) - TCLP

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	ND		0.25	mg/L		10/18/24 14:32	10/18/24 16:58	1
Barium	ND		0.50	mg/L		10/18/24 14:32	10/18/24 16:58	1
Cadmium	ND		0.025	mg/L		10/18/24 14:32	10/18/24 16:58	1
Chromium	ND		0.050	mg/L		10/18/24 14:32	10/18/24 16:58	1
Lead	ND		0.050	mg/L		10/18/24 14:32	10/18/24 16:58	1
Selenium	ND		0.10	mg/L		10/18/24 14:32	10/18/24 16:58	1
Silver	ND		0.025	mg/L		10/18/24 14:32	10/18/24 16:58	1

Method: SW846 7470A - Mercury (CVAA) - TCLP

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	ND	^+	0.0050	mg/L		10/18/24 14:11	10/18/24 18:36	1

General Chemistry

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Ignitability (SW846 1030)	**N**			NONE			10/18/24 10:35	1
corrosivity by pH (SW846 9045D)	**7.3**	**HF**	0.01	SU			10/17/24 10:50	1
Temperature (SW846 9045D)	**22.0**	**HF**	0.01	Degrees C			10/17/24 10:50	1
Free Liquid (SW846 9095B)	**NEGATIVE**			NONE			10/16/24 13:02	1

Client Sample ID: B-2 0-5'

Lab Sample ID: 705-9904-2

Date Collected: 10/10/24 14:54

Matrix: Solid

Date Received: 10/14/24 13:05

Percent Solids: 94.4

Method: SW846 8270E SIM - Semivolatile Organic Compounds (GC/MS SIM)

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
1-Methylnaphthalene	ND		0.018	mg/Kg	☼	10/22/24 14:26	10/22/24 19:57	1
2-Methylnaphthalene	ND		0.018	mg/Kg	☼	10/22/24 14:26	10/22/24 19:57	1
Acenaphthene	ND		0.018	mg/Kg	☼	10/22/24 14:26	10/22/24 19:57	1
Acenaphthylene	ND		0.035	mg/Kg	☼	10/22/24 14:26	10/22/24 19:57	1
Anthracene	**0.0057**		0.0018	mg/Kg	☼	10/22/24 14:26	10/22/24 19:57	1
Benzo[a]anthracene	**0.029**		0.0018	mg/Kg	☼	10/22/24 14:26	10/22/24 19:57	1
Benzo[a]pyrene	**0.021**		0.0018	mg/Kg	☼	10/22/24 14:26	10/22/24 19:57	1
Benzo[b]fluoranthene	**0.046**		0.0035	mg/Kg	☼	10/22/24 14:26	10/22/24 19:57	1
Benzo[g,h,i]perylene	**0.019**		0.0035	mg/Kg	☼	10/22/24 14:26	10/22/24 19:57	1
Benzo[k]fluoranthene	**0.013**		0.0018	mg/Kg	☼	10/22/24 14:26	10/22/24 19:57	1
Chrysene	**0.031**		0.0018	mg/Kg	☼	10/22/24 14:26	10/22/24 19:57	1
Dibenz(a,h)anthracene	**0.0040**		0.0035	mg/Kg	☼	10/22/24 14:26	10/22/24 19:57	1
Fluoranthene	**0.061**		0.0035	mg/Kg	☼	10/22/24 14:26	10/22/24 19:57	1
Fluorene	ND		0.0035	mg/Kg	☼	10/22/24 14:26	10/22/24 19:57	1
Indeno[1,2,3-cd]pyrene	**0.016**		0.0018	mg/Kg	☼	10/22/24 14:26	10/22/24 19:57	1
Naphthalene	ND		0.018	mg/Kg	☼	10/22/24 14:26	10/22/24 19:57	1
Phenanthrene	**0.017**		0.0018	mg/Kg	☼	10/22/24 14:26	10/22/24 19:57	1
Pyrene	**0.050**		0.0018	mg/Kg	☼	10/22/24 14:26	10/22/24 19:57	1

Surrogate	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
p-Terphenyl-d14 (Surr)	*84*		*59 - 129*	*10/22/24 14:26*	*10/22/24 19:57*	*1*

Client: Terracon Consultants Inc
Project/Site: RAFB B110

Job ID: 705-9904-1

Client Sample ID: B-3 0-5'
Date Collected: 10/10/24 13:29
Date Received: 10/14/24 13:05

Lab Sample ID: 705-9904-3
Matrix: Solid

Method: SW846 8260D - Volatile Organic Compounds by GC/MS - TCLP

Analyte	Result	Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
Benzene	ND		100		ug/L			10/17/24 14:57	20
Carbon tetrachloride	ND		100		ug/L			10/17/24 14:57	20
Chlorobenzene	ND		100		ug/L			10/17/24 14:57	20
Chloroform	ND		100		ug/L			10/17/24 14:57	20
1,2-Dichloroethane	ND		100		ug/L			10/17/24 14:57	20
1,1-Dichloroethene	ND		100		ug/L			10/17/24 14:57	20
2-Butanone	ND		1000		ug/L			10/17/24 14:57	20
Tetrachloroethene	ND		100		ug/L			10/17/24 14:57	20
Vinyl chloride	ND		100		ug/L			10/17/24 14:57	20
Trichloroethene	ND		100		ug/L			10/17/24 14:57	20

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
4-Bromofluorobenzene	*95*		*70 - 126*		*10/17/24 14:57*	*20*
Dibromofluoromethane (Surr)	*109*		*77 - 121*		*10/17/24 14:57*	*20*
Toluene-d8 (Surr)	*97*		*79 - 119*		*10/17/24 14:57*	*20*

Method: SW846 8270E - Semivolatile Organic Compounds (GC/MS) - TCLP

Analyte	Result	Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
2-Methylphenol	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:30	1
3 & 4 Methylphenol	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:30	1
2,4-Dinitrotoluene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:30	1
Hexachlorobenzene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:30	1
Hexachlorobutadiene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:30	1
Hexachloroethane	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:30	1
Nitrobenzene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:30	1
Pentachlorophenol	ND		0.25		mg/L		10/18/24 11:39	10/18/24 22:30	1
Pyridine	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:30	1
2,4,5-Trichlorophenol	ND		0.25		mg/L		10/18/24 11:39	10/18/24 22:30	1
2,4,6-Trichlorophenol	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:30	1
1,4-Dichlorobenzene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:30	1

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
2,4,6-Tribromophenol (Surr)	*64*		*53 - 132*	*10/18/24 11:39*	*10/18/24 22:30*	*1*
2-Fluorophenol (Surr)	*63*		*29 - 120*	*10/18/24 11:39*	*10/18/24 22:30*	*1*
Nitrobenzene-d5 (Surr)	*67*		*41 - 129*	*10/18/24 11:39*	*10/18/24 22:30*	*1*
Phenol-d5 (Surr)				*10/18/24 11:39*	*10/18/24 22:30*	*1*
2-Fluorobiphenyl (Surr)	*73*		*48 - 126*	*10/18/24 11:39*	*10/18/24 22:30*	*1*
p-Terphenyl-d14 (Surr)	*81*		*48 - 130*	*10/18/24 11:39*	*10/18/24 22:30*	*1*

Method: SW846 8081B - Organochlorine Pesticides (GC) - TCLP

Analyte	Result	Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
Chlordane (technical)	ND		0.00050		mg/L		10/23/24 10:27	10/23/24 18:02	1
Endrin	ND		0.00010		mg/L		10/23/24 10:27	10/23/24 18:02	1
gamma-BHC (Lindane)	ND		0.000050		mg/L		10/23/24 10:27	10/23/24 18:02	1
Heptachlor	ND		0.000050		mg/L		10/23/24 10:27	10/23/24 18:02	1
Heptachlor epoxide	ND		0.000050		mg/L		10/23/24 10:27	10/23/24 18:02	1
Methoxychlor	ND		0.00050		mg/L		10/23/24 10:27	10/23/24 18:02	1
Toxaphene	ND		0.0050		mg/L		10/23/24 10:27	10/23/24 18:02	1

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
DCB Decachlorobiphenyl (Surr)	*108*		*50 - 130*	*10/23/24 10:27*	*10/23/24 18:02*	*1*

Client Sample ID: B-3 0-5' — **Lab Sample ID: 705-9904-3**
Date Collected: 10/10/24 13:29 — **Matrix: Solid**
Date Received: 10/14/24 13:05

Method: SW846 8081B - Organochlorine Pesticides (GC) - TCLP (Continued)

Surrogate	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
Tetrachloro-m-xylene (Surr)	*110*		*46 - 120*	*10/23/24 10:27*	*10/23/24 18:02*	*1*

Method: SW846 6010D - Metals (ICP) - TCLP

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	ND		0.25	mg/L		10/18/24 14:32	10/18/24 17:07	1
Barium	ND		0.50	mg/L		10/18/24 14:32	10/18/24 17:07	1
Cadmium	**0.073**		0.025	mg/L		10/18/24 14:32	10/18/24 17:07	1
Chromium	ND		0.050	mg/L		10/18/24 14:32	10/18/24 17:07	1
Lead	**0.23**		0.050	mg/L		10/18/24 14:32	10/18/24 17:07	1
Selenium	ND		0.10	mg/L		10/18/24 14:32	10/18/24 17:07	1
Silver	ND		0.025	mg/L		10/18/24 14:32	10/18/24 17:07	1

Method: SW846 7470A - Mercury (CVAA) - TCLP

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	ND	^+	0.0050	mg/L		10/18/24 14:11	10/18/24 18:39	1

General Chemistry

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Ignitability (SW846 1030)	**N**			NONE			10/18/24 10:35	1
corrosivity by pH (SW846 9045D)	**7.6**	**HF**	0.01	SU			10/17/24 10:50	1
Temperature (SW846 9045D)	**21.8**	**HF**	0.01	Degrees C			10/17/24 10:50	1
Free Liquid (SW846 9095B)	**NEGATIVE**			NONE			10/16/24 13:02	1

Client Sample ID: B-3 0-5' — **Lab Sample ID: 705-9904-3**
Date Collected: 10/10/24 13:29 — **Matrix: Solid**
Date Received: 10/14/24 13:05 — **Percent Solids: 88.8**

Method: SW846 8270E SIM - Semivolatile Organic Compounds (GC/MS SIM)

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
1-Methylnaphthalene	ND		0.019	mg/Kg	☼	10/22/24 14:26	10/22/24 20:21	1
2-Methylnaphthalene	ND		0.019	mg/Kg	☼	10/22/24 14:26	10/22/24 20:21	1
Acenaphthene	ND		0.019	mg/Kg	☼	10/22/24 14:26	10/22/24 20:21	1
Acenaphthylene	ND		0.037	mg/Kg	☼	10/22/24 14:26	10/22/24 20:21	1
Anthracene	**0.029**		0.0019	mg/Kg	☼	10/22/24 14:26	10/22/24 20:21	1
Benzo[a]anthracene	**0.15**		0.0019	mg/Kg	☼	10/22/24 14:26	10/22/24 20:21	1
Benzo[a]pyrene	**0.15**		0.0019	mg/Kg	☼	10/22/24 14:26	10/22/24 20:21	1
Benzo[b]fluoranthene	**0.25**		0.0037	mg/Kg	☼	10/22/24 14:26	10/22/24 20:21	1
Benzo[g,h,i]perylene	**0.20**		0.0037	mg/Kg	☼	10/22/24 14:26	10/22/24 20:21	1
Benzo[k]fluoranthene	**0.078**		0.0019	mg/Kg	☼	10/22/24 14:26	10/22/24 20:21	1
Chrysene	**0.14**		0.0019	mg/Kg	☼	10/22/24 14:26	10/22/24 20:21	1
Dibenz(a,h)anthracene	**0.042**		0.0037	mg/Kg	☼	10/22/24 14:26	10/22/24 20:21	1
Fluoranthene	**0.23**		0.0037	mg/Kg	☼	10/22/24 14:26	10/22/24 20:21	1
Fluorene	**0.0074**		0.0037	mg/Kg	☼	10/22/24 14:26	10/22/24 20:21	1
Indeno[1,2,3-cd]pyrene	**0.16**		0.0019	mg/Kg	☼	10/22/24 14:26	10/22/24 20:21	1
Naphthalene	ND		0.019	mg/Kg	☼	10/22/24 14:26	10/22/24 20:21	1
Phenanthrene	**0.11**		0.0019	mg/Kg	☼	10/22/24 14:26	10/22/24 20:21	1
Pyrene	**0.25**		0.0019	mg/Kg	☼	10/22/24 14:26	10/22/24 20:21	1

Surrogate	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
p-Terphenyl-d14 (Surr)	*96*		*59 - 129*	*10/22/24 14:26*	*10/22/24 20:21*	*1*

Client: Terracon Consultants Inc
Project/Site: RAFB B110

Job ID: 705-9904-1

Client Sample ID: B-4 0-5'
Date Collected: 10/10/24 10:45
Date Received: 10/14/24 13:05

Lab Sample ID: 705-9904-4
Matrix: Solid

Method: SW846 8260D - Volatile Organic Compounds by GC/MS - TCLP

Analyte	Result	Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
Benzene	ND		100		ug/L			10/17/24 15:20	20
Carbon tetrachloride	ND		100		ug/L			10/17/24 15:20	20
Chlorobenzene	ND		100		ug/L			10/17/24 15:20	20
Chloroform	ND		100		ug/L			10/17/24 15:20	20
1,2-Dichloroethane	ND		100		ug/L			10/17/24 15:20	20
1,1-Dichloroethene	ND		100		ug/L			10/17/24 15:20	20
2-Butanone	ND		1000		ug/L			10/17/24 15:20	20
Tetrachloroethene	ND		100		ug/L			10/17/24 15:20	20
Vinyl chloride	ND		100		ug/L			10/17/24 15:20	20
Trichloroethene	ND		100		ug/L			10/17/24 15:20	20

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
4-Bromofluorobenzene	*95*		*70 - 126*		*10/17/24 15:20*	*20*
Dibromofluoromethane (Surr)	*106*		*77 - 121*		*10/17/24 15:20*	*20*
Toluene-d8 (Surr)	*97*		*79 - 119*		*10/17/24 15:20*	*20*

Method: SW846 8270E - Semivolatile Organic Compounds (GC/MS) - TCLP

Analyte	Result	Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
2-Methylphenol	ND		0.10		mg/L		10/18/24 11:39	10/18/24 23:25	1
3 & 4 Methylphenol	ND		0.10		mg/L		10/18/24 11:39	10/18/24 23:25	1
2,4-Dinitrotoluene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 23:25	1
Hexachlorobenzene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 23:25	1
Hexachlorobutadiene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 23:25	1
Hexachloroethane	ND		0.10		mg/L		10/18/24 11:39	10/18/24 23:25	1
Nitrobenzene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 23:25	1
Pentachlorophenol	ND		0.25		mg/L		10/18/24 11:39	10/18/24 23:25	1
Pyridine	ND		0.10		mg/L		10/18/24 11:39	10/18/24 23:25	1
2,4,5-Trichlorophenol	ND		0.25		mg/L		10/18/24 11:39	10/18/24 23:25	1
2,4,6-Trichlorophenol	ND		0.10		mg/L		10/18/24 11:39	10/18/24 23:25	1
1,4-Dichlorobenzene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 23:25	1

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
2,4,6-Tribromophenol (Surr)	*60*		*53 - 132*	*10/18/24 11:39*	*10/18/24 23:25*	*1*
2-Fluorophenol (Surr)	*69*		*29 - 120*	*10/18/24 11:39*	*10/18/24 23:25*	*1*
Nitrobenzene-d5 (Surr)	*75*		*41 - 129*	*10/18/24 11:39*	*10/18/24 23:25*	*1*
Phenol-d5 (Surr)				*10/18/24 11:39*	*10/18/24 23:25*	*1*
2-Fluorobiphenyl (Surr)	*71*		*48 - 126*	*10/18/24 11:39*	*10/18/24 23:25*	*1*
p-Terphenyl-d14 (Surr)	*79*		*48 - 130*	*10/18/24 11:39*	*10/18/24 23:25*	*1*

Method: SW846 8081B - Organochlorine Pesticides (GC) - TCLP

Analyte	Result	Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
Chlordane (technical)	ND		0.00050		mg/L		10/23/24 10:32	10/23/24 18:14	1
Endrin	ND		0.00010		mg/L		10/23/24 10:32	10/23/24 18:14	1
gamma-BHC (Lindane)	ND		0.000050		mg/L		10/23/24 10:32	10/23/24 18:14	1
Heptachlor	ND		0.000050		mg/L		10/23/24 10:32	10/23/24 18:14	1
Heptachlor epoxide	ND		0.000050		mg/L		10/23/24 10:32	10/23/24 18:14	1
Methoxychlor	ND		0.00050		mg/L		10/23/24 10:32	10/23/24 18:14	1
Toxaphene	ND		0.0050		mg/L		10/23/24 10:32	10/23/24 18:14	1

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
DCB Decachlorobiphenyl (Surr)	*140*	*S1+*	*50 - 130*	*10/23/24 10:32*	*10/23/24 18:14*	*1*

Client Sample ID: B-4 0-5' — **Lab Sample ID: 705-9904-4**
Date Collected: 10/10/24 10:45 — **Matrix: Solid**
Date Received: 10/14/24 13:05

Method: SW846 8081B - Organochlorine Pesticides (GC) - TCLP (Continued)

Surrogate	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
Tetrachloro-m-xylene (Surr)	*113*		*46 - 120*	*10/23/24 10:32*	*10/23/24 18:14*	*1*

Method: SW846 6010D - Metals (ICP) - TCLP

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	ND		0.25	mg/L		10/18/24 14:32	10/18/24 17:10	1
Barium	ND		0.50	mg/L		10/18/24 14:32	10/18/24 17:10	1
Cadmium	ND		0.025	mg/L		10/18/24 14:32	10/18/24 17:10	1
Chromium	ND		0.050	mg/L		10/18/24 14:32	10/18/24 17:10	1
Lead	ND		0.050	mg/L		10/18/24 14:32	10/18/24 17:10	1
Selenium	ND		0.10	mg/L		10/18/24 14:32	10/18/24 17:10	1
Silver	ND		0.025	mg/L		10/18/24 14:32	10/18/24 17:10	1

Method: SW846 7470A - Mercury (CVAA) - TCLP

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	ND	^+	0.0050	mg/L		10/18/24 14:11	10/18/24 18:43	1

General Chemistry

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Ignitability (SW846 1030)	N			NONE			10/18/24 10:35	1
corrosivity by pH (SW846 9045D)	5.6	HF	0.01	SU			10/17/24 10:50	1
Temperature (SW846 9045D)	21.8	HF	0.01	Degrees C			10/17/24 10:50	1
Free Liquid (SW846 9095B)	NEGATIVE			NONE			10/16/24 13:02	1

Client Sample ID: B-4 0-5' — **Lab Sample ID: 705-9904-4**
Date Collected: 10/10/24 10:45 — **Matrix: Solid**
Date Received: 10/14/24 13:05 — **Percent Solids: 92.5**

Method: SW846 8270E SIM - Semivolatile Organic Compounds (GC/MS SIM)

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
1-Methylnaphthalene	ND		0.018	mg/Kg	☼	10/22/24 14:26	10/22/24 20:46	1
2-Methylnaphthalene	ND		0.018	mg/Kg	☼	10/22/24 14:26	10/22/24 20:46	1
Acenaphthene	ND		0.018	mg/Kg	☼	10/22/24 14:26	10/22/24 20:46	1
Acenaphthylene	ND		0.036	mg/Kg	☼	10/22/24 14:26	10/22/24 20:46	1
Anthracene	ND		0.0018	mg/Kg	☼	10/22/24 14:26	10/22/24 20:46	1
Benzo[a]anthracene	ND		0.0018	mg/Kg	☼	10/22/24 14:26	10/22/24 20:46	1
Benzo[a]pyrene	ND		0.0018	mg/Kg	☼	10/22/24 14:26	10/22/24 20:46	1
Benzo[b]fluoranthene	ND		0.0036	mg/Kg	☼	10/22/24 14:26	10/22/24 20:46	1
Benzo[g,h,i]perylene	ND		0.0036	mg/Kg	☼	10/22/24 14:26	10/22/24 20:46	1
Benzo[k]fluoranthene	ND		0.0018	mg/Kg	☼	10/22/24 14:26	10/22/24 20:46	1
Chrysene	ND		0.0018	mg/Kg	☼	10/22/24 14:26	10/22/24 20:46	1
Dibenz(a,h)anthracene	ND		0.0036	mg/Kg	☼	10/22/24 14:26	10/22/24 20:46	1
Fluoranthene	ND		0.0036	mg/Kg	☼	10/22/24 14:26	10/22/24 20:46	1
Fluorene	ND		0.0036	mg/Kg	☼	10/22/24 14:26	10/22/24 20:46	1
Indeno[1,2,3-cd]pyrene	ND		0.0018	mg/Kg	☼	10/22/24 14:26	10/22/24 20:46	1
Naphthalene	ND		0.018	mg/Kg	☼	10/22/24 14:26	10/22/24 20:46	1
Phenanthrene	ND		0.0018	mg/Kg	☼	10/22/24 14:26	10/22/24 20:46	1
Pyrene	ND		0.0018	mg/Kg	☼	10/22/24 14:26	10/22/24 20:46	1

