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Wilmington District

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Construct SOF Group Headquarters

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SECTION 25 05 11.01

CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS
11/17

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 are available online at the Information Assurance Support Environment (IASE) website at http://iase.disa.mil/stigs/Pages/index.aspx. Not all control system components have applicable STIGs or SRGs.

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.

1.2 RELATED REQUIREMENTS

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.

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	(2016; INT 1 2016; ERTA 1 2016) 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

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 Computer

As used in this Section, 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 OS, where Android is considered separate from Linux

e. a device running a version of Apple iOS

1.4.2 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 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).

Any device that supports wireless communication is network connected, regardless of whether the device is communicating using wireless.

1.4.3 User Account Support Levels

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

1.4.3.1 FULLY Supported

Device supports configurable individual accounts. Accounts can be created, deleted, modified, etc. Privileges can be assigned to accounts.

1.4.3.2 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 "user name and password" structure).

1.4.3.3 NOT Supported

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

1.4.4 User Interface

Generally, a user interface is hardware on a device allowing user interaction with that device via input (buttons, switches, sliders, keyboard, touch screen, etc.) and a screen. There are three types of user interfaces defined in this Section: Limited Local User Interface, Full Local User Interface and Remote User Interface. In this Section, when the term "User Interface" is used without specifying which type, it refers only to Full Local User Interface and Remote User Interface (NOT to Limited Local User Interface).

1.4.4.1 Limited Local User Interface

A Limited Local User Interface is a user interface where the interaction is limited, fixed at the factory, and cannot be modified in the field. The user must be physically at the device to interact with it.

Examples of Limited Local User Interface include thermostats (Space Sensor Modules as defined in Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS.

1.4.4.2 Full Local User Interface

A Full Local User Interface is a user interface where the interaction and displays are field-configurable.

Examples of a Full Local User Interface include local applications on a computer and user interfaces to Variable Speed Drives.

1.4.4.3 Remote User Interface

A Remote User Interface is a user interface on a Client device allowing user interaction with a different Server device. The user need not be physically at the Server device to interact with it.

Examples of Remote User Interfaces include web browsers and Local Display Panels as defined in Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS.

1.5 ADMINISTRATIVE REQUIREMENTS

1.5.1 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 communication, the Wireless Communication Request submittal must be approved prior to control system device selection and integration.

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 integration.

c. If requesting permission for the use of a device with multiple IP connections, the Multiple IP Connection Device Request must be

approved prior to control system device selection and integration.

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. 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, HTTP web server certificates must be obtained from the indicated contact for the project site.

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

1.6 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance with Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Device Account Lock Exception Request; G

Multiple IP Connection Device Request; G

Contractor Computer Cybersecurity Compliance Statements; G

Contractor Temporary Network Cybersecurity Compliance Statements; G

SD-02 Shop Drawings

User Interface Banner Schedule; G

Network Communication Report; G

Cybersecurity Riser Diagram; G

Control System Inventory Report; G

SD-03 Product Data

Control System Cybersecurity Documentation; G

SD-07 Certificates

Software Licenses; G

SD-11 Closeout Submittals

Password Summary Report; G

Software Recovery And Reconstitution Images; G

Device Audit Record Upload Software; G

1.7 QUALITY CONTROL

1.7.1 Control System Cybersecurity Subject Matter Expert

The individual will oversee all work within this specification. This position requires that the individual currently meet Information Assurance Manager Level II Certification requirements in accordance with DoDI 8570 Information Workforce Improvement Program.

Individuals for this poistion should have experience securing DoD systems and with Risk Management Framework. Control System experience is highly desirable.

Resumes should be submitted to the Government within 14 days after notice to proceed. All certifications must be in effect prior to beginning work.

This position may serve across the contract for all control systems. There is no requirement to have one Cybersecurity SME per platform.

1.8 CYBERSECURITY DOCUMENTATION

1.8.1 Network Communication Report

{For Reference Only: This subpart (and its subparts) relates to CA-9; CCI-002102, CCI-002103, CCI-002104, CCI-002105 and also the submittal requirements associated with CM-6, CM-7 and SC-41}

Provide a network communication report. For each networked controller, document the communication characteristics of the controller including communication protocols, services used, and a general description of what information is communicated over the network. For each controller using IP, document all TCP and UDP ports 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.