Surrogate	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
p-Terphenyl-d14 (Surr)	*106*		*59 - 129*	*10/22/24 14:26*	*10/22/24 20:46*	*1*

Login Sample Receipt Checklist

Client: Terracon Consultants Inc

Job Number: 705-9904-1
SDG Number:

Login Number: 9904
List Number: 1
Creator: Pomuti, Carmen

List Source: Eurofins Atlanta

Question	Answer	Comment
Radioactivity wasn't checked or is </= background as measured by a survey meter.	True	
The cooler's custody seal, if present, is intact.	True	Not present
Sample custody seals, if present, are intact.	True	
The cooler or samples do not appear to have been compromised or tampered with.	True	
Samples were received on ice.	True	
Cooler Temperature is acceptable.	True	
Cooler Temperature is recorded.	True	
COC is present.	True	
COC is filled out in ink and legible.	True	
COC is filled out with all pertinent information.	True	
Is the Field Sampler's name present on COC?	True	
There are no discrepancies between the containers received and the COC.	True	
Samples are received within Holding Time (excluding tests with immediate HTs)	True	
Sample containers have legible labels.	True	
Containers are not broken or leaking.	True	
Sample collection date/times are provided.	True	
Appropriate sample containers are used.	True	
Sample bottles are completely filled.	True	
Sample Preservation Verified.	True	
There is sufficient vol. for all requested analyses, incl. any requested MS/MSDs	True	
Containers requiring zero headspace have no headspace or bubble is <6mm (1/4").	N/A	
Multiphasic samples are not present.	True	
Samples do not require splitting or compositing.	True	
Residual Chlorine Checked.	N/A	

Lab Chronicle

Client: Terracon Consultants Inc
Project/Site: RAFB B110

Job ID: 705-9904-1

Client Sample ID: B-1 0-5'

Lab Sample ID: 705-9904-1

Date Collected: 10/10/24 16:00

Matrix: Solid

Date Received: 10/14/24 13:05

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
TCLP	Leach	1311			16938	GB	EET ATL	10/15/24 18:32 - 10/16/24 10:35 [1]
TCLP	Analysis	8260D		20	17392	AG	EET ATL	10/17/24 14:35
TCLP	Leach	1311			17234	GB	EET ATL	10/17/24 19:15 - 10/18/24 11:15 [1]
TCLP	Prep	3510C			17160	TT	EET ATL	10/18/24 11:39
TCLP	Analysis	8270E		1	17832	YH	EET ATL	10/18/24 21:35
TCLP	Leach	1311			17234	GB	EET ATL	10/17/24 19:15 - 10/18/24 11:15 [1]
TCLP	Prep	3510C			18161	ZS	EET ATL	10/23/24 10:27
TCLP	Analysis	8081B		1	18464	NT	EET ATL	10/23/24 17:38
TCLP	Leach	1311			17234	GB	EET ATL	10/17/24 19:15 - 10/18/24 11:15 [1]
TCLP	Prep	3010A			17537	EF	EET ATL	10/18/24 14:32
TCLP	Analysis	6010D		1	17673	DS	EET ATL	10/18/24 16:55
TCLP	Leach	1311			17234	GB	EET ATL	10/17/24 19:15 - 10/18/24 11:15 [1]
TCLP	Prep	7470A			17544	GR	EET ATL	10/18/24 14:11
TCLP	Analysis	7470A		1	17622	GR	EET ATL	10/18/24 18:32
Total/NA	Analysis	1030		1	17489	IG	EET ATL	10/18/24 10:35
Total/NA	Analysis	9045D		1	17227	AH	EET ATL	10/17/24 10:50
Total/NA	Analysis	9095B		1	17078	IG	EET ATL	10/16/24 13:02
Total/NA	Analysis	D 2216		1	17111	ASA	EET ATL	10/16/24 11:44

Client Sample ID: B-1 0-5'

Lab Sample ID: 705-9904-1

Date Collected: 10/10/24 16:00

Matrix: Solid

Date Received: 10/14/24 13:05

Percent Solids: 94.0

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	3550C			17473	KE	EET ATL 2	10/18/24 11:24
Total/NA	Analysis	8270E SIM		1	17742	NHN	EET ATL	10/18/24 18:04

Client Sample ID: B-2 0-5'

Lab Sample ID: 705-9904-2

Date Collected: 10/10/24 14:54

Matrix: Solid

Date Received: 10/14/24 13:05

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
TCLP	Leach	1311			16938	GB	EET ATL	10/15/24 18:32 - 10/16/24 10:35 [1]
TCLP	Analysis	8260D		20	17392	AG	EET ATL	10/17/24 13:24
TCLP	Leach	1311			17234	GB	EET ATL	10/17/24 19:15 - 10/18/24 11:15 [1]
TCLP	Prep	3510C			17160	TT	EET ATL	10/18/24 11:39
TCLP	Analysis	8270E		1	17832	YH	EET ATL	10/18/24 22:02
TCLP	Leach	1311			17234	GB	EET ATL	10/17/24 19:15 - 10/18/24 11:15 [1]
TCLP	Prep	3510C			18161	ZS	EET ATL	10/23/24 10:27
TCLP	Analysis	8081B		1	18464	NT	EET ATL	10/23/24 17:50
TCLP	Leach	1311			17234	GB	EET ATL	10/17/24 19:15 - 10/18/24 11:15 [1]
TCLP	Prep	3010A			17537	EF	EET ATL	10/18/24 14:32
TCLP	Analysis	6010D		1	17673	DS	EET ATL	10/18/24 16:58

Lab Chronicle

Client: Terracon Consultants Inc
Project/Site: RAFB B110

Job ID: 705-9904-1

Client Sample ID: B-2 0-5'

Date Collected: 10/10/24 14:54
Date Received: 10/14/24 13:05

Lab Sample ID: 705-9904-2
Matrix: Solid

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
TCLP	Leach	1311			17234	GB	EET ATL	10/17/24 19:15 - 10/18/24 11:15 [1]
TCLP	Prep	7470A			17544	GR	EET ATL	10/18/24 14:11
TCLP	Analysis	7470A		1	17622	GR	EET ATL	10/18/24 18:36
Total/NA	Analysis	1030		1	17489	IG	EET ATL	10/18/24 10:35
Total/NA	Analysis	9045D		1	17227	AH	EET ATL	10/17/24 10:50
Total/NA	Analysis	9095B		1	17078	IG	EET ATL	10/16/24 13:02
Total/NA	Analysis	D 2216		1	17111	ASA	EET ATL	10/16/24 11:44

Client Sample ID: B-2 0-5'

Date Collected: 10/10/24 14:54
Date Received: 10/14/24 13:05

Lab Sample ID: 705-9904-2
Matrix: Solid
Percent Solids: 94.4

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	3550C			17473	KE	EET ATL 2	10/22/24 14:26
Total/NA	Analysis	8270E SIM		1	18181	NHN	EET ATL	10/22/24 19:57

Client Sample ID: B-3 0-5'

Date Collected: 10/10/24 13:29
Date Received: 10/14/24 13:05

Lab Sample ID: 705-9904-3
Matrix: Solid

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
TCLP	Leach	1311			16938	GB	EET ATL	10/15/24 18:32 - 10/16/24 10:35 [1]
TCLP	Analysis	8260D		20	17392	AG	EET ATL	10/17/24 14:57
TCLP	Leach	1311			17234	GB	EET ATL	10/17/24 19:15 - 10/18/24 11:15 [1]
TCLP	Prep	3510C			17160	TT	EET ATL	10/18/24 11:39
TCLP	Analysis	8270E		1	17832	YH	EET ATL	10/18/24 22:30
TCLP	Leach	1311			17234	GB	EET ATL	10/17/24 19:15 - 10/18/24 11:15 [1]
TCLP	Prep	3510C			18161	ZS	EET ATL	10/23/24 10:27
TCLP	Analysis	8081B		1	18464	NT	EET ATL	10/23/24 18:02
TCLP	Leach	1311			17234	GB	EET ATL	10/17/24 19:15 - 10/18/24 11:15 [1]
TCLP	Prep	3010A			17537	EF	EET ATL	10/18/24 14:32
TCLP	Analysis	6010D		1	17673	DS	EET ATL	10/18/24 17:07
TCLP	Leach	1311			17234	GB	EET ATL	10/17/24 19:15 - 10/18/24 11:15 [1]
TCLP	Prep	7470A			17544	GR	EET ATL	10/18/24 14:11
TCLP	Analysis	7470A		1	17622	GR	EET ATL	10/18/24 18:39
Total/NA	Analysis	1030		1	17489	IG	EET ATL	10/18/24 10:35
Total/NA	Analysis	9045D		1	17227	AH	EET ATL	10/17/24 10:50
Total/NA	Analysis	9095B		1	17078	IG	EET ATL	10/16/24 13:02
Total/NA	Analysis	D 2216		1	17111	ASA	EET ATL	10/16/24 11:44

Lab Chronicle

Client: Terracon Consultants Inc
Project/Site: RAFB B110

Job ID: 705-9904-1

Client Sample ID: B-3 0-5'

Lab Sample ID: 705-9904-3

Date Collected: 10/10/24 13:29

Matrix: Solid

Date Received: 10/14/24 13:05

Percent Solids: 88.8

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	3550C			17473	KE	EET ATL 2	10/22/24 14:26
Total/NA	Analysis	8270E SIM		1	18181	NHN	EET ATL	10/22/24 20:21

Client Sample ID: B-4 0-5'

Lab Sample ID: 705-9904-4

Date Collected: 10/10/24 10:45

Matrix: Solid

Date Received: 10/14/24 13:05

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
TCLP	Leach	1311			16938	GB	EET ATL	10/15/24 18:32 - 10/16/24 10:35 [1]
TCLP	Analysis	8260D		20	17392	AG	EET ATL	10/17/24 15:20
TCLP	Leach	1311			17234	GB	EET ATL	10/17/24 19:15 - 10/18/24 11:15 [1]
TCLP	Prep	3510C			17160	TT	EET ATL	10/18/24 11:39
TCLP	Analysis	8270E		1	17832	YH	EET ATL	10/18/24 23:25
TCLP	Leach	1311			17234	GB	EET ATL	10/17/24 19:15 - 10/18/24 11:15 [1]
TCLP	Prep	3510C			18161	ZS	EET ATL	10/23/24 10:32
TCLP	Analysis	8081B		1	18464	NT	EET ATL	10/23/24 18:14
TCLP	Leach	1311			17234	GB	EET ATL	10/17/24 19:15 - 10/18/24 11:15 [1]
TCLP	Prep	3010A			17537	EF	EET ATL	10/18/24 14:32
TCLP	Analysis	6010D		1	17673	DS	EET ATL	10/18/24 17:10
TCLP	Leach	1311			17234	GB	EET ATL	10/17/24 19:15 - 10/18/24 11:15 [1]
TCLP	Prep	7470A			17544	GR	EET ATL	10/18/24 14:11
TCLP	Analysis	7470A		1	17622	GR	EET ATL	10/18/24 18:43
Total/NA	Analysis	1030		1	17489	IG	EET ATL	10/18/24 10:35
Total/NA	Analysis	9045D		1	17227	AH	EET ATL	10/17/24 10:50
Total/NA	Analysis	9095B		1	17078	IG	EET ATL	10/16/24 13:02
Total/NA	Analysis	D 2216		1	17111	ASA	EET ATL	10/16/24 11:44

Client Sample ID: B-4 0-5'

Lab Sample ID: 705-9904-4

Date Collected: 10/10/24 10:45

Matrix: Solid

Date Received: 10/14/24 13:05

Percent Solids: 92.5

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	3550C			17473	KE	EET ATL 2	10/22/24 14:26
Total/NA	Analysis	8270E SIM		1	18181	NHN	EET ATL	10/22/24 20:46

[1] This procedure uses a method stipulated length of time for the process. Both start and end times are displayed.

Laboratory References:

EET ATL = Eurofins Atlanta, 3080 Presidential Dr, Atlanta, GA 30340, TEL (770)457-8177

EET ATL 2 = Eurofins Atlanta Building A, 3080 Presidential Pkwy, Atlanta, GA 30340, TEL (770)457-8177

Method: 8260D - Volatile Organic Compounds by GC/MS

Lab Sample ID: LCS 705-17392/2 ^20
Matrix: Solid
Analysis Batch: 17392

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits		
Benzene			400	363		ug/L		91	76 - 122		
Carbon tetrachloride			400	429		ug/L		107	72 - 133		
Chlorobenzene			400	360		ug/L		90	75 - 121		
Chloroform			400	386		ug/L		96	72 - 121		
1,2-Dichloroethane			400	377		ug/L		94	72 - 127		
1,1-Dichloroethene			400	378		ug/L		95	69 - 130		
2-Butanone			800	718		ug/L		90	74 - 131		
Tetrachloroethene			400	354		ug/L		89	74 - 129		
Vinyl chloride			400	435		ug/L		109	65 - 132		
Trichloroethene			400	360		ug/L		90	72 - 129		

Surrogate	*LCS %Recovery*	*LCS Qualifier*	*Limits*
4-Bromofluorobenzene	*100*		*70 - 126*
Dibromofluoromethane (Surr)	*107*		*77 - 121*
Toluene-d8 (Surr)	*105*		*79 - 119*

Lab Sample ID: MRL 705-17392/10
Matrix: Solid
Analysis Batch: 17392

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte			Spike Added	MRL Result	MRL Qualifier	Unit	D	%Rec	%Rec Limits		
2-Butanone			10.0	6.90	J	ug/L		69	50 - 150		

Surrogate	*MRL %Recovery*	*MRL Qualifier*	*Limits*
4-Bromofluorobenzene	*102*		*70 - 126*
Dibromofluoromethane (Surr)	*111*		*77 - 121*
Toluene-d8 (Surr)	*103*		*79 - 119*

Lab Sample ID: LB 705-16938/1-A ^20
Matrix: Solid
Analysis Batch: 17392

Client Sample ID: Method Blank
Prep Type: TCLP

Analyte	LB Result	LB Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
Benzene	ND		100		ug/L			10/17/24 11:54	20
Carbon tetrachloride	ND		100		ug/L			10/17/24 11:54	20
Chlorobenzene	ND		100		ug/L			10/17/24 11:54	20
Chloroform	ND		100		ug/L			10/17/24 11:54	20
1,2-Dichloroethane	ND		100		ug/L			10/17/24 11:54	20
1,1-Dichloroethene	ND		100		ug/L			10/17/24 11:54	20
2-Butanone	ND		1000		ug/L			10/17/24 11:54	20
Tetrachloroethene	ND		100		ug/L			10/17/24 11:54	20
Vinyl chloride	ND		100		ug/L			10/17/24 11:54	20
Trichloroethene	ND		100		ug/L			10/17/24 11:54	20

Surrogate	*LB %Recovery*	*LB Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
4-Bromofluorobenzene	*99*		*70 - 126*		*10/17/24 11:54*	*20*
Dibromofluoromethane (Surr)	*114*		*77 - 121*		*10/17/24 11:54*	*20*

Method: 8260D - Volatile Organic Compounds by GC/MS (Continued)

Lab Sample ID: LB 705-16938/1-A ^20
Matrix: Solid
Analysis Batch: 17392

Client Sample ID: Method Blank
Prep Type: TCLP

Surrogate	LB %Recovery	LB Qualifier	Limits	Prepared	Analyzed	Dil Fac
Toluene-d8 (Surr)	99		79 - 119		10/17/24 11:54	20

Lab Sample ID: 705-9904-4 MS
Matrix: Solid
Analysis Batch: 17392

Client Sample ID: B-4 0-5'
Prep Type: TCLP

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits
Benzene	ND		400	411		ug/L		102	71 - 133
Carbon tetrachloride	ND		400	475		ug/L		119	70 - 139
Chlorobenzene	ND		400	400		ug/L		99	78 - 128
Chloroform	ND		400	442		ug/L		109	68 - 132
1,2-Dichloroethane	ND		400	449		ug/L		112	70 - 133
1,1-Dichloroethene	ND		400	451		ug/L		113	69 - 139
2-Butanone	ND		800	732		ug/L		92	50 - 150
Tetrachloroethene	ND		400	401		ug/L		99	74 - 135
Vinyl chloride	ND		400	421		ug/L		105	66 - 138
Trichloroethene	ND		400	406		ug/L		102	77 - 136

Surrogate	MS %Recovery	MS Qualifier	Limits
4-Bromofluorobenzene	97		70 - 126
Dibromofluoromethane (Surr)	108		77 - 121
Toluene-d8 (Surr)	103		79 - 119

Lab Sample ID: 705-9904-4 MSD
Matrix: Solid
Analysis Batch: 17392

Client Sample ID: B-4 0-5'
Prep Type: TCLP

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Benzene	ND		420	401		ug/L		94	71 - 133	2	42
Carbon tetrachloride	ND		420	457		ug/L		109	70 - 139	4	22
Chlorobenzene	ND		420	404		ug/L		95	78 - 128	1	50
Chloroform	ND		420	433		ug/L		102	68 - 132	2	20
1,2-Dichloroethane	ND		420	448		ug/L		107	70 - 133	0	41
1,1-Dichloroethene	ND		420	475		ug/L		113	69 - 139	5	56
2-Butanone	ND		840	773		ug/L		92	50 - 150	5	20
Tetrachloroethene	ND		420	396		ug/L		93	74 - 135	1	20
Vinyl chloride	ND		420	418		ug/L		100	66 - 138	1	23
Trichloroethene	ND		420	402		ug/L		96	77 - 136	1	51

Surrogate	MSD %Recovery	MSD Qualifier	Limits
4-Bromofluorobenzene	99		70 - 126
Dibromofluoromethane (Surr)	105		77 - 121
Toluene-d8 (Surr)	103		79 - 119

Method: 8270E - Semivolatile Organic Compounds (GC/MS)

Lab Sample ID: LCS 705-17160/2-A
Matrix: Solid
Analysis Batch: 17566

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 17160

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits		
2-Methylphenol			1.00	0.899		mg/L		90	66 - 130		
3 & 4 Methylphenol			2.00	1.75		mg/L		88	50 - 150		
2,4-Dinitrotoluene			1.00	0.841		mg/L		84	62 - 130		
Hexachlorobenzene			1.00	0.799		mg/L		80	70 - 130		
Hexachlorobutadiene			1.00	0.849		mg/L		85	51 - 125		
Hexachloroethane			1.00	0.898		mg/L		90	55 - 120		
Nitrobenzene			1.00	0.829		mg/L		83	68 - 130		
Pentachlorophenol			1.00	0.622		mg/L		62	51 - 130		
Pyridine			1.00	0.227		mg/L		23	10 - 120		
2,4,5-Trichlorophenol			1.00	0.783		mg/L		78	60 - 124		
2,4,6-Trichlorophenol			1.00	0.747		mg/L		75	69 - 129		
1,4-Dichlorobenzene			1.00	0.801		mg/L		80	56 - 128		

Surrogate	*LCS %Recovery*	*LCS Qualifier*	*Limits*
2,4,6-Tribromophenol (Surr)	*78*		*53 - 132*
2-Fluorophenol (Surr)	*80*		*29 - 120*
Nitrobenzene-d5 (Surr)	*74*		*41 - 129*
2-Fluorobiphenyl (Surr)	*72*		*48 - 126*
p-Terphenyl-d14 (Surr)	*77*		*48 - 130*

Lab Sample ID: LB 705-17071/1-E
Matrix: Solid
Analysis Batch: 17566

Client Sample ID: Method Blank
Prep Type: TCLP
Prep Batch: 17160

Analyte	LB Result	LB Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
2-Methylphenol	ND		0.10		mg/L		10/17/24 11:39	10/18/24 02:44	1
3 & 4 Methylphenol	ND		0.10		mg/L		10/17/24 11:39	10/18/24 02:44	1
2,4-Dinitrotoluene	ND		0.10		mg/L		10/17/24 11:39	10/18/24 02:44	1
Hexachlorobenzene	ND		0.10		mg/L		10/17/24 11:39	10/18/24 02:44	1
Hexachlorobutadiene	ND		0.10		mg/L		10/17/24 11:39	10/18/24 02:44	1
Hexachloroethane	ND		0.10		mg/L		10/17/24 11:39	10/18/24 02:44	1
Nitrobenzene	ND		0.10		mg/L		10/17/24 11:39	10/18/24 02:44	1
Pentachlorophenol	ND		0.25		mg/L		10/17/24 11:39	10/18/24 02:44	1
Pyridine	ND		0.10		mg/L		10/17/24 11:39	10/18/24 02:44	1
2,4,5-Trichlorophenol	ND		0.25		mg/L		10/17/24 11:39	10/18/24 02:44	1
2,4,6-Trichlorophenol	ND		0.10		mg/L		10/17/24 11:39	10/18/24 02:44	1
1,4-Dichlorobenzene	ND		0.10		mg/L		10/17/24 11:39	10/18/24 02:44	1

Surrogate	*LB %Recovery*	*LB Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
2,4,6-Tribromophenol (Surr)	*67*		*53 - 132*	*10/17/24 11:39*	*10/18/24 02:44*	*1*
2-Fluorophenol (Surr)	*82*		*29 - 120*	*10/17/24 11:39*	*10/18/24 02:44*	*1*
Nitrobenzene-d5 (Surr)	*64*		*41 - 129*	*10/17/24 11:39*	*10/18/24 02:44*	*1*
Phenol-d5 (Surr)				*10/17/24 11:39*	*10/18/24 02:44*	*1*
2-Fluorobiphenyl (Surr)	*71*		*48 - 126*	*10/17/24 11:39*	*10/18/24 02:44*	*1*
p-Terphenyl-d14 (Surr)	*79*		*48 - 130*	*10/17/24 11:39*	*10/18/24 02:44*	*1*

Method: 8270E - Semivolatile Organic Compounds (GC/MS) (Continued)

Lab Sample ID: 705-10016-A-3-G MS
Matrix: Solid
Analysis Batch: 17566

Client Sample ID: Matrix Spike
Prep Type: TCLP
Prep Batch: 17160

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits
2-Methylphenol	ND	F1	1.00	0.170	F1	mg/L		17	50 - 120
3 & 4 Methylphenol	ND	F1	2.00	0.248	F1	mg/L		12	50 - 150
2,4-Dinitrotoluene	ND		1.00	0.830		mg/L		83	50 - 130
Hexachlorobenzene	ND		1.00	0.825		mg/L		82	54 - 130
Hexachlorobutadiene	ND		1.00	0.888		mg/L		89	45 - 130
Hexachloroethane	ND		1.00	0.917		mg/L		92	50 - 150
Nitrobenzene	ND		1.00	0.774		mg/L		77	56 - 135
Pentachlorophenol	ND		1.00	0.595		mg/L		60	45 - 117
Pyridine	ND	F1	1.00	0.144	F1	mg/L		14	50 - 150
2,4,5-Trichlorophenol	ND		1.00	0.720		mg/L		72	53 - 128
2,4,6-Trichlorophenol	ND		1.00	0.764		mg/L		76	54 - 132
1,4-Dichlorobenzene	ND		1.00	0.792		mg/L		79	48 - 130

Surrogate	*MS %Recovery*	*MS Qualifier*	*Limits*
2,4,6-Tribromophenol (Surr)	*76*		*53 - 132*
2-Fluorophenol (Surr)	*56*		*29 - 120*
Nitrobenzene-d5 (Surr)	*76*		*41 - 129*
2-Fluorobiphenyl (Surr)	*77*		*48 - 126*
p-Terphenyl-d14 (Surr)	*80*		*48 - 130*

Lab Sample ID: 705-10016-A-3-H DU
Matrix: Solid
Analysis Batch: 17566

Client Sample ID: Duplicate
Prep Type: TCLP
Prep Batch: 17160

Analyte	Sample Result	Sample Qualifier		DU Result	DU Qualifier	Unit	D			RPD	RPD Limit
2-Methylphenol	ND	F1		ND		mg/L				NC	
3 & 4 Methylphenol	ND	F1		ND		mg/L				NC	
2,4-Dinitrotoluene	ND			ND		mg/L				NC	
Hexachlorobenzene	ND			ND		mg/L				NC	
Hexachlorobutadiene	ND			ND		mg/L				NC	
Hexachloroethane	ND			ND		mg/L				NC	
Nitrobenzene	ND			ND		mg/L				NC	
Pentachlorophenol	ND			ND		mg/L				NC	
Pyridine	ND	F1		ND		mg/L				NC	
2,4,5-Trichlorophenol	ND			ND		mg/L				NC	
2,4,6-Trichlorophenol	ND			ND		mg/L				NC	
1,4-Dichlorobenzene	ND			ND		mg/L				NC	

Surrogate	*DU %Recovery*	*DU Qualifier*	*Limits*
2,4,6-Tribromophenol (Surr)	*67*		*53 - 132*
2-Fluorophenol (Surr)	*52*		*29 - 120*
Nitrobenzene-d5 (Surr)	*72*		*41 - 129*
Phenol-d5 (Surr)			
2-Fluorobiphenyl (Surr)	*71*		*48 - 126*
p-Terphenyl-d14 (Surr)	*81*		*48 - 130*

Method: 8270E SIM - Semivolatile Organic Compounds (GC/MS SIM)

Lab Sample ID: MB 705-17473/1-A
Matrix: Solid
Analysis Batch: 17742

Client Sample ID: Method Blank
Prep Type: Total/NA
Prep Batch: 17473

Analyte	MB Result	MB Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
1-Methylnaphthalene	ND		0.017		mg/Kg		10/18/24 11:24	10/18/24 17:14	1
2-Methylnaphthalene	ND		0.017		mg/Kg		10/18/24 11:24	10/18/24 17:14	1
Acenaphthene	ND		0.017		mg/Kg		10/18/24 11:24	10/18/24 17:14	1
Acenaphthylene	ND		0.033		mg/Kg		10/18/24 11:24	10/18/24 17:14	1
Anthracene	ND		0.0017		mg/Kg		10/18/24 11:24	10/18/24 17:14	1
Benzo[a]anthracene	ND		0.0017		mg/Kg		10/18/24 11:24	10/18/24 17:14	1
Benzo[a]pyrene	ND		0.0017		mg/Kg		10/18/24 11:24	10/18/24 17:14	1
Benzo[b]fluoranthene	ND		0.0033		mg/Kg		10/18/24 11:24	10/18/24 17:14	1
Benzo[g,h,i]perylene	ND		0.0033		mg/Kg		10/18/24 11:24	10/18/24 17:14	1
Benzo[k]fluoranthene	ND		0.0017		mg/Kg		10/18/24 11:24	10/18/24 17:14	1
Chrysene	ND		0.0017		mg/Kg		10/18/24 11:24	10/18/24 17:14	1
Dibenz(a,h)anthracene	ND		0.0033		mg/Kg		10/18/24 11:24	10/18/24 17:14	1
Fluoranthene	ND		0.0033		mg/Kg		10/18/24 11:24	10/18/24 17:14	1
Fluorene	ND		0.0033		mg/Kg		10/18/24 11:24	10/18/24 17:14	1
Indeno[1,2,3-cd]pyrene	ND		0.0017		mg/Kg		10/18/24 11:24	10/18/24 17:14	1
Naphthalene	ND		0.017		mg/Kg		10/18/24 11:24	10/18/24 17:14	1
Phenanthrene	ND		0.0017		mg/Kg		10/18/24 11:24	10/18/24 17:14	1
Pyrene	ND		0.0017		mg/Kg		10/18/24 11:24	10/18/24 17:14	1

Surrogate	*MB %Recovery*	*MB Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
p-Terphenyl-d14 (Surr)	*108*		*59 - 129*	*10/18/24 11:24*	*10/18/24 17:14*	*1*

Lab Sample ID: LCS 705-17473/2-A
Matrix: Solid
Analysis Batch: 17742

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 17473

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits		
1-Methylnaphthalene			0.0667	0.0760		mg/Kg		114	65 - 121		
2-Methylnaphthalene			0.0667	0.0629		mg/Kg		94	64 - 117		
Acenaphthene			0.0667	0.0638		mg/Kg		96	64 - 120		
Acenaphthylene			0.0667	0.0620		mg/Kg		93	66 - 120		
Anthracene			0.0667	0.0666		mg/Kg		100	65 - 120		
Benzo[a]anthracene			0.0667	0.0645		mg/Kg		97	67 - 130		
Benzo[a]pyrene			0.0667	0.0634		mg/Kg		95	68 - 122		
Benzo[b]fluoranthene			0.0667	0.0557		mg/Kg		84	63 - 127		
Benzo[g,h,i]perylene			0.0667	0.0660		mg/Kg		99	65 - 126		
Benzo[k]fluoranthene			0.0667	0.0791		mg/Kg		119	67 - 133		
Chrysene			0.0667	0.0706		mg/Kg		106	71 - 124		
Dibenz(a,h)anthracene			0.0667	0.0659		mg/Kg		99	70 - 130		
Fluoranthene			0.0667	0.0688		mg/Kg		103	68 - 128		
Fluorene			0.0667	0.0646		mg/Kg		97	68 - 120		
Indeno[1,2,3-cd]pyrene			0.0667	0.0653		mg/Kg		98	68 - 121		
Naphthalene			0.0667	0.0637		mg/Kg		95	63 - 120		
Phenanthrene			0.0667	0.0616		mg/Kg		92	66 - 122		
Pyrene			0.0667	0.0717		mg/Kg		108	66 - 128		

Surrogate	*LCS %Recovery*	*LCS Qualifier*	*Limits*
p-Terphenyl-d14 (Surr)	*107*		*59 - 129*

Method: 8270E SIM - Semivolatile Organic Compounds (GC/MS SIM)

Lab Sample ID: 705-9904-1 MS
Matrix: Solid
Analysis Batch: 17742

Client Sample ID: B-1 0-5'
Prep Type: Total/NA
Prep Batch: 17473

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits
1-Methylnaphthalene	ND		0.0710	0.0838		mg/Kg	☼	118	50 - 121
2-Methylnaphthalene	ND		0.0710	0.0654		mg/Kg	☼	92	50 - 119
Acenaphthene	ND		0.0710	0.0686		mg/Kg	☼	97	54 - 121
Acenaphthylene	ND		0.0710	0.0650		mg/Kg	☼	92	52 - 131
Anthracene	ND		0.0710	0.0693		mg/Kg	☼	98	58 - 124
Benzo[a]anthracene	ND		0.0710	0.0786		mg/Kg	☼	111	58 - 132
Benzo[a]pyrene	ND		0.0710	0.0698		mg/Kg	☼	98	52 - 129
Benzo[b]fluoranthene	ND		0.0710	0.0677		mg/Kg	☼	95	53 - 130
Benzo[g,h,i]perylene	ND		0.0710	0.0591		mg/Kg	☼	83	51 - 130
Benzo[k]fluoranthene	ND		0.0710	0.0820		mg/Kg	☼	116	53 - 130
Chrysene	ND		0.0710	0.0672		mg/Kg	☼	95	57 - 129
Dibenz(a,h)anthracene	ND		0.0710	0.0704		mg/Kg	☼	99	52 - 130
Fluoranthene	ND		0.0710	0.0741		mg/Kg	☼	104	55 - 129
Fluorene	ND		0.0710	0.0667		mg/Kg	☼	94	50 - 127
Indeno[1,2,3-cd]pyrene	ND		0.0710	0.0628		mg/Kg	☼	88	51 - 129
Naphthalene	ND		0.0710	0.0673		mg/Kg	☼	95	51 - 120
Phenanthrene	ND		0.0710	0.0700		mg/Kg	☼	99	52 - 133
Pyrene	ND		0.0710	0.0793		mg/Kg	☼	112	58 - 129

Surrogate	*MS %Recovery*	*MS Qualifier*	*Limits*
p-Terphenyl-d14 (Surr)	*109*		*59 - 129*

Lab Sample ID: 705-9904-1 MSD
Matrix: Solid
Analysis Batch: 17742

Client Sample ID: B-1 0-5'
Prep Type: Total/NA
Prep Batch: 17473

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
1-Methylnaphthalene	ND		0.0710	0.0701		mg/Kg	☼	99	50 - 121	18	30
2-Methylnaphthalene	ND		0.0710	0.0654		mg/Kg	☼	92	50 - 119	0	33
Acenaphthene	ND		0.0710	0.0691		mg/Kg	☼	97	54 - 121	1	27
Acenaphthylene	ND		0.0710	0.0681		mg/Kg	☼	96	52 - 131	5	37
Anthracene	ND		0.0710	0.0713		mg/Kg	☼	101	58 - 124	3	25
Benzo[a]anthracene	ND		0.0710	0.0767		mg/Kg	☼	108	58 - 132	2	33
Benzo[a]pyrene	ND		0.0710	0.0713		mg/Kg	☼	100	52 - 129	2	38
Benzo[b]fluoranthene	ND		0.0710	0.0699		mg/Kg	☼	98	53 - 130	3	39
Benzo[g,h,i]perylene	ND		0.0710	0.0623		mg/Kg	☼	88	51 - 130	5	33
Benzo[k]fluoranthene	ND		0.0710	0.0839		mg/Kg	☼	118	53 - 130	2	37
Chrysene	ND		0.0710	0.0699		mg/Kg	☼	99	57 - 129	4	27
Dibenz(a,h)anthracene	ND		0.0710	0.0612		mg/Kg	☼	86	52 - 130	14	30
Fluoranthene	ND		0.0710	0.0741		mg/Kg	☼	104	55 - 129	0	45
Fluorene	ND		0.0710	0.0691		mg/Kg	☼	97	50 - 127	4	37
Indeno[1,2,3-cd]pyrene	ND		0.0710	0.0613		mg/Kg	☼	86	51 - 129	2	32
Naphthalene	ND		0.0710	0.0684		mg/Kg	☼	96	51 - 120	2	26
Phenanthrene	ND		0.0710	0.0696		mg/Kg	☼	98	52 - 133	1	54
Pyrene	ND		0.0710	0.0753		mg/Kg	☼	106	58 - 129	5	30

Surrogate	*MSD %Recovery*	*MSD Qualifier*	*Limits*
p-Terphenyl-d14 (Surr)	*109*		*59 - 129*

Method: 8081B - Organochlorine Pesticides (GC)

Lab Sample ID: LCS 705-18161/2-A
Matrix: Solid
Analysis Batch: 18464

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 18161

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits		
Endrin			0.00800	0.00870		mg/L		109	77 - 137		
gamma-BHC (Lindane)			0.00800	0.00867		mg/L		108	69 - 123		
Heptachlor			0.00800	0.00872		mg/L		109	66 - 134		
Heptachlor epoxide			0.00800	0.00739		mg/L		92	75 - 139		
Methoxychlor			0.0280	0.0304		mg/L		108	59 - 135		

Surrogate	*LCS %Recovery*	*LCS Qualifier*	*Limits*
DCB Decachlorobiphenyl (Surr)	*107*		*50 - 130*
Tetrachloro-m-xylene (Surr)	*102*		*46 - 120*

Lab Sample ID: LB 705-17234/1-C
Matrix: Solid
Analysis Batch: 18464

Client Sample ID: Method Blank
Prep Type: TCLP
Prep Batch: 18161

Analyte	LB Result	LB Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
Chlordane (technical)	ND		0.00050		mg/L		10/23/24 10:27	10/23/24 13:44	1
Endrin	ND		0.00010		mg/L		10/23/24 10:27	10/23/24 13:44	1
gamma-BHC (Lindane)	ND		0.000050		mg/L		10/23/24 10:27	10/23/24 13:44	1
Heptachlor	ND		0.000050		mg/L		10/23/24 10:27	10/23/24 13:44	1
Heptachlor epoxide	ND		0.000050		mg/L		10/23/24 10:27	10/23/24 13:44	1
Methoxychlor	ND		0.00050		mg/L		10/23/24 10:27	10/23/24 13:44	1
Toxaphene	ND		0.0050		mg/L		10/23/24 10:27	10/23/24 13:44	1

Surrogate	*LB %Recovery*	*LB Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
DCB Decachlorobiphenyl (Surr)	*103*		*50 - 130*	*10/23/24 10:27*	*10/23/24 13:44*	*1*
Tetrachloro-m-xylene (Surr)	*98*		*46 - 120*	*10/23/24 10:27*	*10/23/24 13:44*	*1*

Lab Sample ID: 705-9901-A-1-G MS
Matrix: Solid
Analysis Batch: 18464

Client Sample ID: Matrix Spike
Prep Type: TCLP
Prep Batch: 18161

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits		
Endrin	ND		0.00800	0.00860		mg/L		107	67 - 136		
gamma-BHC (Lindane)	ND		0.00800	0.00854		mg/L		107	59 - 127		
Heptachlor	ND		0.00800	0.00832		mg/L		104	59 - 132		
Heptachlor epoxide	ND		0.00800	0.00735		mg/L		92	61 - 129		
Methoxychlor	ND		0.0280	0.0279		mg/L		100	57 - 135		

Surrogate	*MS %Recovery*	*MS Qualifier*	*Limits*
DCB Decachlorobiphenyl (Surr)	*115*		*50 - 130*
Tetrachloro-m-xylene (Surr)	*115*		*46 - 120*

Lab Sample ID: 705-9899-A-1-L DU
Matrix: Solid
Analysis Batch: 18464

Client Sample ID: Duplicate
Prep Type: TCLP
Prep Batch: 18161

Analyte	Sample Result	Sample Qualifier		DU Result	DU Qualifier	Unit	D			RPD	RPD Limit
Chlordane (technical)	ND			ND		mg/L				NC	30

Method: 8081B - Organochlorine Pesticides (GC) (Continued)

Lab Sample ID: 705-9899-A-1-L DU
Matrix: Solid
Analysis Batch: 18464

Client Sample ID: Duplicate
Prep Type: TCLP
Prep Batch: 18161

Analyte	Sample Result	Sample Qualifier		DU Result	DU Qualifier	Unit	D			RPD	RPD Limit
Endrin	ND			ND		mg/L				NC	17
gamma-BHC (Lindane)	ND			ND		mg/L				NC	26
Heptachlor	ND			ND		mg/L				NC	24
Heptachlor epoxide	ND			ND		mg/L				NC	30
Methoxychlor	ND			ND		mg/L				NC	30
Toxaphene	ND			ND		mg/L				NC	30

Surrogate	*DU %Recovery*	*DU Qualifier*	*Limits*
DCB Decachlorobiphenyl (Surr)	*124*		*50 - 130*
Tetrachloro-m-xylene (Surr)	*108*		*46 - 120*

Method: 6010D - Metals (ICP)

Lab Sample ID: LCS 705-17537/2-A
Matrix: Solid
Analysis Batch: 17673

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 17537

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits		
Arsenic			5.00	4.91		mg/L		98	80 - 120		
Barium			5.00	4.76		mg/L		95	80 - 120		
Cadmium			5.00	4.96		mg/L		99	80 - 120		
Chromium			5.00	4.68		mg/L		94	80 - 120		
Lead			5.00	4.64		mg/L		93	80 - 120		
Selenium			5.00	4.94		mg/L		99	80 - 120		
Silver			0.500	0.484		mg/L		97	80 - 120		

Lab Sample ID: LB 705-17234/1-B
Matrix: Solid
Analysis Batch: 17673

Client Sample ID: Method Blank
Prep Type: TCLP
Prep Batch: 17537

Analyte	LB Result	LB Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	ND		0.25		mg/L		10/18/24 14:32	10/18/24 16:05	1
Barium	ND		0.50		mg/L		10/18/24 14:32	10/18/24 16:05	1
Cadmium	ND		0.025		mg/L		10/18/24 14:32	10/18/24 16:05	1
Chromium	ND		0.050		mg/L		10/18/24 14:32	10/18/24 16:05	1
Lead	ND		0.050		mg/L		10/18/24 14:32	10/18/24 16:05	1
Selenium	ND		0.10		mg/L		10/18/24 14:32	10/18/24 16:05	1
Silver	ND		0.025		mg/L		10/18/24 14:32	10/18/24 16:05	1