1.8.2 Control System Inventory Report

{For Reference Only: This subpart (and its subparts) relates to CM-8(a), CP-12, SI-17, IA-3; CCI-000389, CCI-000392, CCI-000398, CCI-002855,

CCI-002856, CCI-002857, 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 http://www.wbdg.org/FFC/NAVGRAPH/graphtoc.pdf documenting 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 Report as an editable Microsoft Excel file.

1.8.3 Software Recovery and Reconstitution Images

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

For control system device 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.

1.8.4 Cybersecurity Riser Diagram

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

Provide a cybersecurity riser diagram of the complete control system including all network and controller 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.

1.8.5 Control System Cybersecurity Documentation

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

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

1.8.5.1 For HVAC Control System Devices

1.8.5.1.1 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 reference only: relates to CCI-003124}

b. Documentation that describes secure operation of the device {for reference only: relates to CCI-003124}

c. Documentation that describes effective use and maintenance of security functions or mechanisms for the device {for 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 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 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 reference only: relates to CCI-003130}

1.8.5.1.2 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 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 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 reference only: relates to CCI-003130}

1.8.5.2 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 reference only: relates to CCI-003124}

b. Documentation that describes secure installation of the device {for reference only: relates to CCI-003125}

c. Documentation that describes secure operation of the device {for reference only: relates to CCI-003124}

d. Documentation that describes effective use and maintenance of security functions or mechanisms for the device {for 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 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 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 reference only: relates to CCI-003130}

h. Documentation that describes user responsibilities in maintaining the security of the device {for reference only: relates to CCI-003131}

1.9 SOFTWARE UPDATE LICENSING

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

In addition to all other licensing requirements, all software licensing must include licensing of the following software updates for a period of no less than 5 years:

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 Reference Only: This subpart (and its subparts) relates to AC-18, SA-3, CCI-00258}

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. When used, contractor computers 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. All 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 all computers 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 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 http://www.wbdg.org/FFC/NAVGRAPH/graphtoc.pdf. 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 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 IP networks provided under this project or Government furnished IP networks provided for this purpose. Any and all network access 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 must not interfere with existing wireless network and must use WPA2 security. 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 http://www.wbdg.org/FFC/NAVGRAPH/graphtoc.pdf. 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 ACCESS CONTROL REQUIREMENTS

3.1.1 User Accounts

{For Reference Only: This subpart (and its subparts) relate to AC-2(a)and AC-3; CCI-002110, CCI-000213.}

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

3.1.1.1 For HVAC Control System Devices

Devices with web interfaces must either FULLY support user accounts or have their web interface disabled. Field devices with full local user interfaces allowing modification of data must at least MINIMALLY support user accounts.

3.1.1.2 Default Requirements for Control System Devices

For control system devices where User Account requirements are not otherwise indicated in this Section:

a. Devices with web interfaces must either at least MINIMALLY support user accounts or have their web interface disabled.

b. Field devices with full local user interfaces allowing modification of data must at least MINIMALLY support user accounts.

c. Field devices with read-only full local user interfaces must at least MINIMALLY support user accounts.

d. All devices must at least MINIMALLY support user accounts.

3.1.2 Unsuccessful Logon Attempts

{For Reference Only: This subpart (and its subparts) relate 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.

3.1.2.1 Devices MINIMALLY Supporting Accounts

Devices which MINIMALLY support accounts are not required to lock based on unsuccessful logon attempts.

3.1.2.2 Devices FULLY Supporting Accounts

Devices which FULLY support accounts must meet the following requirements. If a device cannot meet these requirements, document device capabilities to protect from subsequent unsuccessful logon attempts and propose alternate protections in a Device Account Lock Exception Request submittal. Do not implement alternate protection measures without explicit permission from the Government.

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.

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

3.1.2.3 High Availability Interfaces Exempt from Unsuccessful Logon Attempts Requirements

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

3.1.3 System Use Notification

{For 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}

Web interfaces must display a warning banner meeting the requirements of DTM 08-060.

Devices which are connected to a network and have a user interface must display a warning banner meeting the requirements of DTM 08-060 if capable of doing so. Devices which are connected to a network and have a user interface but are not capable of displaying a banner must have a permanently affixed label displaying an approved banner from DTM 08-060.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 contract between font and background colors.