Lab Sample ID: 705-9899-A-1-E MS
Matrix: Solid
Analysis Batch: 17673

Client Sample ID: Matrix Spike
Prep Type: TCLP
Prep Batch: 17537

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits		
Arsenic	ND		5.00	4.87		mg/L		97	50 - 150		
Barium	ND		5.00	4.98		mg/L		94	50 - 150		
Cadmium	ND		5.00	4.92		mg/L		98	50 - 150		
Chromium	ND		5.00	4.65		mg/L		93	50 - 150		
Lead	ND		5.00	4.61		mg/L		92	50 - 150		

Method: 6010D - Metals (ICP) (Continued)

Lab Sample ID: 705-9899-A-1-E MS
Matrix: Solid
Analysis Batch: 17673

Client Sample ID: Matrix Spike
Prep Type: TCLP
Prep Batch: 17537

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits
Selenium	ND		5.00	4.89		mg/L		97	50 - 150
Silver	ND		0.500	0.481		mg/L		96	50 - 150

Lab Sample ID: 705-9899-A-1-F MSD
Matrix: Solid
Analysis Batch: 17673

Client Sample ID: Matrix Spike Duplicate
Prep Type: TCLP
Prep Batch: 17537

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Arsenic	ND		5.00	4.97		mg/L		99	50 - 150	2	30
Barium	ND		5.00	5.01		mg/L		95	50 - 150	1	30
Cadmium	ND		5.00	4.96		mg/L		99	50 - 150	1	30
Chromium	ND		5.00	4.70		mg/L		94	50 - 150	1	30
Lead	ND		5.00	4.67		mg/L		93	50 - 150	1	30
Selenium	ND		5.00	4.99		mg/L		99	50 - 150	2	30
Silver	ND		0.500	0.483		mg/L		97	50 - 150	0	30

Method: 7470A - Mercury (CVAA)

Lab Sample ID: LCS 705-17544/2-A
Matrix: Solid
Analysis Batch: 17622

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 17544

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Mercury	0.0400	0.0417	^+	mg/L		104	80 - 120

Lab Sample ID: LB 705-17349/1-C
Matrix: Solid
Analysis Batch: 17622

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	LB Result	LB Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	ND	^+	0.00050	mg/L			10/18/24 17:37	1

Lab Sample ID: 705-9899-A-1-I MS
Matrix: Solid
Analysis Batch: 17622

Client Sample ID: Matrix Spike
Prep Type: TCLP
Prep Batch: 17544

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits
Mercury	ND	^+	0.0400	0.0446	^+	mg/L		112	75 - 125

Lab Sample ID: 705-9899-A-1-J MSD
Matrix: Solid
Analysis Batch: 17622

Client Sample ID: Matrix Spike Duplicate
Prep Type: TCLP
Prep Batch: 17544

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Mercury	ND	^+	0.0400	0.0394	^+	mg/L		98	75 - 125	13	20

Method: 9045D - pH

Lab Sample ID: 705-9718-A-1 DU
Matrix: Solid
Analysis Batch: 17227

Client Sample ID: Duplicate
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier		DU Result	DU Qualifier	Unit	D			RPD	RPD Limit
corrosivity by pH	8.7			8.6		SU				1	10
Temperature	21.3			21.4		Degrees C				0.5	10

Lab Sample ID: 705-9975-A-1 DU
Matrix: Solid
Analysis Batch: 17227

Client Sample ID: Duplicate
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier		DU Result	DU Qualifier	Unit	D			RPD	RPD Limit
corrosivity by pH	8.9			9.1		SU				2	10
Temperature	21.7			21.9		Degrees C				0.9	10

Method: 9095B - Paint Filter (Presence/Absence)

Lab Sample ID: 705-9899-A-1 DU
Matrix: Solid
Analysis Batch: 17078

Client Sample ID: Duplicate
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier		DU Result	DU Qualifier	Unit	D			RPD	RPD Limit
Free Liquid	NEGATIVE			NEGATIVE		NONE				NC	

Accreditation/Certification Summary

Client: Terracon Consultants Inc
Project/Site: RAFB B110

Job ID: 705-9904-1

Laboratory: Eurofins Atlanta

Unless otherwise noted, all analytes for this laboratory were covered under each accreditation/certification below.

Authority	Program	Identification Number	Expiration Date
Florida	NELAP	E87582	06-30-25

The following analytes are included in this report, but the laboratory is not certified by the governing authority. This list may include analytes for which the agency does not offer certification.

Analysis Method	Prep Method	Matrix	Analyte
9045D		Solid	Temperature
D 2216		Solid	Percent Moisture

END OF REPORT

Detected PAHs Concentrations in Soil

Compound	Concentration[1,2]				Georgia EPD Notification Concentration[1,3]
	B-1	B-2	B-3	B-4	
Anthracene	<0.0018	**0.0057**	**0.029**	<0.0018	500
Benzo(a)anthracene	<0.0018	**0.029**	**0.15**	<0.0018	5
Benzo(a)pyrene	<0.0018	**0.021**	**0.15**	<0.0018	1.64
Benzo(b)fluoranthene	<0.0035	**0.046**	**0.25**	<0.0035	5
Benzo(g,h,i)perylene	<0.0035	**0.019**	**0.20**	<0.0035	500
Benzo(k)fluoranthene	<0.0018	**0.013**	**0.078**	<0.0018	5
Chrysene	<0.0018	**0.031**	**0.14**	<0.0018	5
Fluoranthene	<0.0035	**0.061**	**0.23**	<0.0035	500
Fluorene	<0.0035	<0.0035	**0.0074**	<0.0035	360
Indeno(1,2,3-cd)pyrene	<0.0018	**0.016**	**0.16**	<0.0018	5
Phenanthrene	<0.0018	**0.017**	**0.11**	<0.0018	110
Pyrene	<0.0018	**0.05**	**0.25**	<0.0018	500
Cadmium[4]	<0.025	<0.025	**0.073**	<0.025	NA
Lead[4]	<0.050	<0.050	**0.23**	<0.050	NA

1. PAH concentrations are reported in milligrams/kilogram (mg/kg) & Metals concentrations are reported in milligrams/Liter (mg/l).
2. Concentrations in bold font indicate a value greater than the applicable laboratory reporting limit.
3. EPD = Environmental Protection Division.
4. The Environmental Protection Agency (EPA) regulatory level for TCLP (Toxicity Leaching Characteristic Procedure) for Cadmium and Lead is 1 and 5 mg/L, respectively.

Supporting Information

Contents:

General Notes
Unified Soil Classification System

Note: All attachments are one page unless noted above.

General Notes

Sampling	Water Level	Field Tests
	Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.	N Standard Penetration Test Resistance (Blows/Ft.) (HP) Hand Penetrometer (T) Torvane (DCP) Dynamic Cone Penetrometer UC Unconfined Compressive Strength (PID) Photo-Ionization Detector (OVA) Organic Vapor Analyzer

Descriptive Soil Classification

Soil classification as noted on the soil boring logs is based Unified Soil Classification System. Where sufficient laboratory data exist to classify the soils consistent with ASTM D2487 "Classification of Soils for Engineering Purposes" this procedure is used. ASTM D2488 "Description and Identification of Soils (Visual-Manual Procedure)" is also used to classify the soils, particularly where insufficient laboratory data exist to classify the soils in accordance with ASTM D2487. In addition to USCS classification, coarse grained soils are classified on the basis of their in-place relative density, and fine-grained soils are classified on the basis of their consistency. See "Strength Terms" table below for details. The ASTM standards noted above are for reference to methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgment.

Location And Elevation Notes

Exploration point locations as shown on the Exploration Plan and as noted on the soil boring logs in the form of Latitude and Longitude are approximate. See Exploration and Testing Procedures in the report for the methods used to locate the exploration points for this project. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

Strength Terms

Relative Density of Coarse-Grained Soils (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance		**Consistency of Fine-Grained Soils** (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance		
Relative Density	**Standard Penetration or N-Value (Blows/Ft.)**	**Consistency**	**Unconfined Compressive Strength Qu (tsf)**	**Standard Penetration or N-Value (Blows/Ft.)**
Very Loose	0 - 3	Very Soft	less than 0.25	0 - 1
Loose	4 - 9	Soft	0.25 to 0.50	2 - 4
Medium Dense	10 - 29	Medium Stiff	0.50 to 1.00	4 - 8
Dense	30 - 50	Stiff	1.00 to 2.00	8 - 15
Very Dense	> 50	Very Stiff	2.00 to 4.00	15 - 30
		Hard	> 4.00	> 30

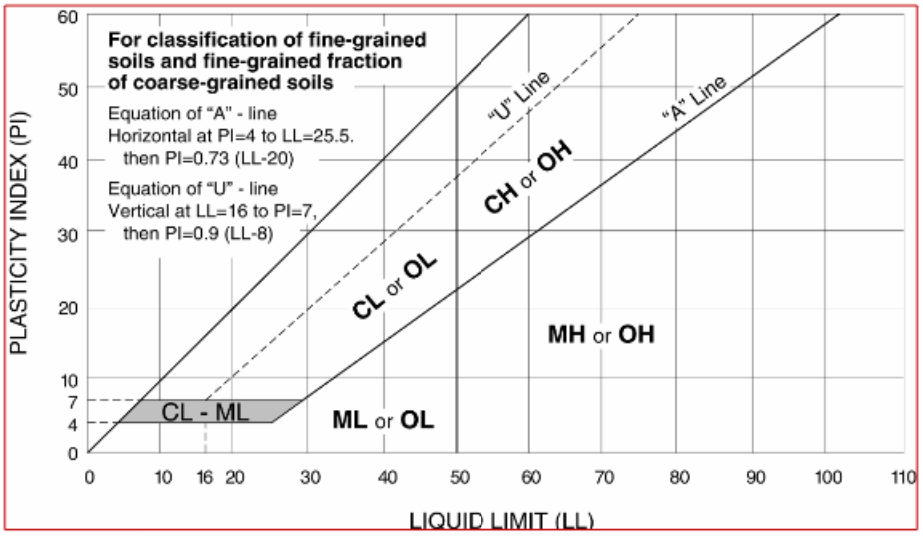
Relevance of Exploration and Laboratory Test Results

Exploration/field results and/or laboratory test data contained within this document are intended for application to the project as described in this document. Use of such exploration/field results and/or laboratory test data should not be used independently of this document.

Unified Soil Classification System

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]				Soil Classification	
				Group Symbol	Group Name [B]
Coarse-Grained Soils: More than 50% retained on No. 4 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	Cu≥4 and 1≤Cc≤3 [E]	GW	Well-graded gravel [F]
			Cu<4 and/or [Cc<1 or Cc>3.0] [E]	GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH	GM	Silty gravel [F, G, H]
			Fines classify as CL or CH	GC	Clayey gravel [F, G, H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	Cu≥6 and 1≤Cc≤3 [E]	SW	Well-graded sand [I]
			Cu<6 and/or [Cc<1 or Cc>3.0] [E]	SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH	SM	Silty sand [G, H, I]
			Fines classify as CL or CH	SC	Clayey sand [G, H, I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots above "A" line [J]	CL	Lean clay [K, L, M]
			PI < 4 or plots below "A" line [J]	ML	Silt [K, L, M]
		Organic:	$\frac{LL\ oven\ dried}{LL\ not\ dried} < 0.75$	OL	Organic clay [K, L, M, N]
					Organic silt [K, L, M, O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line	CH	Fat clay [K, L, M]
			PI plots below "A" line	MH	Elastic silt [K, L, M]
		Organic:	$\frac{LL\ oven\ dried}{LL\ not\ dried} < 0.75$	OH	Organic clay [K, L, M, P]
					Organic silt [K, L, M, Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve.
[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.
[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay.
[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$
[F] If soil contains ≥ 15% sand, add "with sand" to group name.
[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.
[H] If fines are organic, add "with organic fines" to group name.
[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.
[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.
[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.
[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.
[N] PI ≥ 4 and plots on or above "A" line.
[O] PI < 4 or plots below "A" line.
[P] PI plots on or above "A" line.
[Q] PI plots below "A" line.



Appendix D

eurofins | Environment Testing

ANALYTICAL REPORT

PREPARED FOR

Attn: Cole Angelo
Terracon Consultants Inc
514 Hillcrest Industrial Blvd.
Macon, Georgia 31204

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JOB DESCRIPTION

RAFB B110

JOB NUMBER

705-9904-1

Eurofins Atlanta
3080 Presidential Dr
Atlanta GA 30340

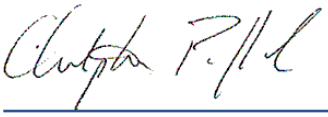
See page two for job notes and contact information.

my EOL

Job Notes

The test results in this report relate only to the samples as received by the laboratory and will meet all requirements of the methodology, with any exceptions noted. This report shall not be reproduced except in full, without the express written approval of the laboratory. All questions should be directed to the Eurofins Environment Testing Southeast, LLC Project Manager.

Authorization



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Definitions/Glossary

Client: Terracon Consultants Inc
Project/Site: RAFB B110

Job ID: 705-9904-1

Qualifiers

GC/MS VOA

Qualifier	Qualifier Description
J	Result is less than the RL but greater than or equal to the MDL and the concentration is an approximate value.

GC/MS Semi VOA

Qualifier	Qualifier Description
F1	MS and/or MSD recovery exceeds control limits.

GC Semi VOA

Qualifier	Qualifier Description
S1+	Surrogate recovery exceeds control limits, high biased.

Metals

Qualifier	Qualifier Description
^+	Continuing Calibration Verification (CCV) is outside acceptance limits, high biased.

General Chemistry

Qualifier	Qualifier Description
HF	Parameter with a holding time of 15 minutes. Test performed by laboratory at client's request. Sample was analyzed outside of hold time.

Glossary

Abbreviation	These commonly used abbreviations may or may not be present in this report.
☼	Listed under the "D" column to designate that the result is reported on a dry weight basis
%R	Percent Recovery
CFL	Contains Free Liquid
CFU	Colony Forming Unit
CNF	Contains No Free Liquid
DER	Duplicate Error Ratio (normalized absolute difference)
Dil Fac	Dilution Factor
DL	Detection Limit (DoD/DOE)
DL, RA, RE, IN	Indicates a Dilution, Re-analysis, Re-extraction, or additional Initial metals/anion analysis of the sample
DLC	Decision Level Concentration (Radiochemistry)
EDL	Estimated Detection Limit (Dioxin)
LOD	Limit of Detection (DoD/DOE)
LOQ	Limit of Quantitation (DoD/DOE)
MCL	EPA recommended "Maximum Contaminant Level"
MDA	Minimum Detectable Activity (Radiochemistry)
MDC	Minimum Detectable Concentration (Radiochemistry)
MDL	Method Detection Limit
ML	Minimum Level (Dioxin)
MPN	Most Probable Number
MQL	Method Quantitation Limit
NC	Not Calculated
ND	Not Detected at the reporting limit (or MDL or EDL if shown)
NEG	Negative / Absent
POS	Positive / Present
PQL	Practical Quantitation Limit
PRES	Presumptive
QC	Quality Control
RER	Relative Error Ratio (Radiochemistry)
RL	Reporting Limit or Requested Limit (Radiochemistry)
RPD	Relative Percent Difference, a measure of the relative difference between two points
TEF	Toxicity Equivalent Factor (Dioxin)
TEQ	Toxicity Equivalent Quotient (Dioxin)
TNTC	Too Numerous To Count

AES | ENVIRONMENTAL SERVICES, INC.

3080 Presidential Drive, Atlanta, GA 30340 Phone: (770)-457-8177

CHAIN OF CUSTODY

Work Order: _____

Page 1 of 1

COMPANY:	ADDRESS:
Terracon	514 Hillcrest Industrial Macon, GA 31204
PHONE: 478-757-1606	EMAIL: cole.angelo@terracon.com
SAMPLED BY: C. Angelo	SIGNATURE:

#	SAMPLE ID	SAMPLED: DATE	SAMPLED: TIME	GRAB	COMPOSITE	MATRIX (see codes)	ANALYSIS REQUESTED: Flashpoint	Pit	TCLP 8 RCRA Metals	TCLP VOCs	TCLP SVOCs	TCLP Pest	Lowlevel PAH	Paint Filter	PRESERVATION (see codes)	REMARKS	Number of Containers
1	B-1 0-5'	10-10-24	1600		✓	Soil	✓	✓	✓	✓	✓	✓	✓	✓			1
2	B-2 0-5'	10-10-24	14:54		✓	Soil	✓	✓	✓	✓	✓	✓	✓	✓			1
3	B-3 0-5'	10-10-24	13:29		✓	Soil	✓	✓	✓	✓	✓	✓	✓	✓			1
4	B-4 0-5'	10-10-24	10:45		✓	Soil	✓	✓	✓	✓	✓	✓	✓	✓			1
5																	
6																	
7																	
8																	
9																	
10																	
11																	
12																	
13																	
14																	

Visit our website www.aesatlanta.com for downloadable COCs and to log in to your AESAccess account.

705-9904 COC

RELINQUISHED BY:	DATE/TIME:	RECEIVED BY:	DATE/TIME:
1.	10/14/2024 10:00	1.	10-14 1124
2.	10-14 1405	2.	10 14 24 1305
3.		3.	

SPECIAL INSTRUCTIONS/COMMENTS:

SHIPMENT METHOD 2.3°

OUT: / / VIA:

IN: / / VIA: #0665

Client FedEx UPS US mail courier

other: _____

PROJECT INFORMATION

PROJECT NAME: RAFB B110

PROJECT #: HN23522

SITE ADDRESS:

SEND REPORT TO: Cole Angelo

INVOICE TO (IF DIFFERENT FROM ABOVE):

QUOTE #: _____ PO#: _____

RECEIPT

Total # of Containers: 4

Turnaround Time (TAT) Request

- [x] Standard
- [ ] 2 Business Day Rush
- [ ] Next Business Day Rush
- [ ] Same-Day Rush (auth req.)
- [ ] Other _____

REGULATORY PROGRAM (If any):

DATA PACKAGE: I ○ II ○ III ○ IV ○

Submission of samples to the laboratory constitutes acceptance of AES's Terms & Conditions. Client assumes sole responsibility for damage or loss of samples before we accept them. Samples received after 3PM or on Saturday are considered as received the following business day. If no TAT is marked on COC, AES will proceed with standard TAT. Samples are disposed of 30 days after completion of report unless other arrangements are made.

Matrix Codes: A = Air GW = Groundwater SE = Sediment SO = Soil SW = Surface Water ST=Stormwater WW = Waste Water W = Water (Blanks) DW = Drinking Water (Blanks) O = Other (specify)

Preservative Codes: H+I = Hydrochloric acid + ice I = Ice only N = Nitric acid S+I = Sulfuric acid + ice S/M+I = Sodium Bisulfate/Methanol + ice O = Other (specify) NA = None

4.30.20_COC

Job Narrative
705-9904-1

Analytical test results meet all requirements of the associated regulatory program listed on the Accreditation/Certification Summary Page unless otherwise noted under the individual analysis. Data qualifiers and/or narrative comments are included to explain any exceptions, if applicable.

- Matrix QC may not be reported if insufficient sample is provided or site-specific QC samples were not submitted. In these situations, to demonstrate precision and accuracy at a batch level, a LCS/LCSD may be performed, unless otherwise specified in the method.
- Surrogate and/or isotope dilution analyte recoveries (if applicable) which are outside of the QC window are confirmed unless attributed to a dilution or otherwise noted in the narrative.

Regulated compliance samples (e.g. SDWA, NPDES) must comply with the associated agency requirements/permits.

Receipt
The samples were received on 10/14/2024 1:05 PM. Unless otherwise noted below, the samples arrived in good condition, and, where required, properly preserved and on ice. The temperature of the cooler at receipt time was 2.3°C.

GC/MS VOA
No additional analytical or quality issues were noted, other than those described above or in the Definitions/ Glossary page.

GC/MS Semi VOA
Method 8270E - TCLP: The matrix spike / matrix spike duplicate (MS/MSD) recoveries for preparation batch 705-17234 and 705-17160 and analytical batch 705-17832 were outside control limits for one or more analytes. See QC Sample Results for detail. Sample matrix interference and/or non-homogeneity are suspected because the associated laboratory control sample (LCS) recovery is within acceptance limits.

No additional analytical or quality issues were noted, other than those described above or in the Definitions/ Glossary page.

Pesticides
Method 8081B - TCLP: Surrogate DCB Decachlorobiphenyl (Surr) and Tetrachloro-m-xylene (Surr) recovery for the following samples were outside the upper control limit: B-2 0-5' (705-9904-2) and B-4 0-5' (705-9904-4).

No additional analytical or quality issues were noted, other than those described above or in the Definitions/ Glossary page.