3.1.3.1 User Interface Banner Schedule

Provide a User Interface Schedule using the format indicated showing each user interface provided and how the information banner requirement has been implemented for each user interface.

User Interface Schedule Format (with sample entries)			
User Interface Description	**User Interface Location**	**Type of User Interface**	**Banner Implementation**
Sample 1	Room 1	Remote	DTM 08-060 Banner "A" Displayed at Logon
Sample 2	Room 2	Limited Local	DTM 08-060 Banner "B" on Affixed Label
Sample 3	Room 3	Full Local	DTM 08-060 Banner "B" Displayed on Screen

3.1.4 Permitted Actions Without Identification or Authentication

{For 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.

3.1.5 Wireless Access

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

Unless explicitly authorized by the Government, do not use any wireless communication. Any device with wireless communication capability is considered to be using wireless communication, regardless of whether or not the device is actively communicating wirelessly, except when wireless communication has been physically permanently disabled (such as through the removal of the wireless transceiver).

3.1.5.1 Wireless IP Communications

Do not install wireless 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.

3.1.5.2 Non-IP Wireless Communication

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 CYBERSECURITY AUDITING

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

{For Reference Only: This subpart (and its subparts) relates to AU-2(a),(c),(d), AU-3, AU-12; CCI-000123, CCI-001571, CCI-000125, CCI-001485, CCI-000130, CCI-000131, CCI-000132, CCI-00133, CCI-000134, CCI-001487, CCI-000169, CCI-001459, CCI-000171, CCI-000172, CCI-001910}

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.

3.2.1.1 For HVAC Control System Devices

3.2.1.1.1 HVAC Control System Devices FULLY Supporting User Accounts

For devices FULLY supporting accounts, provide the capability to select audited events, and the contents of audit logs. Configure devices to audit the following events:

a. Successful and unsuccessful logon attempts to the device

b. Starting and ending time for user access to the device

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

d. All device shutdown and startup

Configure the device to record for each event the following information (as applicable): the type of event, when the event occurred and the identity of any individuals or subjects associated with the event

3.2.1.1.2 Other HVAC Control System Devices

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

3.2.1.2 Default Requirements for Control System Devices

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

3.2.1.2.1 Devices Which FULLY Support Accounts

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

3.2.1.2.1.1 Audited Events

Configure each device 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)

a. Successful and unsuccessful logon attempts

b. Privileged activities or other system level access

c. Starting and ending time for user access to the system

d. Concurrent logons from different workstations

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

f. All kernel module load, unload, and restart

3.2.1.2.2 Devices Which Do Not FULLY Support Accounts

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

3.2.2 Audit Storage Capacity and Audit Upload

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

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 non-computer control system devices capable of generating audit records, provide 60 days worth of secure local storage, assuming 10 auditable events per day.

3.2.2.1 Device Audit Record Upload Software

For each non-computer device required to audit events, provide, and license to the Government, software implementing a secure mechanism of uploading audit records from the device to a computer and of exporting the uploaded audit records as a Microsoft Excel file or comma separated value text file. Where different devices use different software, provide software of each type required to upload audit logs from all devices.

Submit copies of device audit record upload software. If there are no non-computer devices requiring auditing, provide a document stating this in lieu of this submittal.

3.2.3 Time Stamps

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

3.2.3.1 For HVAC Control System Devices

Time stamp requirements for HVAC Control Systems are as indicated in the HVAC Control System specifications.

3.2.3.2 Default Requirements for Control System Devices

For control system devices where Time Stamps requirements are not otherwise indicated in this Section: Devices generating audit records must have internal clocks capable of providing time with a resolution of 1 second. Clocks must not drift more than 10 seconds per day. Configure

the system so that each device generating audit records maintains accurate time to within 1 second.

3.3 REQUIREMENTS FOR LEAST FUNCTIONALITY

{For Reference Only: This subpart (and its subparts), along with the network communication report submittal specified elsewhere in this section, relates to CM-6 (a), (c), CM-7, CM-7 (1)(b), SC-41; CCI-000363, CCI-000364, CCI-000365, CCI-001588, CCI-001755, CCI-000381, CCI-000380, CCI-00382, 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.

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

3.3.1 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, or use any protocol on ports other than those specified.

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

3.3.2 IP Control Networks

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.