Metals
No additional analytical or quality issues were noted, other than those described above or in the Definitions/ Glossary page.

General Chemistry
Method 9045D: This analysis is normally performed in the field and has a method-defined holding time of 15 minutes. The following samples has been qualified with the "HF" flag to indicate analysis was performed in the laboratory outside the 15 minute timeframe: B-1 0-5' (705-9904-1), B-2 0-5' (705-9904-2), B-3 0-5' (705-9904-3), B-4 0-5' (705-9904-4), (705-9718-A-1), (705-9718-A-1 DU), (705-9975-A-1) and (705-9975-A-1 DU).

No additional analytical or quality issues were noted, other than those described above or in the Definitions/ Glossary page.

Client: Terracon Consultants Inc
Project/Site: RAFB B110

Job ID: 705-9904-1

Client Sample ID: B-1 0-5'
Date Collected: 10/10/24 16:00
Date Received: 10/14/24 13:05

Lab Sample ID: 705-9904-1
Matrix: Solid

Method: SW846 8260D - Volatile Organic Compounds by GC/MS - TCLP

Analyte	Result	Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
Benzene	ND		100		ug/L			10/17/24 14:35	20
Carbon tetrachloride	ND		100		ug/L			10/17/24 14:35	20
Chlorobenzene	ND		100		ug/L			10/17/24 14:35	20
Chloroform	ND		100		ug/L			10/17/24 14:35	20
1,2-Dichloroethane	ND		100		ug/L			10/17/24 14:35	20
1,1-Dichloroethene	ND		100		ug/L			10/17/24 14:35	20
2-Butanone	ND		1000		ug/L			10/17/24 14:35	20
Tetrachloroethene	ND		100		ug/L			10/17/24 14:35	20
Vinyl chloride	ND		100		ug/L			10/17/24 14:35	20
Trichloroethene	ND		100		ug/L			10/17/24 14:35	20

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
4-Bromofluorobenzene	*94*		*70 - 126*		*10/17/24 14:35*	*20*
Dibromofluoromethane (Surr)	*105*		*77 - 121*		*10/17/24 14:35*	*20*
Toluene-d8 (Surr)	*99*		*79 - 119*		*10/17/24 14:35*	*20*

Method: SW846 8270E - Semivolatile Organic Compounds (GC/MS) - TCLP

Analyte	Result	Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
2-Methylphenol	ND		0.10		mg/L		10/18/24 11:39	10/18/24 21:35	1
3 & 4 Methylphenol	ND		0.10		mg/L		10/18/24 11:39	10/18/24 21:35	1
2,4-Dinitrotoluene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 21:35	1
Hexachlorobenzene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 21:35	1
Hexachlorobutadiene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 21:35	1
Hexachloroethane	ND		0.10		mg/L		10/18/24 11:39	10/18/24 21:35	1
Nitrobenzene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 21:35	1
Pentachlorophenol	ND		0.25		mg/L		10/18/24 11:39	10/18/24 21:35	1
Pyridine	ND		0.10		mg/L		10/18/24 11:39	10/18/24 21:35	1
2,4,5-Trichlorophenol	ND		0.25		mg/L		10/18/24 11:39	10/18/24 21:35	1
2,4,6-Trichlorophenol	ND		0.10		mg/L		10/18/24 11:39	10/18/24 21:35	1
1,4-Dichlorobenzene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 21:35	1

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
2,4,6-Tribromophenol (Surr)	*62*		*53 - 132*	*10/18/24 11:39*	*10/18/24 21:35*	*1*
2-Fluorophenol (Surr)	*62*		*29 - 120*	*10/18/24 11:39*	*10/18/24 21:35*	*1*
Nitrobenzene-d5 (Surr)	*72*		*41 - 129*	*10/18/24 11:39*	*10/18/24 21:35*	*1*
Phenol-d5 (Surr)				*10/18/24 11:39*	*10/18/24 21:35*	*1*
2-Fluorobiphenyl (Surr)	*72*		*48 - 126*	*10/18/24 11:39*	*10/18/24 21:35*	*1*
p-Terphenyl-d14 (Surr)	*78*		*48 - 130*	*10/18/24 11:39*	*10/18/24 21:35*	*1*

Method: SW846 8081B - Organochlorine Pesticides (GC) - TCLP

Analyte	Result	Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
Chlordane (technical)	ND		0.00050		mg/L		10/23/24 10:27	10/23/24 17:38	1
Endrin	ND		0.00010		mg/L		10/23/24 10:27	10/23/24 17:38	1
gamma-BHC (Lindane)	ND		0.000050		mg/L		10/23/24 10:27	10/23/24 17:38	1
Heptachlor	ND		0.000050		mg/L		10/23/24 10:27	10/23/24 17:38	1
Heptachlor epoxide	ND		0.000050		mg/L		10/23/24 10:27	10/23/24 17:38	1
Methoxychlor	ND		0.00050		mg/L		10/23/24 10:27	10/23/24 17:38	1
Toxaphene	ND		0.0050		mg/L		10/23/24 10:27	10/23/24 17:38	1

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
DCB Decachlorobiphenyl (Surr)	*122*		*50 - 130*	*10/23/24 10:27*	*10/23/24 17:38*	*1*

Client Sample ID: B-1 0-5'

Date Collected: 10/10/24 16:00
Date Received: 10/14/24 13:05

Lab Sample ID: 705-9904-1
Matrix: Solid

Method: SW846 8081B - Organochlorine Pesticides (GC) - TCLP (Continued)

Surrogate	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
Tetrachloro-m-xylene (Surr)	*115*		*46 - 120*	*10/23/24 10:27*	*10/23/24 17:38*	*1*

Method: SW846 6010D - Metals (ICP) - TCLP

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	ND		0.25	mg/L		10/18/24 14:32	10/18/24 16:55	1
Barium	ND		0.50	mg/L		10/18/24 14:32	10/18/24 16:55	1
Cadmium	ND		0.025	mg/L		10/18/24 14:32	10/18/24 16:55	1
Chromium	ND		0.050	mg/L		10/18/24 14:32	10/18/24 16:55	1
Lead	ND		0.050	mg/L		10/18/24 14:32	10/18/24 16:55	1
Selenium	ND		0.10	mg/L		10/18/24 14:32	10/18/24 16:55	1
Silver	ND		0.025	mg/L		10/18/24 14:32	10/18/24 16:55	1

Method: SW846 7470A - Mercury (CVAA) - TCLP

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	ND	^+	0.0050	mg/L		10/18/24 14:11	10/18/24 18:32	1

General Chemistry

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Ignitability (SW846 1030)	N			NONE			10/18/24 10:35	1
corrosivity by pH (SW846 9045D)	5.4	HF	0.01	SU			10/17/24 10:50	1
Temperature (SW846 9045D)	22.1	HF	0.01	Degrees C			10/17/24 10:50	1
Free Liquid (SW846 9095B)	NEGATIVE			NONE			10/16/24 13:02	1

Client Sample ID: B-1 0-5'

Date Collected: 10/10/24 16:00
Date Received: 10/14/24 13:05

Lab Sample ID: 705-9904-1
Matrix: Solid
Percent Solids: 94.0

Method: SW846 8270E SIM - Semivolatile Organic Compounds (GC/MS SIM)

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
1-Methylnaphthalene	ND		0.018	mg/Kg	☼	10/18/24 11:24	10/18/24 18:04	1
2-Methylnaphthalene	ND		0.018	mg/Kg	☼	10/18/24 11:24	10/18/24 18:04	1
Acenaphthene	ND		0.018	mg/Kg	☼	10/18/24 11:24	10/18/24 18:04	1
Acenaphthylene	ND		0.035	mg/Kg	☼	10/18/24 11:24	10/18/24 18:04	1
Anthracene	ND		0.0018	mg/Kg	☼	10/18/24 11:24	10/18/24 18:04	1
Benzo[a]anthracene	ND		0.0018	mg/Kg	☼	10/18/24 11:24	10/18/24 18:04	1
Benzo[a]pyrene	ND		0.0018	mg/Kg	☼	10/18/24 11:24	10/18/24 18:04	1
Benzo[b]fluoranthene	ND		0.0035	mg/Kg	☼	10/18/24 11:24	10/18/24 18:04	1
Benzo[g,h,i]perylene	ND		0.0035	mg/Kg	☼	10/18/24 11:24	10/18/24 18:04	1
Benzo[k]fluoranthene	ND		0.0018	mg/Kg	☼	10/18/24 11:24	10/18/24 18:04	1
Chrysene	ND		0.0018	mg/Kg	☼	10/18/24 11:24	10/18/24 18:04	1
Dibenz(a,h)anthracene	ND		0.0035	mg/Kg	☼	10/18/24 11:24	10/18/24 18:04	1
Fluoranthene	ND		0.0035	mg/Kg	☼	10/18/24 11:24	10/18/24 18:04	1
Fluorene	ND		0.0035	mg/Kg	☼	10/18/24 11:24	10/18/24 18:04	1
Indeno[1,2,3-cd]pyrene	ND		0.0018	mg/Kg	☼	10/18/24 11:24	10/18/24 18:04	1
Naphthalene	ND		0.018	mg/Kg	☼	10/18/24 11:24	10/18/24 18:04	1
Phenanthrene	ND		0.0018	mg/Kg	☼	10/18/24 11:24	10/18/24 18:04	1
Pyrene	ND		0.0018	mg/Kg	☼	10/18/24 11:24	10/18/24 18:04	1

Surrogate	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
p-Terphenyl-d14 (Surr)	*107*		*59 - 129*	*10/18/24 11:24*	*10/18/24 18:04*	*1*

Client Sample ID: B-2 0-5'
Date Collected: 10/10/24 14:54
Date Received: 10/14/24 13:05

Lab Sample ID: 705-9904-2
Matrix: Solid

Method: SW846 8260D - Volatile Organic Compounds by GC/MS - TCLP

Analyte	Result	Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
Benzene	ND		100		ug/L			10/17/24 13:24	20
Carbon tetrachloride	ND		100		ug/L			10/17/24 13:24	20
Chlorobenzene	ND		100		ug/L			10/17/24 13:24	20
Chloroform	ND		100		ug/L			10/17/24 13:24	20
1,2-Dichloroethane	ND		100		ug/L			10/17/24 13:24	20
1,1-Dichloroethene	ND		100		ug/L			10/17/24 13:24	20
2-Butanone	ND		1000		ug/L			10/17/24 13:24	20
Tetrachloroethene	ND		100		ug/L			10/17/24 13:24	20
Vinyl chloride	ND		100		ug/L			10/17/24 13:24	20
Trichloroethene	ND		100		ug/L			10/17/24 13:24	20

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
4-Bromofluorobenzene	*96*		*70 - 126*		*10/17/24 13:24*	*20*
Dibromofluoromethane (Surr)	*101*		*77 - 121*		*10/17/24 13:24*	*20*
Toluene-d8 (Surr)	*97*		*79 - 119*		*10/17/24 13:24*	*20*

Method: SW846 8270E - Semivolatile Organic Compounds (GC/MS) - TCLP

Analyte	Result	Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
2-Methylphenol	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:02	1
3 & 4 Methylphenol	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:02	1
2,4-Dinitrotoluene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:02	1
Hexachlorobenzene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:02	1
Hexachlorobutadiene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:02	1
Hexachloroethane	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:02	1
Nitrobenzene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:02	1
Pentachlorophenol	ND		0.25		mg/L		10/18/24 11:39	10/18/24 22:02	1
Pyridine	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:02	1
2,4,5-Trichlorophenol	ND		0.25		mg/L		10/18/24 11:39	10/18/24 22:02	1
2,4,6-Trichlorophenol	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:02	1
1,4-Dichlorobenzene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:02	1

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
2,4,6-Tribromophenol (Surr)	*63*		*53 - 132*	*10/18/24 11:39*	*10/18/24 22:02*	*1*
2-Fluorophenol (Surr)	*60*		*29 - 120*	*10/18/24 11:39*	*10/18/24 22:02*	*1*
Nitrobenzene-d5 (Surr)	*67*		*41 - 129*	*10/18/24 11:39*	*10/18/24 22:02*	*1*
Phenol-d5 (Surr)				*10/18/24 11:39*	*10/18/24 22:02*	*1*
2-Fluorobiphenyl (Surr)	*70*		*48 - 126*	*10/18/24 11:39*	*10/18/24 22:02*	*1*
p-Terphenyl-d14 (Surr)	*79*		*48 - 130*	*10/18/24 11:39*	*10/18/24 22:02*	*1*

Method: SW846 8081B - Organochlorine Pesticides (GC) - TCLP

Analyte	Result	Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
Chlordane (technical)	ND		0.00050		mg/L		10/23/24 10:27	10/23/24 17:50	1
Endrin	ND		0.00010		mg/L		10/23/24 10:27	10/23/24 17:50	1
gamma-BHC (Lindane)	ND		0.000050		mg/L		10/23/24 10:27	10/23/24 17:50	1
Heptachlor	ND		0.000050		mg/L		10/23/24 10:27	10/23/24 17:50	1
Heptachlor epoxide	ND		0.000050		mg/L		10/23/24 10:27	10/23/24 17:50	1
Methoxychlor	ND		0.00050		mg/L		10/23/24 10:27	10/23/24 17:50	1
Toxaphene	ND		0.0050		mg/L		10/23/24 10:27	10/23/24 17:50	1

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
DCB Decachlorobiphenyl (Surr)	*130*		*50 - 130*	*10/23/24 10:27*	*10/23/24 17:50*	*1*

Client Sample ID: B-2 0-5'

Lab Sample ID: 705-9904-2

Date Collected: 10/10/24 14:54

Matrix: Solid

Date Received: 10/14/24 13:05

Method: SW846 8081B - Organochlorine Pesticides (GC) - TCLP (Continued)

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
Tetrachloro-m-xylene (Surr)	*123*	*S1+*	*46 - 120*	*10/23/24 10:27*	*10/23/24 17:50*	*1*

Method: SW846 6010D - Metals (ICP) - TCLP

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	ND		0.25	mg/L		10/18/24 14:32	10/18/24 16:58	1
Barium	ND		0.50	mg/L		10/18/24 14:32	10/18/24 16:58	1
Cadmium	ND		0.025	mg/L		10/18/24 14:32	10/18/24 16:58	1
Chromium	ND		0.050	mg/L		10/18/24 14:32	10/18/24 16:58	1
Lead	ND		0.050	mg/L		10/18/24 14:32	10/18/24 16:58	1
Selenium	ND		0.10	mg/L		10/18/24 14:32	10/18/24 16:58	1
Silver	ND		0.025	mg/L		10/18/24 14:32	10/18/24 16:58	1

Method: SW846 7470A - Mercury (CVAA) - TCLP

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	ND	^+	0.0050	mg/L		10/18/24 14:11	10/18/24 18:36	1

General Chemistry

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Ignitability (SW846 1030)	**N**			NONE			10/18/24 10:35	1
corrosivity by pH (SW846 9045D)	**7.3**	**HF**	0.01	SU			10/17/24 10:50	1
Temperature (SW846 9045D)	**22.0**	**HF**	0.01	Degrees C			10/17/24 10:50	1
Free Liquid (SW846 9095B)	**NEGATIVE**			NONE			10/16/24 13:02	1

Client Sample ID: B-2 0-5'

Lab Sample ID: 705-9904-2

Date Collected: 10/10/24 14:54

Matrix: Solid

Date Received: 10/14/24 13:05

Percent Solids: 94.4

Method: SW846 8270E SIM - Semivolatile Organic Compounds (GC/MS SIM)

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
1-Methylnaphthalene	ND		0.018	mg/Kg	☼	10/22/24 14:26	10/22/24 19:57	1
2-Methylnaphthalene	ND		0.018	mg/Kg	☼	10/22/24 14:26	10/22/24 19:57	1
Acenaphthene	ND		0.018	mg/Kg	☼	10/22/24 14:26	10/22/24 19:57	1
Acenaphthylene	ND		0.035	mg/Kg	☼	10/22/24 14:26	10/22/24 19:57	1
Anthracene	**0.0057**		0.0018	mg/Kg	☼	10/22/24 14:26	10/22/24 19:57	1
Benzo[a]anthracene	**0.029**		0.0018	mg/Kg	☼	10/22/24 14:26	10/22/24 19:57	1
Benzo[a]pyrene	**0.021**		0.0018	mg/Kg	☼	10/22/24 14:26	10/22/24 19:57	1
Benzo[b]fluoranthene	**0.046**		0.0035	mg/Kg	☼	10/22/24 14:26	10/22/24 19:57	1
Benzo[g,h,i]perylene	**0.019**		0.0035	mg/Kg	☼	10/22/24 14:26	10/22/24 19:57	1
Benzo[k]fluoranthene	**0.013**		0.0018	mg/Kg	☼	10/22/24 14:26	10/22/24 19:57	1
Chrysene	**0.031**		0.0018	mg/Kg	☼	10/22/24 14:26	10/22/24 19:57	1
Dibenz(a,h)anthracene	**0.0040**		0.0035	mg/Kg	☼	10/22/24 14:26	10/22/24 19:57	1
Fluoranthene	**0.061**		0.0035	mg/Kg	☼	10/22/24 14:26	10/22/24 19:57	1
Fluorene	ND		0.0035	mg/Kg	☼	10/22/24 14:26	10/22/24 19:57	1
Indeno[1,2,3-cd]pyrene	**0.016**		0.0018	mg/Kg	☼	10/22/24 14:26	10/22/24 19:57	1
Naphthalene	ND		0.018	mg/Kg	☼	10/22/24 14:26	10/22/24 19:57	1
Phenanthrene	**0.017**		0.0018	mg/Kg	☼	10/22/24 14:26	10/22/24 19:57	1
Pyrene	**0.050**		0.0018	mg/Kg	☼	10/22/24 14:26	10/22/24 19:57	1

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
p-Terphenyl-d14 (Surr)	*84*		*59 - 129*	*10/22/24 14:26*	*10/22/24 19:57*	*1*

Client Sample ID: B-3 0-5'
Date Collected: 10/10/24 13:29
Date Received: 10/14/24 13:05

Lab Sample ID: 705-9904-3
Matrix: Solid

Method: SW846 8260D - Volatile Organic Compounds by GC/MS - TCLP

Analyte	Result	Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
Benzene	ND		100		ug/L			10/17/24 14:57	20
Carbon tetrachloride	ND		100		ug/L			10/17/24 14:57	20
Chlorobenzene	ND		100		ug/L			10/17/24 14:57	20
Chloroform	ND		100		ug/L			10/17/24 14:57	20
1,2-Dichloroethane	ND		100		ug/L			10/17/24 14:57	20
1,1-Dichloroethene	ND		100		ug/L			10/17/24 14:57	20
2-Butanone	ND		1000		ug/L			10/17/24 14:57	20
Tetrachloroethene	ND		100		ug/L			10/17/24 14:57	20
Vinyl chloride	ND		100		ug/L			10/17/24 14:57	20
Trichloroethene	ND		100		ug/L			10/17/24 14:57	20

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
4-Bromofluorobenzene	*95*		*70 - 126*		*10/17/24 14:57*	*20*
Dibromofluoromethane (Surr)	*109*		*77 - 121*		*10/17/24 14:57*	*20*
Toluene-d8 (Surr)	*97*		*79 - 119*		*10/17/24 14:57*	*20*

Method: SW846 8270E - Semivolatile Organic Compounds (GC/MS) - TCLP

Analyte	Result	Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
2-Methylphenol	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:30	1
3 & 4 Methylphenol	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:30	1
2,4-Dinitrotoluene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:30	1
Hexachlorobenzene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:30	1
Hexachlorobutadiene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:30	1
Hexachloroethane	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:30	1
Nitrobenzene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:30	1
Pentachlorophenol	ND		0.25		mg/L		10/18/24 11:39	10/18/24 22:30	1
Pyridine	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:30	1
2,4,5-Trichlorophenol	ND		0.25		mg/L		10/18/24 11:39	10/18/24 22:30	1
2,4,6-Trichlorophenol	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:30	1
1,4-Dichlorobenzene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 22:30	1

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
2,4,6-Tribromophenol (Surr)	*64*		*53 - 132*	*10/18/24 11:39*	*10/18/24 22:30*	*1*
2-Fluorophenol (Surr)	*63*		*29 - 120*	*10/18/24 11:39*	*10/18/24 22:30*	*1*
Nitrobenzene-d5 (Surr)	*67*		*41 - 129*	*10/18/24 11:39*	*10/18/24 22:30*	*1*
Phenol-d5 (Surr)				*10/18/24 11:39*	*10/18/24 22:30*	*1*
2-Fluorobiphenyl (Surr)	*73*		*48 - 126*	*10/18/24 11:39*	*10/18/24 22:30*	*1*
p-Terphenyl-d14 (Surr)	*81*		*48 - 130*	*10/18/24 11:39*	*10/18/24 22:30*	*1*

Method: SW846 8081B - Organochlorine Pesticides (GC) - TCLP

Analyte	Result	Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
Chlordane (technical)	ND		0.00050		mg/L		10/23/24 10:27	10/23/24 18:02	1
Endrin	ND		0.00010		mg/L		10/23/24 10:27	10/23/24 18:02	1
gamma-BHC (Lindane)	ND		0.000050		mg/L		10/23/24 10:27	10/23/24 18:02	1
Heptachlor	ND		0.000050		mg/L		10/23/24 10:27	10/23/24 18:02	1
Heptachlor epoxide	ND		0.000050		mg/L		10/23/24 10:27	10/23/24 18:02	1
Methoxychlor	ND		0.00050		mg/L		10/23/24 10:27	10/23/24 18:02	1
Toxaphene	ND		0.0050		mg/L		10/23/24 10:27	10/23/24 18:02	1

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
DCB Decachlorobiphenyl (Surr)	*108*		*50 - 130*	*10/23/24 10:27*	*10/23/24 18:02*	*1*

Client Sample ID: B-3 0-5'

Lab Sample ID: 705-9904-3

Date Collected: 10/10/24 13:29

Matrix: Solid

Date Received: 10/14/24 13:05

Method: SW846 8081B - Organochlorine Pesticides (GC) - TCLP (Continued)

Surrogate	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
Tetrachloro-m-xylene (Surr)	*110*		*46 - 120*	*10/23/24 10:27*	*10/23/24 18:02*	*1*

Method: SW846 6010D - Metals (ICP) - TCLP

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	ND		0.25	mg/L		10/18/24 14:32	10/18/24 17:07	1
Barium	ND		0.50	mg/L		10/18/24 14:32	10/18/24 17:07	1
Cadmium	**0.073**		0.025	mg/L		10/18/24 14:32	10/18/24 17:07	1
Chromium	ND		0.050	mg/L		10/18/24 14:32	10/18/24 17:07	1
Lead	**0.23**		0.050	mg/L		10/18/24 14:32	10/18/24 17:07	1
Selenium	ND		0.10	mg/L		10/18/24 14:32	10/18/24 17:07	1
Silver	ND		0.025	mg/L		10/18/24 14:32	10/18/24 17:07	1

Method: SW846 7470A - Mercury (CVAA) - TCLP

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	ND	^+	0.0050	mg/L		10/18/24 14:11	10/18/24 18:39	1

General Chemistry

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Ignitability (SW846 1030)	**N**			NONE			10/18/24 10:35	1
corrosivity by pH (SW846 9045D)	**7.6**	**HF**	0.01	SU			10/17/24 10:50	1
Temperature (SW846 9045D)	**21.8**	**HF**	0.01	Degrees C			10/17/24 10:50	1
Free Liquid (SW846 9095B)	**NEGATIVE**			NONE			10/16/24 13:02	1

Client Sample ID: B-3 0-5'

Lab Sample ID: 705-9904-3

Date Collected: 10/10/24 13:29

Matrix: Solid

Date Received: 10/14/24 13:05

Percent Solids: 88.8

Method: SW846 8270E SIM - Semivolatile Organic Compounds (GC/MS SIM)

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
1-Methylnaphthalene	ND		0.019	mg/Kg	☼	10/22/24 14:26	10/22/24 20:21	1
2-Methylnaphthalene	ND		0.019	mg/Kg	☼	10/22/24 14:26	10/22/24 20:21	1
Acenaphthene	ND		0.019	mg/Kg	☼	10/22/24 14:26	10/22/24 20:21	1
Acenaphthylene	ND		0.037	mg/Kg	☼	10/22/24 14:26	10/22/24 20:21	1
Anthracene	**0.029**		0.0019	mg/Kg	☼	10/22/24 14:26	10/22/24 20:21	1
Benzo[a]anthracene	**0.15**		0.0019	mg/Kg	☼	10/22/24 14:26	10/22/24 20:21	1
Benzo[a]pyrene	**0.15**		0.0019	mg/Kg	☼	10/22/24 14:26	10/22/24 20:21	1
Benzo[b]fluoranthene	**0.25**		0.0037	mg/Kg	☼	10/22/24 14:26	10/22/24 20:21	1
Benzo[g,h,i]perylene	**0.20**		0.0037	mg/Kg	☼	10/22/24 14:26	10/22/24 20:21	1
Benzo[k]fluoranthene	**0.078**		0.0019	mg/Kg	☼	10/22/24 14:26	10/22/24 20:21	1
Chrysene	**0.14**		0.0019	mg/Kg	☼	10/22/24 14:26	10/22/24 20:21	1
Dibenz(a,h)anthracene	**0.042**		0.0037	mg/Kg	☼	10/22/24 14:26	10/22/24 20:21	1
Fluoranthene	**0.23**		0.0037	mg/Kg	☼	10/22/24 14:26	10/22/24 20:21	1
Fluorene	**0.0074**		0.0037	mg/Kg	☼	10/22/24 14:26	10/22/24 20:21	1
Indeno[1,2,3-cd]pyrene	**0.16**		0.0019	mg/Kg	☼	10/22/24 14:26	10/22/24 20:21	1
Naphthalene	ND		0.019	mg/Kg	☼	10/22/24 14:26	10/22/24 20:21	1
Phenanthrene	**0.11**		0.0019	mg/Kg	☼	10/22/24 14:26	10/22/24 20:21	1
Pyrene	**0.25**		0.0019	mg/Kg	☼	10/22/24 14:26	10/22/24 20:21	1

Surrogate	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
p-Terphenyl-d14 (Surr)	*96*		*59 - 129*	*10/22/24 14:26*	*10/22/24 20:21*	*1*

Client Sample ID: B-4 0-5'
Date Collected: 10/10/24 10:45
Date Received: 10/14/24 13:05

Lab Sample ID: 705-9904-4
Matrix: Solid

Method: SW846 8260D - Volatile Organic Compounds by GC/MS - TCLP

Analyte	Result	Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
Benzene	ND		100		ug/L			10/17/24 15:20	20
Carbon tetrachloride	ND		100		ug/L			10/17/24 15:20	20
Chlorobenzene	ND		100		ug/L			10/17/24 15:20	20
Chloroform	ND		100		ug/L			10/17/24 15:20	20
1,2-Dichloroethane	ND		100		ug/L			10/17/24 15:20	20
1,1-Dichloroethene	ND		100		ug/L			10/17/24 15:20	20
2-Butanone	ND		1000		ug/L			10/17/24 15:20	20
Tetrachloroethene	ND		100		ug/L			10/17/24 15:20	20
Vinyl chloride	ND		100		ug/L			10/17/24 15:20	20
Trichloroethene	ND		100		ug/L			10/17/24 15:20	20

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
4-Bromofluorobenzene	*95*		*70 - 126*		*10/17/24 15:20*	*20*
Dibromofluoromethane (Surr)	*106*		*77 - 121*		*10/17/24 15:20*	*20*
Toluene-d8 (Surr)	*97*		*79 - 119*		*10/17/24 15:20*	*20*

Method: SW846 8270E - Semivolatile Organic Compounds (GC/MS) - TCLP

Analyte	Result	Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
2-Methylphenol	ND		0.10		mg/L		10/18/24 11:39	10/18/24 23:25	1
3 & 4 Methylphenol	ND		0.10		mg/L		10/18/24 11:39	10/18/24 23:25	1
2,4-Dinitrotoluene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 23:25	1
Hexachlorobenzene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 23:25	1
Hexachlorobutadiene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 23:25	1
Hexachloroethane	ND		0.10		mg/L		10/18/24 11:39	10/18/24 23:25	1
Nitrobenzene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 23:25	1
Pentachlorophenol	ND		0.25		mg/L		10/18/24 11:39	10/18/24 23:25	1
Pyridine	ND		0.10		mg/L		10/18/24 11:39	10/18/24 23:25	1
2,4,5-Trichlorophenol	ND		0.25		mg/L		10/18/24 11:39	10/18/24 23:25	1
2,4,6-Trichlorophenol	ND		0.10		mg/L		10/18/24 11:39	10/18/24 23:25	1
1,4-Dichlorobenzene	ND		0.10		mg/L		10/18/24 11:39	10/18/24 23:25	1

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
2,4,6-Tribromophenol (Surr)	*60*		*53 - 132*	*10/18/24 11:39*	*10/18/24 23:25*	*1*
2-Fluorophenol (Surr)	*69*		*29 - 120*	*10/18/24 11:39*	*10/18/24 23:25*	*1*
Nitrobenzene-d5 (Surr)	*75*		*41 - 129*	*10/18/24 11:39*	*10/18/24 23:25*	*1*
Phenol-d5 (Surr)				*10/18/24 11:39*	*10/18/24 23:25*	*1*
2-Fluorobiphenyl (Surr)	*71*		*48 - 126*	*10/18/24 11:39*	*10/18/24 23:25*	*1*
p-Terphenyl-d14 (Surr)	*79*		*48 - 130*	*10/18/24 11:39*	*10/18/24 23:25*	*1*

Method: SW846 8081B - Organochlorine Pesticides (GC) - TCLP

Analyte	Result	Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
Chlordane (technical)	ND		0.00050		mg/L		10/23/24 10:32	10/23/24 18:14	1
Endrin	ND		0.00010		mg/L		10/23/24 10:32	10/23/24 18:14	1
gamma-BHC (Lindane)	ND		0.000050		mg/L		10/23/24 10:32	10/23/24 18:14	1
Heptachlor	ND		0.000050		mg/L		10/23/24 10:32	10/23/24 18:14	1
Heptachlor epoxide	ND		0.000050		mg/L		10/23/24 10:32	10/23/24 18:14	1
Methoxychlor	ND		0.00050		mg/L		10/23/24 10:32	10/23/24 18:14	1
Toxaphene	ND		0.0050		mg/L		10/23/24 10:32	10/23/24 18:14	1

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
DCB Decachlorobiphenyl (Surr)	*140*	*S1+*	*50 - 130*	*10/23/24 10:32*	*10/23/24 18:14*	*1*

Client Sample ID: B-4 0-5'

Lab Sample ID: 705-9904-4

Date Collected: 10/10/24 10:45

Matrix: Solid

Date Received: 10/14/24 13:05

Method: SW846 8081B - Organochlorine Pesticides (GC) - TCLP (Continued)

Surrogate	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
Tetrachloro-m-xylene (Surr)	*113*		*46 - 120*	*10/23/24 10:32*	*10/23/24 18:14*	*1*

Method: SW846 6010D - Metals (ICP) - TCLP

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	ND		0.25	mg/L		10/18/24 14:32	10/18/24 17:10	1
Barium	ND		0.50	mg/L		10/18/24 14:32	10/18/24 17:10	1
Cadmium	ND		0.025	mg/L		10/18/24 14:32	10/18/24 17:10	1
Chromium	ND		0.050	mg/L		10/18/24 14:32	10/18/24 17:10	1
Lead	ND		0.050	mg/L		10/18/24 14:32	10/18/24 17:10	1
Selenium	ND		0.10	mg/L		10/18/24 14:32	10/18/24 17:10	1
Silver	ND		0.025	mg/L		10/18/24 14:32	10/18/24 17:10	1

Method: SW846 7470A - Mercury (CVAA) - TCLP

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	ND	^+	0.0050	mg/L		10/18/24 14:11	10/18/24 18:43	1

General Chemistry

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Ignitability (SW846 1030)	**N**			NONE			10/18/24 10:35	1
corrosivity by pH (SW846 9045D)	**5.6**	**HF**	0.01	SU			10/17/24 10:50	1
Temperature (SW846 9045D)	**21.8**	**HF**	0.01	Degrees C			10/17/24 10:50	1
Free Liquid (SW846 9095B)	**NEGATIVE**			NONE			10/16/24 13:02	1

Client Sample ID: B-4 0-5'

Lab Sample ID: 705-9904-4

Date Collected: 10/10/24 10:45

Matrix: Solid

Date Received: 10/14/24 13:05

Percent Solids: 92.5

Method: SW846 8270E SIM - Semivolatile Organic Compounds (GC/MS SIM)

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
1-Methylnaphthalene	ND		0.018	mg/Kg	☼	10/22/24 14:26	10/22/24 20:46	1
2-Methylnaphthalene	ND		0.018	mg/Kg	☼	10/22/24 14:26	10/22/24 20:46	1
Acenaphthene	ND		0.018	mg/Kg	☼	10/22/24 14:26	10/22/24 20:46	1
Acenaphthylene	ND		0.036	mg/Kg	☼	10/22/24 14:26	10/22/24 20:46	1
Anthracene	ND		0.0018	mg/Kg	☼	10/22/24 14:26	10/22/24 20:46	1
Benzo[a]anthracene	ND		0.0018	mg/Kg	☼	10/22/24 14:26	10/22/24 20:46	1
Benzo[a]pyrene	ND		0.0018	mg/Kg	☼	10/22/24 14:26	10/22/24 20:46	1
Benzo[b]fluoranthene	ND		0.0036	mg/Kg	☼	10/22/24 14:26	10/22/24 20:46	1
Benzo[g,h,i]perylene	ND		0.0036	mg/Kg	☼	10/22/24 14:26	10/22/24 20:46	1
Benzo[k]fluoranthene	ND		0.0018	mg/Kg	☼	10/22/24 14:26	10/22/24 20:46	1
Chrysene	ND		0.0018	mg/Kg	☼	10/22/24 14:26	10/22/24 20:46	1
Dibenz(a,h)anthracene	ND		0.0036	mg/Kg	☼	10/22/24 14:26	10/22/24 20:46	1
Fluoranthene	ND		0.0036	mg/Kg	☼	10/22/24 14:26	10/22/24 20:46	1
Fluorene	ND		0.0036	mg/Kg	☼	10/22/24 14:26	10/22/24 20:46	1
Indeno[1,2,3-cd]pyrene	ND		0.0018	mg/Kg	☼	10/22/24 14:26	10/22/24 20:46	1
Naphthalene	ND		0.018	mg/Kg	☼	10/22/24 14:26	10/22/24 20:46	1
Phenanthrene	ND		0.0018	mg/Kg	☼	10/22/24 14:26	10/22/24 20:46	1
Pyrene	ND		0.0018	mg/Kg	☼	10/22/24 14:26	10/22/24 20:46	1

Surrogate	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
p-Terphenyl-d14 (Surr)	*106*		*59 - 129*	*10/22/24 14:26*	*10/22/24 20:46*	*1*

Login Sample Receipt Checklist

Client: Terracon Consultants Inc

Job Number: 705-9904-1
SDG Number:

Login Number: 9904
List Number: 1
Creator: Pomuti, Carmen

List Source: Eurofins Atlanta

Question	Answer	Comment
Radioactivity wasn't checked or is </= background as measured by a survey meter.	True	
The cooler's custody seal, if present, is intact.	True	Not present
Sample custody seals, if present, are intact.	True	
The cooler or samples do not appear to have been compromised or tampered with.	True	
Samples were received on ice.	True	
Cooler Temperature is acceptable.	True	
Cooler Temperature is recorded.	True	
COC is present.	True	
COC is filled out in ink and legible.	True	
COC is filled out with all pertinent information.	True	
Is the Field Sampler's name present on COC?	True	
There are no discrepancies between the containers received and the COC.	True	
Samples are received within Holding Time (excluding tests with immediate HTs)	True	
Sample containers have legible labels.	True	
Containers are not broken or leaking.	True	
Sample collection date/times are provided.	True	
Appropriate sample containers are used.	True	
Sample bottles are completely filled.	True	
Sample Preservation Verified.	True	
There is sufficient vol. for all requested analyses, incl. any requested MS/MSDs	True	
Containers requiring zero headspace have no headspace or bubble is <6mm (1/4").	N/A	
Multiphasic samples are not present.	True	
Samples do not require splitting or compositing.	True	
Residual Chlorine Checked.	N/A	

Lab Chronicle

Client: Terracon Consultants Inc
Project/Site: RAFB B110

Job ID: 705-9904-1

Client Sample ID: B-1 0-5'

Lab Sample ID: 705-9904-1

Date Collected: 10/10/24 16:00

Matrix: Solid

Date Received: 10/14/24 13:05

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
TCLP	Leach	1311			16938	GB	EET ATL	10/15/24 18:32 - 10/16/24 10:35 [1]
TCLP	Analysis	8260D		20	17392	AG	EET ATL	10/17/24 14:35
TCLP	Leach	1311			17234	GB	EET ATL	10/17/24 19:15 - 10/18/24 11:15 [1]
TCLP	Prep	3510C			17160	TT	EET ATL	10/18/24 11:39
TCLP	Analysis	8270E		1	17832	YH	EET ATL	10/18/24 21:35
TCLP	Leach	1311			17234	GB	EET ATL	10/17/24 19:15 - 10/18/24 11:15 [1]
TCLP	Prep	3510C			18161	ZS	EET ATL	10/23/24 10:27
TCLP	Analysis	8081B		1	18464	NT	EET ATL	10/23/24 17:38
TCLP	Leach	1311			17234	GB	EET ATL	10/17/24 19:15 - 10/18/24 11:15 [1]
TCLP	Prep	3010A			17537	EF	EET ATL	10/18/24 14:32
TCLP	Analysis	6010D		1	17673	DS	EET ATL	10/18/24 16:55
TCLP	Leach	1311			17234	GB	EET ATL	10/17/24 19:15 - 10/18/24 11:15 [1]
TCLP	Prep	7470A			17544	GR	EET ATL	10/18/24 14:11
TCLP	Analysis	7470A		1	17622	GR	EET ATL	10/18/24 18:32
Total/NA	Analysis	1030		1	17489	IG	EET ATL	10/18/24 10:35
Total/NA	Analysis	9045D		1	17227	AH	EET ATL	10/17/24 10:50
Total/NA	Analysis	9095B		1	17078	IG	EET ATL	10/16/24 13:02
Total/NA	Analysis	D 2216		1	17111	ASA	EET ATL	10/16/24 11:44

Client Sample ID: B-1 0-5'

Lab Sample ID: 705-9904-1

Date Collected: 10/10/24 16:00

Matrix: Solid

Date Received: 10/14/24 13:05

Percent Solids: 94.0

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	3550C			17473	KE	EET ATL 2	10/18/24 11:24
Total/NA	Analysis	8270E SIM		1	17742	NHN	EET ATL	10/18/24 18:04

Client Sample ID: B-2 0-5'

Lab Sample ID: 705-9904-2

Date Collected: 10/10/24 14:54

Matrix: Solid

Date Received: 10/14/24 13:05

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
TCLP	Leach	1311			16938	GB	EET ATL	10/15/24 18:32 - 10/16/24 10:35 [1]
TCLP	Analysis	8260D		20	17392	AG	EET ATL	10/17/24 13:24
TCLP	Leach	1311			17234	GB	EET ATL	10/17/24 19:15 - 10/18/24 11:15 [1]
TCLP	Prep	3510C			17160	TT	EET ATL	10/18/24 11:39
TCLP	Analysis	8270E		1	17832	YH	EET ATL	10/18/24 22:02
TCLP	Leach	1311			17234	GB	EET ATL	10/17/24 19:15 - 10/18/24 11:15 [1]
TCLP	Prep	3510C			18161	ZS	EET ATL	10/23/24 10:27
TCLP	Analysis	8081B		1	18464	NT	EET ATL	10/23/24 17:50
TCLP	Leach	1311			17234	GB	EET ATL	10/17/24 19:15 - 10/18/24 11:15 [1]
TCLP	Prep	3010A			17537	EF	EET ATL	10/18/24 14:32
TCLP	Analysis	6010D		1	17673	DS	EET ATL	10/18/24 16:58

Lab Chronicle

Client: Terracon Consultants Inc
Project/Site: RAFB B110

Job ID: 705-9904-1

Client Sample ID: B-2 0-5'

Lab Sample ID: 705-9904-2

Date Collected: 10/10/24 14:54

Matrix: Solid

Date Received: 10/14/24 13:05

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
TCLP	Leach	1311			17234	GB	EET ATL	10/17/24 19:15 - 10/18/24 11:15 [1]
TCLP	Prep	7470A			17544	GR	EET ATL	10/18/24 14:11
TCLP	Analysis	7470A		1	17622	GR	EET ATL	10/18/24 18:36
Total/NA	Analysis	1030		1	17489	IG	EET ATL	10/18/24 10:35
Total/NA	Analysis	9045D		1	17227	AH	EET ATL	10/17/24 10:50
Total/NA	Analysis	9095B		1	17078	IG	EET ATL	10/16/24 13:02
Total/NA	Analysis	D 2216		1	17111	ASA	EET ATL	10/16/24 11:44

Client Sample ID: B-2 0-5'

Lab Sample ID: 705-9904-2

Date Collected: 10/10/24 14:54

Matrix: Solid

Date Received: 10/14/24 13:05

Percent Solids: 94.4

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	3550C			17473	KE	EET ATL 2	10/22/24 14:26
Total/NA	Analysis	8270E SIM		1	18181	NHN	EET ATL	10/22/24 19:57

Client Sample ID: B-3 0-5'

Lab Sample ID: 705-9904-3

Date Collected: 10/10/24 13:29

Matrix: Solid

Date Received: 10/14/24 13:05

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
TCLP	Leach	1311			16938	GB	EET ATL	10/15/24 18:32 - 10/16/24 10:35 [1]
TCLP	Analysis	8260D		20	17392	AG	EET ATL	10/17/24 14:57
TCLP	Leach	1311			17234	GB	EET ATL	10/17/24 19:15 - 10/18/24 11:15 [1]
TCLP	Prep	3510C			17160	TT	EET ATL	10/18/24 11:39
TCLP	Analysis	8270E		1	17832	YH	EET ATL	10/18/24 22:30
TCLP	Leach	1311			17234	GB	EET ATL	10/17/24 19:15 - 10/18/24 11:15 [1]
TCLP	Prep	3510C			18161	ZS	EET ATL	10/23/24 10:27
TCLP	Analysis	8081B		1	18464	NT	EET ATL	10/23/24 18:02
TCLP	Leach	1311			17234	GB	EET ATL	10/17/24 19:15 - 10/18/24 11:15 [1]
TCLP	Prep	3010A			17537	EF	EET ATL	10/18/24 14:32
TCLP	Analysis	6010D		1	17673	DS	EET ATL	10/18/24 17:07
TCLP	Leach	1311			17234	GB	EET ATL	10/17/24 19:15 - 10/18/24 11:15 [1]
TCLP	Prep	7470A			17544	GR	EET ATL	10/18/24 14:11
TCLP	Analysis	7470A		1	17622	GR	EET ATL	10/18/24 18:39
Total/NA	Analysis	1030		1	17489	IG	EET ATL	10/18/24 10:35
Total/NA	Analysis	9045D		1	17227	AH	EET ATL	10/17/24 10:50
Total/NA	Analysis	9095B		1	17078	IG	EET ATL	10/16/24 13:02
Total/NA	Analysis	D 2216		1	17111	ASA	EET ATL	10/16/24 11:44

Lab Chronicle

Client: Terracon Consultants Inc
Project/Site: RAFB B110

Job ID: 705-9904-1

Client Sample ID: B-3 0-5'

Lab Sample ID: 705-9904-3

Date Collected: 10/10/24 13:29
Matrix: Solid
Date Received: 10/14/24 13:05
Percent Solids: 88.8

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	3550C			17473	KE	EET ATL 2	10/22/24 14:26
Total/NA	Analysis	8270E SIM		1	18181	NHN	EET ATL	10/22/24 20:21

Client Sample ID: B-4 0-5'

Lab Sample ID: 705-9904-4

Date Collected: 10/10/24 10:45
Matrix: Solid
Date Received: 10/14/24 13:05

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
TCLP	Leach	1311			16938	GB	EET ATL	10/15/24 18:32 - 10/16/24 10:35 [1]
TCLP	Analysis	8260D		20	17392	AG	EET ATL	10/17/24 15:20
TCLP	Leach	1311			17234	GB	EET ATL	10/17/24 19:15 - 10/18/24 11:15 [1]
TCLP	Prep	3510C			17160	TT	EET ATL	10/18/24 11:39
TCLP	Analysis	8270E		1	17832	YH	EET ATL	10/18/24 23:25
TCLP	Leach	1311			17234	GB	EET ATL	10/17/24 19:15 - 10/18/24 11:15 [1]
TCLP	Prep	3510C			18161	ZS	EET ATL	10/23/24 10:32
TCLP	Analysis	8081B		1	18464	NT	EET ATL	10/23/24 18:14
TCLP	Leach	1311			17234	GB	EET ATL	10/17/24 19:15 - 10/18/24 11:15 [1]
TCLP	Prep	3010A			17537	EF	EET ATL	10/18/24 14:32
TCLP	Analysis	6010D		1	17673	DS	EET ATL	10/18/24 17:10
TCLP	Leach	1311			17234	GB	EET ATL	10/17/24 19:15 - 10/18/24 11:15 [1]
TCLP	Prep	7470A			17544	GR	EET ATL	10/18/24 14:11
TCLP	Analysis	7470A		1	17622	GR	EET ATL	10/18/24 18:43
Total/NA	Analysis	1030		1	17489	IG	EET ATL	10/18/24 10:35
Total/NA	Analysis	9045D		1	17227	AH	EET ATL	10/17/24 10:50
Total/NA	Analysis	9095B		1	17078	IG	EET ATL	10/16/24 13:02
Total/NA	Analysis	D 2216		1	17111	ASA	EET ATL	10/16/24 11:44

Client Sample ID: B-4 0-5'

Lab Sample ID: 705-9904-4

Date Collected: 10/10/24 10:45
Matrix: Solid
Date Received: 10/14/24 13:05
Percent Solids: 92.5

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	3550C			17473	KE	EET ATL 2	10/22/24 14:26
Total/NA	Analysis	8270E SIM		1	18181	NHN	EET ATL	10/22/24 20:46

[1] This procedure uses a method stipulated length of time for the process. Both start and end times are displayed.

Laboratory References:

EET ATL = Eurofins Atlanta, 3080 Presidential Dr, Atlanta, GA 30340, TEL (770)457-8177

EET ATL 2 = Eurofins Atlanta Building A, 3080 Presidential Pkwy, Atlanta, GA 30340, TEL (770)457-8177

Method: 8260D - Volatile Organic Compounds by GC/MS

Lab Sample ID: LCS 705-17392/2 ^20
Matrix: Solid
Analysis Batch: 17392

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits		
Benzene			400	363		ug/L		91	76 - 122		
Carbon tetrachloride			400	429		ug/L		107	72 - 133		
Chlorobenzene			400	360		ug/L		90	75 - 121		
Chloroform			400	386		ug/L		96	72 - 121		
1,2-Dichloroethane			400	377		ug/L		94	72 - 127		
1,1-Dichloroethene			400	378		ug/L		95	69 - 130		
2-Butanone			800	718		ug/L		90	74 - 131		
Tetrachloroethene			400	354		ug/L		89	74 - 129		
Vinyl chloride			400	435		ug/L		109	65 - 132		
Trichloroethene			400	360		ug/L		90	72 - 129		

Surrogate	*LCS %Recovery*	*LCS Qualifier*	*Limits*
4-Bromofluorobenzene	*100*		*70 - 126*
Dibromofluoromethane (Surr)	*107*		*77 - 121*
Toluene-d8 (Surr)	*105*		*79 - 119*

Lab Sample ID: MRL 705-17392/10
Matrix: Solid
Analysis Batch: 17392

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte			Spike Added	MRL Result	MRL Qualifier	Unit	D	%Rec	%Rec Limits		
2-Butanone			10.0	6.90	J	ug/L		69	50 - 150		

Surrogate	*MRL %Recovery*	*MRL Qualifier*	*Limits*
4-Bromofluorobenzene	*102*		*70 - 126*
Dibromofluoromethane (Surr)	*111*		*77 - 121*
Toluene-d8 (Surr)	*103*		*79 - 119*

Lab Sample ID: LB 705-16938/1-A ^20
Matrix: Solid
Analysis Batch: 17392

Client Sample ID: Method Blank
Prep Type: TCLP

Analyte	LB Result	LB Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
Benzene	ND		100		ug/L			10/17/24 11:54	20
Carbon tetrachloride	ND		100		ug/L			10/17/24 11:54	20
Chlorobenzene	ND		100		ug/L			10/17/24 11:54	20
Chloroform	ND		100		ug/L			10/17/24 11:54	20
1,2-Dichloroethane	ND		100		ug/L			10/17/24 11:54	20
1,1-Dichloroethene	ND		100		ug/L			10/17/24 11:54	20
2-Butanone	ND		1000		ug/L			10/17/24 11:54	20
Tetrachloroethene	ND		100		ug/L			10/17/24 11:54	20
Vinyl chloride	ND		100		ug/L			10/17/24 11:54	20
Trichloroethene	ND		100		ug/L			10/17/24 11:54	20

Surrogate	*LB %Recovery*	*LB Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
4-Bromofluorobenzene	*99*		*70 - 126*		*10/17/24 11:54*	*20*
Dibromofluoromethane (Surr)	*114*		*77 - 121*		*10/17/24 11:54*	*20*

Method: 8260D - Volatile Organic Compounds by GC/MS (Continued)

Lab Sample ID: LB 705-16938/1-A ^20
Matrix: Solid
Analysis Batch: 17392

Client Sample ID: Method Blank
Prep Type: TCLP

Surrogate	LB %Recovery	LB Qualifier	Limits	Prepared	Analyzed	Dil Fac
Toluene-d8 (Surr)	99		79 - 119		10/17/24 11:54	20

Lab Sample ID: 705-9904-4 MS
Matrix: Solid
Analysis Batch: 17392

Client Sample ID: B-4 0-5'
Prep Type: TCLP

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits
Benzene	ND		400	411		ug/L		102	71 - 133
Carbon tetrachloride	ND		400	475		ug/L		119	70 - 139
Chlorobenzene	ND		400	400		ug/L		99	78 - 128
Chloroform	ND		400	442		ug/L		109	68 - 132
1,2-Dichloroethane	ND		400	449		ug/L		112	70 - 133
1,1-Dichloroethene	ND		400	451		ug/L		113	69 - 139
2-Butanone	ND		800	732		ug/L		92	50 - 150
Tetrachloroethene	ND		400	401		ug/L		99	74 - 135
Vinyl chloride	ND		400	421		ug/L		105	66 - 138
Trichloroethene	ND		400	406		ug/L		102	77 - 136

Surrogate	MS %Recovery	MS Qualifier	Limits
4-Bromofluorobenzene	97		70 - 126
Dibromofluoromethane (Surr)	108		77 - 121
Toluene-d8 (Surr)	103		79 - 119

Lab Sample ID: 705-9904-4 MSD
Matrix: Solid
Analysis Batch: 17392

Client Sample ID: B-4 0-5'
Prep Type: TCLP

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Benzene	ND		420	401		ug/L		94	71 - 133	2	42
Carbon tetrachloride	ND		420	457		ug/L		109	70 - 139	4	22
Chlorobenzene	ND		420	404		ug/L		95	78 - 128	1	50
Chloroform	ND		420	433		ug/L		102	68 - 132	2	20
1,2-Dichloroethane	ND		420	448		ug/L		107	70 - 133	0	41
1,1-Dichloroethene	ND		420	475		ug/L		113	69 - 139	5	56
2-Butanone	ND		840	773		ug/L		92	50 - 150	5	20
Tetrachloroethene	ND		420	396		ug/L		93	74 - 135	1	20
Vinyl chloride	ND		420	418		ug/L		100	66 - 138	1	23
Trichloroethene	ND		420	402		ug/L		96	77 - 136	1	51

Surrogate	MSD %Recovery	MSD Qualifier	Limits
4-Bromofluorobenzene	99		70 - 126
Dibromofluoromethane (Surr)	105		77 - 121
Toluene-d8 (Surr)	103		79 - 119

Client: Terracon Consultants Inc
Project/Site: RAFB B110

Job ID: 705-9904-1

Method: 8270E - Semivolatile Organic Compounds (GC/MS)

Lab Sample ID: LCS 705-17160/2-A
Matrix: Solid
Analysis Batch: 17566

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 17160

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits		
2-Methylphenol			1.00	0.899		mg/L		90	66 - 130		
3 & 4 Methylphenol			2.00	1.75		mg/L		88	50 - 150		
2,4-Dinitrotoluene			1.00	0.841		mg/L		84	62 - 130		
Hexachlorobenzene			1.00	0.799		mg/L		80	70 - 130		
Hexachlorobutadiene			1.00	0.849		mg/L		85	51 - 125		
Hexachloroethane			1.00	0.898		mg/L		90	55 - 120		
Nitrobenzene			1.00	0.829		mg/L		83	68 - 130		
Pentachlorophenol			1.00	0.622		mg/L		62	51 - 130		
Pyridine			1.00	0.227		mg/L		23	10 - 120		
2,4,5-Trichlorophenol			1.00	0.783		mg/L		78	60 - 124		
2,4,6-Trichlorophenol			1.00	0.747		mg/L		75	69 - 129		
1,4-Dichlorobenzene			1.00	0.801		mg/L		80	56 - 128		

Surrogate	*LCS %Recovery*	*LCS Qualifier*	*Limits*
2,4,6-Tribromophenol (Surr)	*78*		*53 - 132*
2-Fluorophenol (Surr)	*80*		*29 - 120*
Nitrobenzene-d5 (Surr)	*74*		*41 - 129*
2-Fluorobiphenyl (Surr)	*72*		*48 - 126*
p-Terphenyl-d14 (Surr)	*77*		*48 - 130*

Lab Sample ID: LB 705-17071/1-E
Matrix: Solid
Analysis Batch: 17566

Client Sample ID: Method Blank
Prep Type: TCLP
Prep Batch: 17160

Analyte	LB Result	LB Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
2-Methylphenol	ND		0.10		mg/L		10/17/24 11:39	10/18/24 02:44	1
3 & 4 Methylphenol	ND		0.10		mg/L		10/17/24 11:39	10/18/24 02:44	1
2,4-Dinitrotoluene	ND		0.10		mg/L		10/17/24 11:39	10/18/24 02:44	1
Hexachlorobenzene	ND		0.10		mg/L		10/17/24 11:39	10/18/24 02:44	1
Hexachlorobutadiene	ND		0.10		mg/L		10/17/24 11:39	10/18/24 02:44	1
Hexachloroethane	ND		0.10		mg/L		10/17/24 11:39	10/18/24 02:44	1
Nitrobenzene	ND		0.10		mg/L		10/17/24 11:39	10/18/24 02:44	1
Pentachlorophenol	ND		0.25		mg/L		10/17/24 11:39	10/18/24 02:44	1
Pyridine	ND		0.10		mg/L		10/17/24 11:39	10/18/24 02:44	1
2,4,5-Trichlorophenol	ND		0.25		mg/L		10/17/24 11:39	10/18/24 02:44	1
2,4,6-Trichlorophenol	ND		0.10		mg/L		10/17/24 11:39	10/18/24 02:44	1
1,4-Dichlorobenzene	ND		0.10		mg/L		10/17/24 11:39	10/18/24 02:44	1

Surrogate	*LB %Recovery*	*LB Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
2,4,6-Tribromophenol (Surr)	*67*		*53 - 132*	*10/17/24 11:39*	*10/18/24 02:44*	*1*
2-Fluorophenol (Surr)	*82*		*29 - 120*	*10/17/24 11:39*	*10/18/24 02:44*	*1*
Nitrobenzene-d5 (Surr)	*64*		*41 - 129*	*10/17/24 11:39*	*10/18/24 02:44*	*1*
Phenol-d5 (Surr)				*10/17/24 11:39*	*10/18/24 02:44*	*1*
2-Fluorobiphenyl (Surr)	*71*		*48 - 126*	*10/17/24 11:39*	*10/18/24 02:44*	*1*
p-Terphenyl-d14 (Surr)	*79*		*48 - 130*	*10/17/24 11:39*	*10/18/24 02:44*	*1*

Method: 8270E - Semivolatile Organic Compounds (GC/MS) (Continued)

Lab Sample ID: 705-10016-A-3-G MS
Matrix: Solid
Analysis Batch: 17566

Client Sample ID: Matrix Spike
Prep Type: TCLP
Prep Batch: 17160

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits
2-Methylphenol	ND	F1	1.00	0.170	F1	mg/L		17	50 - 120
3 & 4 Methylphenol	ND	F1	2.00	0.248	F1	mg/L		12	50 - 150
2,4-Dinitrotoluene	ND		1.00	0.830		mg/L		83	50 - 130
Hexachlorobenzene	ND		1.00	0.825		mg/L		82	54 - 130
Hexachlorobutadiene	ND		1.00	0.888		mg/L		89	45 - 130
Hexachloroethane	ND		1.00	0.917		mg/L		92	50 - 150
Nitrobenzene	ND		1.00	0.774		mg/L		77	56 - 135
Pentachlorophenol	ND		1.00	0.595		mg/L		60	45 - 117
Pyridine	ND	F1	1.00	0.144	F1	mg/L		14	50 - 150
2,4,5-Trichlorophenol	ND		1.00	0.720		mg/L		72	53 - 128
2,4,6-Trichlorophenol	ND		1.00	0.764		mg/L		76	54 - 132
1,4-Dichlorobenzene	ND		1.00	0.792		mg/L		79	48 - 130

Surrogate	*MS %Recovery*	*MS Qualifier*	*Limits*
2,4,6-Tribromophenol (Surr)	*76*		*53 - 132*
2-Fluorophenol (Surr)	*56*		*29 - 120*
Nitrobenzene-d5 (Surr)	*76*		*41 - 129*
2-Fluorobiphenyl (Surr)	*77*		*48 - 126*
p-Terphenyl-d14 (Surr)	*80*		*48 - 130*

Lab Sample ID: 705-10016-A-3-H DU
Matrix: Solid
Analysis Batch: 17566

Client Sample ID: Duplicate
Prep Type: TCLP
Prep Batch: 17160

Analyte	Sample Result	Sample Qualifier	DU Result	DU Qualifier	Unit	D	RPD	RPD Limit
2-Methylphenol	ND	F1	ND		mg/L		NC	
3 & 4 Methylphenol	ND	F1	ND		mg/L		NC	
2,4-Dinitrotoluene	ND		ND		mg/L		NC	
Hexachlorobenzene	ND		ND		mg/L		NC	
Hexachlorobutadiene	ND		ND		mg/L		NC	
Hexachloroethane	ND		ND		mg/L		NC	
Nitrobenzene	ND		ND		mg/L		NC	
Pentachlorophenol	ND		ND		mg/L		NC	
Pyridine	ND	F1	ND		mg/L		NC	
2,4,5-Trichlorophenol	ND		ND		mg/L		NC	
2,4,6-Trichlorophenol	ND		ND		mg/L		NC	
1,4-Dichlorobenzene	ND		ND		mg/L		NC	

Surrogate	*DU %Recovery*	*DU Qualifier*	*Limits*
2,4,6-Tribromophenol (Surr)	*67*		*53 - 132*
2-Fluorophenol (Surr)	*52*		*29 - 120*
Nitrobenzene-d5 (Surr)	*72*		*41 - 129*
Phenol-d5 (Surr)			
2-Fluorobiphenyl (Surr)	*71*		*48 - 126*
p-Terphenyl-d14 (Surr)	*81*		*48 - 130*

Method: 8270E SIM - Semivolatile Organic Compounds (GC/MS SIM)

Lab Sample ID: MB 705-17473/1-A
Matrix: Solid
Analysis Batch: 17742

Client Sample ID: Method Blank
Prep Type: Total/NA
Prep Batch: 17473

Analyte	MB Result	MB Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
1-Methylnaphthalene	ND		0.017		mg/Kg		10/18/24 11:24	10/18/24 17:14	1
2-Methylnaphthalene	ND		0.017		mg/Kg		10/18/24 11:24	10/18/24 17:14	1
Acenaphthene	ND		0.017		mg/Kg		10/18/24 11:24	10/18/24 17:14	1
Acenaphthylene	ND		0.033		mg/Kg		10/18/24 11:24	10/18/24 17:14	1
Anthracene	ND		0.0017		mg/Kg		10/18/24 11:24	10/18/24 17:14	1
Benzo[a]anthracene	ND		0.0017		mg/Kg		10/18/24 11:24	10/18/24 17:14	1
Benzo[a]pyrene	ND		0.0017		mg/Kg		10/18/24 11:24	10/18/24 17:14	1
Benzo[b]fluoranthene	ND		0.0033		mg/Kg		10/18/24 11:24	10/18/24 17:14	1
Benzo[g,h,i]perylene	ND		0.0033		mg/Kg		10/18/24 11:24	10/18/24 17:14	1
Benzo[k]fluoranthene	ND		0.0017		mg/Kg		10/18/24 11:24	10/18/24 17:14	1
Chrysene	ND		0.0017		mg/Kg		10/18/24 11:24	10/18/24 17:14	1
Dibenz(a,h)anthracene	ND		0.0033		mg/Kg		10/18/24 11:24	10/18/24 17:14	1
Fluoranthene	ND		0.0033		mg/Kg		10/18/24 11:24	10/18/24 17:14	1
Fluorene	ND		0.0033		mg/Kg		10/18/24 11:24	10/18/24 17:14	1
Indeno[1,2,3-cd]pyrene	ND		0.0017		mg/Kg		10/18/24 11:24	10/18/24 17:14	1
Naphthalene	ND		0.017		mg/Kg		10/18/24 11:24	10/18/24 17:14	1
Phenanthrene	ND		0.0017		mg/Kg		10/18/24 11:24	10/18/24 17:14	1
Pyrene	ND		0.0017		mg/Kg		10/18/24 11:24	10/18/24 17:14	1

Surrogate	*MB %Recovery*	*MB Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
p-Terphenyl-d14 (Surr)	*108*		*59 - 129*	*10/18/24 11:24*	*10/18/24 17:14*	*1*

Lab Sample ID: LCS 705-17473/2-A
Matrix: Solid
Analysis Batch: 17742

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 17473

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits		
1-Methylnaphthalene			0.0667	0.0760		mg/Kg		114	65 - 121		
2-Methylnaphthalene			0.0667	0.0629		mg/Kg		94	64 - 117		
Acenaphthene			0.0667	0.0638		mg/Kg		96	64 - 120		
Acenaphthylene			0.0667	0.0620		mg/Kg		93	66 - 120		
Anthracene			0.0667	0.0666		mg/Kg		100	65 - 120		
Benzo[a]anthracene			0.0667	0.0645		mg/Kg		97	67 - 130		
Benzo[a]pyrene			0.0667	0.0634		mg/Kg		95	68 - 122		
Benzo[b]fluoranthene			0.0667	0.0557		mg/Kg		84	63 - 127		
Benzo[g,h,i]perylene			0.0667	0.0660		mg/Kg		99	65 - 126		
Benzo[k]fluoranthene			0.0667	0.0791		mg/Kg		119	67 - 133		
Chrysene			0.0667	0.0706		mg/Kg		106	71 - 124		
Dibenz(a,h)anthracene			0.0667	0.0659		mg/Kg		99	70 - 130		
Fluoranthene			0.0667	0.0688		mg/Kg		103	68 - 128		
Fluorene			0.0667	0.0646		mg/Kg		97	68 - 120		
Indeno[1,2,3-cd]pyrene			0.0667	0.0653		mg/Kg		98	68 - 121		
Naphthalene			0.0667	0.0637		mg/Kg		95	63 - 120		
Phenanthrene			0.0667	0.0616		mg/Kg		92	66 - 122		
Pyrene			0.0667	0.0717		mg/Kg		108	66 - 128		

Surrogate	*LCS %Recovery*	*LCS Qualifier*	*Limits*
p-Terphenyl-d14 (Surr)	*107*		*59 - 129*

Method: 8270E SIM - Semivolatile Organic Compounds (GC/MS SIM)

Lab Sample ID: 705-9904-1 MS
Matrix: Solid
Analysis Batch: 17742

Client Sample ID: B-1 0-5'
Prep Type: Total/NA
Prep Batch: 17473

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits
1-Methylnaphthalene	ND		0.0710	0.0838		mg/Kg	☼	118	50 - 121
2-Methylnaphthalene	ND		0.0710	0.0654		mg/Kg	☼	92	50 - 119
Acenaphthene	ND		0.0710	0.0686		mg/Kg	☼	97	54 - 121
Acenaphthylene	ND		0.0710	0.0650		mg/Kg	☼	92	52 - 131
Anthracene	ND		0.0710	0.0693		mg/Kg	☼	98	58 - 124
Benzo[a]anthracene	ND		0.0710	0.0786		mg/Kg	☼	111	58 - 132
Benzo[a]pyrene	ND		0.0710	0.0698		mg/Kg	☼	98	52 - 129
Benzo[b]fluoranthene	ND		0.0710	0.0677		mg/Kg	☼	95	53 - 130
Benzo[g,h,i]perylene	ND		0.0710	0.0591		mg/Kg	☼	83	51 - 130
Benzo[k]fluoranthene	ND		0.0710	0.0820		mg/Kg	☼	116	53 - 130
Chrysene	ND		0.0710	0.0672		mg/Kg	☼	95	57 - 129
Dibenz(a,h)anthracene	ND		0.0710	0.0704		mg/Kg	☼	99	52 - 130
Fluoranthene	ND		0.0710	0.0741		mg/Kg	☼	104	55 - 129
Fluorene	ND		0.0710	0.0667		mg/Kg	☼	94	50 - 127
Indeno[1,2,3-cd]pyrene	ND		0.0710	0.0628		mg/Kg	☼	88	51 - 129
Naphthalene	ND		0.0710	0.0673		mg/Kg	☼	95	51 - 120
Phenanthrene	ND		0.0710	0.0700		mg/Kg	☼	99	52 - 133
Pyrene	ND		0.0710	0.0793		mg/Kg	☼	112	58 - 129

Surrogate	*MS %Recovery*	*MS Qualifier*	*Limits*
p-Terphenyl-d14 (Surr)	*109*		*59 - 129*

Lab Sample ID: 705-9904-1 MSD
Matrix: Solid
Analysis Batch: 17742

Client Sample ID: B-1 0-5'
Prep Type: Total/NA
Prep Batch: 17473

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
1-Methylnaphthalene	ND		0.0710	0.0701		mg/Kg	☼	99	50 - 121	18	30
2-Methylnaphthalene	ND		0.0710	0.0654		mg/Kg	☼	92	50 - 119	0	33
Acenaphthene	ND		0.0710	0.0691		mg/Kg	☼	97	54 - 121	1	27
Acenaphthylene	ND		0.0710	0.0681		mg/Kg	☼	96	52 - 131	5	37
Anthracene	ND		0.0710	0.0713		mg/Kg	☼	101	58 - 124	3	25
Benzo[a]anthracene	ND		0.0710	0.0767		mg/Kg	☼	108	58 - 132	2	33
Benzo[a]pyrene	ND		0.0710	0.0713		mg/Kg	☼	100	52 - 129	2	38
Benzo[b]fluoranthene	ND		0.0710	0.0699		mg/Kg	☼	98	53 - 130	3	39
Benzo[g,h,i]perylene	ND		0.0710	0.0623		mg/Kg	☼	88	51 - 130	5	33
Benzo[k]fluoranthene	ND		0.0710	0.0839		mg/Kg	☼	118	53 - 130	2	37
Chrysene	ND		0.0710	0.0699		mg/Kg	☼	99	57 - 129	4	27
Dibenz(a,h)anthracene	ND		0.0710	0.0612		mg/Kg	☼	86	52 - 130	14	30
Fluoranthene	ND		0.0710	0.0741		mg/Kg	☼	104	55 - 129	0	45
Fluorene	ND		0.0710	0.0691		mg/Kg	☼	97	50 - 127	4	37
Indeno[1,2,3-cd]pyrene	ND		0.0710	0.0613		mg/Kg	☼	86	51 - 129	2	32
Naphthalene	ND		0.0710	0.0684		mg/Kg	☼	96	51 - 120	2	26
Phenanthrene	ND		0.0710	0.0696		mg/Kg	☼	98	52 - 133	1	54
Pyrene	ND		0.0710	0.0753		mg/Kg	☼	106	58 - 129	5	30

Surrogate	*MSD %Recovery*	*MSD Qualifier*	*Limits*
p-Terphenyl-d14 (Surr)	*109*		*59 - 129*

Method: 8081B - Organochlorine Pesticides (GC)

Lab Sample ID: LCS 705-18161/2-A
Matrix: Solid
Analysis Batch: 18464

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 18161

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits		
Endrin			0.00800	0.00870		mg/L		109	77 - 137		
gamma-BHC (Lindane)			0.00800	0.00867		mg/L		108	69 - 123		
Heptachlor			0.00800	0.00872		mg/L		109	66 - 134		
Heptachlor epoxide			0.00800	0.00739		mg/L		92	75 - 139		
Methoxychlor			0.0280	0.0304		mg/L		108	59 - 135		

Surrogate	*LCS %Recovery*	*LCS Qualifier*	*Limits*
DCB Decachlorobiphenyl (Surr)	*107*		*50 - 130*
Tetrachloro-m-xylene (Surr)	*102*		*46 - 120*

Lab Sample ID: LB 705-17234/1-C
Matrix: Solid
Analysis Batch: 18464

Client Sample ID: Method Blank
Prep Type: TCLP
Prep Batch: 18161

Analyte	LB Result	LB Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
Chlordane (technical)	ND		0.00050		mg/L		10/23/24 10:27	10/23/24 13:44	1
Endrin	ND		0.00010		mg/L		10/23/24 10:27	10/23/24 13:44	1
gamma-BHC (Lindane)	ND		0.000050		mg/L		10/23/24 10:27	10/23/24 13:44	1
Heptachlor	ND		0.000050		mg/L		10/23/24 10:27	10/23/24 13:44	1
Heptachlor epoxide	ND		0.000050		mg/L		10/23/24 10:27	10/23/24 13:44	1
Methoxychlor	ND		0.00050		mg/L		10/23/24 10:27	10/23/24 13:44	1
Toxaphene	ND		0.0050		mg/L		10/23/24 10:27	10/23/24 13:44	1

Surrogate	*LB %Recovery*	*LB Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
DCB Decachlorobiphenyl (Surr)	*103*		*50 - 130*	*10/23/24 10:27*	*10/23/24 13:44*	*1*
Tetrachloro-m-xylene (Surr)	*98*		*46 - 120*	*10/23/24 10:27*	*10/23/24 13:44*	*1*

Lab Sample ID: 705-9901-A-1-G MS
Matrix: Solid
Analysis Batch: 18464

Client Sample ID: Matrix Spike
Prep Type: TCLP
Prep Batch: 18161

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits		
Endrin	ND		0.00800	0.00860		mg/L		107	67 - 136		
gamma-BHC (Lindane)	ND		0.00800	0.00854		mg/L		107	59 - 127		
Heptachlor	ND		0.00800	0.00832		mg/L		104	59 - 132		
Heptachlor epoxide	ND		0.00800	0.00735		mg/L		92	61 - 129		
Methoxychlor	ND		0.0280	0.0279		mg/L		100	57 - 135		

Surrogate	*MS %Recovery*	*MS Qualifier*	*Limits*
DCB Decachlorobiphenyl (Surr)	*115*		*50 - 130*
Tetrachloro-m-xylene (Surr)	*115*		*46 - 120*

Lab Sample ID: 705-9899-A-1-L DU
Matrix: Solid
Analysis Batch: 18464

Client Sample ID: Duplicate
Prep Type: TCLP
Prep Batch: 18161

Analyte	Sample Result	Sample Qualifier		DU Result	DU Qualifier	Unit	D			RPD	RPD Limit
Chlordane (technical)	ND			ND		mg/L				NC	30

Method: 8081B - Organochlorine Pesticides (GC) (Continued)

Lab Sample ID: 705-9899-A-1-L DU
Matrix: Solid
Analysis Batch: 18464

Client Sample ID: Duplicate
Prep Type: TCLP
Prep Batch: 18161

Analyte	Sample Result	Sample Qualifier	DU Result	DU Qualifier	Unit	D	RPD	RPD Limit
Endrin	ND		ND		mg/L		NC	17
gamma-BHC (Lindane)	ND		ND		mg/L		NC	26
Heptachlor	ND		ND		mg/L		NC	24
Heptachlor epoxide	ND		ND		mg/L		NC	30
Methoxychlor	ND		ND		mg/L		NC	30
Toxaphene	ND		ND		mg/L		NC	30

Surrogate	*DU %Recovery*	*DU Qualifier*	*Limits*
DCB Decachlorobiphenyl (Surr)	*124*		*50 - 130*
Tetrachloro-m-xylene (Surr)	*108*		*46 - 120*

Method: 6010D - Metals (ICP)

Lab Sample ID: LCS 705-17537/2-A
Matrix: Solid
Analysis Batch: 17673

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 17537

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Arsenic	5.00	4.91		mg/L		98	80 - 120
Barium	5.00	4.76		mg/L		95	80 - 120
Cadmium	5.00	4.96		mg/L		99	80 - 120
Chromium	5.00	4.68		mg/L		94	80 - 120
Lead	5.00	4.64		mg/L		93	80 - 120
Selenium	5.00	4.94		mg/L		99	80 - 120
Silver	0.500	0.484		mg/L		97	80 - 120

Lab Sample ID: LB 705-17234/1-B
Matrix: Solid
Analysis Batch: 17673

Client Sample ID: Method Blank
Prep Type: TCLP
Prep Batch: 17537

Analyte	LB Result	LB Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	ND		0.25	mg/L		10/18/24 14:32	10/18/24 16:05	1
Barium	ND		0.50	mg/L		10/18/24 14:32	10/18/24 16:05	1
Cadmium	ND		0.025	mg/L		10/18/24 14:32	10/18/24 16:05	1
Chromium	ND		0.050	mg/L		10/18/24 14:32	10/18/24 16:05	1
Lead	ND		0.050	mg/L		10/18/24 14:32	10/18/24 16:05	1
Selenium	ND		0.10	mg/L		10/18/24 14:32	10/18/24 16:05	1
Silver	ND		0.025	mg/L		10/18/24 14:32	10/18/24 16:05	1

Lab Sample ID: 705-9899-A-1-E MS
Matrix: Solid
Analysis Batch: 17673

Client Sample ID: Matrix Spike
Prep Type: TCLP
Prep Batch: 17537

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits
Arsenic	ND		5.00	4.87		mg/L		97	50 - 150
Barium	ND		5.00	4.98		mg/L		94	50 - 150
Cadmium	ND		5.00	4.92		mg/L		98	50 - 150
Chromium	ND		5.00	4.65		mg/L		93	50 - 150
Lead	ND		5.00	4.61		mg/L		92	50 - 150

Method: 6010D - Metals (ICP) (Continued)

Lab Sample ID: 705-9899-A-1-E MS
Matrix: Solid
Analysis Batch: 17673

Client Sample ID: Matrix Spike
Prep Type: TCLP
Prep Batch: 17537

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits
Selenium	ND		5.00	4.89		mg/L		97	50 - 150
Silver	ND		0.500	0.481		mg/L		96	50 - 150

Lab Sample ID: 705-9899-A-1-F MSD
Matrix: Solid
Analysis Batch: 17673

Client Sample ID: Matrix Spike Duplicate
Prep Type: TCLP
Prep Batch: 17537

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Arsenic	ND		5.00	4.97		mg/L		99	50 - 150	2	30
Barium	ND		5.00	5.01		mg/L		95	50 - 150	1	30
Cadmium	ND		5.00	4.96		mg/L		99	50 - 150	1	30
Chromium	ND		5.00	4.70		mg/L		94	50 - 150	1	30
Lead	ND		5.00	4.67		mg/L		93	50 - 150	1	30
Selenium	ND		5.00	4.99		mg/L		99	50 - 150	2	30
Silver	ND		0.500	0.483		mg/L		97	50 - 150	0	30

Method: 7470A - Mercury (CVAA)

Lab Sample ID: LCS 705-17544/2-A
Matrix: Solid
Analysis Batch: 17622

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 17544

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Mercury	0.0400	0.0417	^+	mg/L		104	80 - 120

Lab Sample ID: LB 705-17349/1-C
Matrix: Solid
Analysis Batch: 17622

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	LB Result	LB Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	ND	^+	0.00050	mg/L			10/18/24 17:37	1

Lab Sample ID: 705-9899-A-1-I MS
Matrix: Solid
Analysis Batch: 17622

Client Sample ID: Matrix Spike
Prep Type: TCLP
Prep Batch: 17544

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits
Mercury	ND	^+	0.0400	0.0446	^+	mg/L		112	75 - 125

Lab Sample ID: 705-9899-A-1-J MSD
Matrix: Solid
Analysis Batch: 17622

Client Sample ID: Matrix Spike Duplicate
Prep Type: TCLP
Prep Batch: 17544

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Mercury	ND	^+	0.0400	0.0394	^+	mg/L		98	75 - 125	13	20

Client: Terracon Consultants Inc
Project/Site: RAFB B110

Job ID: 705-9904-1

Method: 9045D - pH

Lab Sample ID: 705-9718-A-1 DU
Matrix: Solid
Analysis Batch: 17227

Client Sample ID: Duplicate
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier		DU Result	DU Qualifier	Unit	D			RPD	RPD Limit
corrosivity by pH	8.7			8.6		SU				1	10
Temperature	21.3			21.4		Degrees C				0.5	10

Lab Sample ID: 705-9975-A-1 DU
Matrix: Solid
Analysis Batch: 17227

Client Sample ID: Duplicate
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier		DU Result	DU Qualifier	Unit	D			RPD	RPD Limit
corrosivity by pH	8.9			9.1		SU				2	10
Temperature	21.7			21.9		Degrees C				0.9	10

Method: 9095B - Paint Filter (Presence/Absence)

Lab Sample ID: 705-9899-A-1 DU
Matrix: Solid
Analysis Batch: 17078

Client Sample ID: Duplicate
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier		DU Result	DU Qualifier	Unit	D			RPD	RPD Limit
Free Liquid	NEGATIVE			NEGATIVE		NONE				NC	

Accreditation/Certification Summary

Client: Terracon Consultants Inc
Project/Site: RAFB B110

Job ID: 705-9904-1

Laboratory: Eurofins Atlanta

Unless otherwise noted, all analytes for this laboratory were covered under each accreditation/certification below.

Authority	Program	Identification Number	Expiration Date
Florida	NELAP	E87582	06-30-25

The following analytes are included in this report, but the laboratory is not certified by the governing authority. This list may include analytes for which the agency does not offer certification.

Analysis Method	Prep Method	Matrix	Analyte
9045D		Solid	Temperature
D 2216		Solid	Percent Moisture

END OF REPORT

WEIGHT RECORD
HOUSTON COUNTY LANDFILL

AUDIT NO. 1802639

TICKET NO.: 1494967

ORIGIN CODE:5 ROBINS AF BASE

DESTINATION:D1 MSW LANDFILL ACCOUNT ID : 1505

TRUCK NO.:FE CUSTOMER: FIRST ENVIRONMENTAL

ADDRESS1: 1266 SIXTH STREET

GROSS: 12160 LBS 11:46 AM 11/22/2024 CITY: MACON

TARE: 9520 LBS 11:59 AM 11/22/2024 STATE: GA

NET: 2640 LBS (1.32) TONS ZIP: 31206

COMMODITY: 08 PROFILED WASTE

I CERTIFY THAT THE MATERIAL BEING DISPOSED OF IS NON-HAZARDOUS MUNICIPAL SOLID WASTE AS DEFINED BY GEORGIA DNR/EPD RULE 391-3-4.01.

COMMENTS: 688

WEIGHER SIGNATURE

CUSTOMER SIGNATURE

Houston County MSW Landfill
2018 Kings Chapel Road
Perry, Georgia 31069
Telephone: (478) 987-0089

Profile No. 688
(Assigned to SWAA)

WASTE SHIPMENT TRACKING DOCUMENT

Generator Name:	Robins Air Force Base	**Contact:**	Jessy Parker
Address:	78th CEG/CEIE 775 Macon Street, Building 155; Building 1555; Robins AFB, GA 31098-2201		
Telephone:	770-826-7340	**Fax:**	
Description of Waste:	Excess soil boring cuttings		
Location of Waste:	Building 110		
Date Shipped:	11/22/24	**Quantity Shipped:**	(4) 55-gallon drums

Certification: I certify the waste described above is the waste represented by the Special Waste Acceptance Application (SWAA) of the same Profile Number and no regulated hazardous waste has been introduced into the waste.

Generator's Signature: Jessy Parker Date: 11/08/2024

Transporter: First Environmental Contact:
Address: 1866 6th St Macon, GA 31206
Telephone: 478.297.2742

Certification: I certify no regulated hazardous waste was introduced into the waste while in my custody:

Hauler's Signature: [signature] Date: 11/22/2

Waste Disposal Site: Houston County MSW Landfill
Quantity Received: 2640 lbs

Certification: I certify receipt and proper disposal of the Special Waste Profiled materials covered by this manifest.

Operator's Printed Name: Sherry Fullman
Operator's Signature: S Fullman Date: 11/22/24

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CREATE AMAZING.