3.4 SAFE MODE AND FAIL SAFE OPERATION

{For Reference Only: This subpart (and its subparts) relates to CP-12, SI-17; CCI-002855, CCI-002856, CCI-002857, 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.

3.5 IDENTIFICATION AND AUTHENTICATION

3.5.1 User Identification and Authentication

{For Reference Only: This subpart (and its subparts) relates to IA-2,(1),(12); CCI-000764, CCI-000765, CCI-001953, CCI-001954}

a. Devices that FULLY support accounts must uniquely identify and authenticate organizational users.

b. Devices which allow network access to privileged accounts must implement multifactor authentication for network access to privileged accounts.

3.5.1.1 HVAC Control Systems Devices

Identification and Authentication for network access to privileged accounts must be implemented by either accepting and electronically verify Personal Identity Verification (PIV) credentials or inheriting identification and authentication from the operating system.

3.5.1.2 Default Requirements for Control System Devices

For control system devices where User Identification and Authentication requirements are not otherwise indicated in this Section, User Identification and Authentication for network access to privileged accounts must be implemented by accepting and electronically verify Personal Identity Verification (PIV) credentials or inheriting identification and authentication from the operating system.

3.5.2 Authenticator Management

{For Reference Only: This subpart (and its subparts) relates to IA-5 (b),(c),(e),(g),(1),(11); CCI-000176, 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}

3.5.2.1 Authentication Type

3.5.2.1.1 For HVAC Control System Devices

Unless otherwise indicated:

a. Other devices which FULLY support accounts must use password-based authentication.

b. Devices MINIMALLY supporting accounts must use password-based authentication.

3.5.2.1.2 Default Requirements for Control System Devices

For control system devices where Authentication Type requirements are not otherwise indicated in this Section:

a. Other devices which FULLY support accounts must use either password-based authentication or hardware token-based authentication.

b. Devices MINIMALLY supporting accounts must use either password-based authentication or hardware token-based authentication.

3.5.2.2 Password-Based Authentication Requirements

3.5.2.2.1 Passwords for Non-Computer Devices FULLY Supporting Accounts

All non-computer devices 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.

f. Password must have a maximum lifetime of sixty (60) days. When passwords expire, prompt users to change passwords. Do no 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.

3.5.2.2.2 Passwords for Web Interfaces

Passwords for connecting to a web 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.

f. Password must have a maximum lifetime of 60 days. When passwords expire, prompt users to change passwords. Do no 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.

3.5.2.2.3 Passwords for Devices Minimally Supporting Accounts

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

3.5.2.2.4 Password Configuration and Reporting

For all devices with a password, change the password from the default password. Coordinate selection of passwords with the government. Do not use the same password for more than one device unless specifically instructed to do so. Provide a Password Summary Report documenting the password for each device and describing the procedure to change the password for each device.

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.

3.5.2.3 Hardware Token-Based Authentication Requirements

Devices supporting hardware token-based authentication must use Personal Identity Verification (PIV) credentials for the hardware token.

3.5.3 Authenticator Feedback

{For 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.

3.5.4 Device Identification and Authentication

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

All computers must use IEEE 802.1x for authentication to the network. All web servers running on computers must use HTTPS.

3.5.4.1 For HVAC Control System Devices

Devices using Fox Protocol must use HTTPS. Devices using Fox Protocol must support IEEE 802.1x. Devices using Ethernet must support IEEE 802.1x. Devices using BACnet must support Network Security as specified in Clause 24 of ASHRAE 135.

3.5.4.2 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.

3.5.5 Cryptographic Module Authentication

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

For devices that have STIG/SRGs related to cryptographic module authentication (CCI-000803), comply with the requirements of those STIG/SRGs.

3.6 EMERGENCY POWER

{For Reference Only: This subpart (and its subparts) relates to PE-11,(1); CCI-02955, CCI-000961}

Emergency power is specified in the control system and equipment specifications.

3.7 DURABILITY TO VULNERABILITY SCANNING

{For Reference Only: This subpart (and its subparts) relates to RA-5 (a),(b),(c),(d); CCI-001054, CCI-001055, CCI-0010156, 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.

For control system devices other than computers:

3.7.1 HVAC Control System Devices Other Than Computers

HVAC control system devices other than computers are not required to respond to scans.

3.7.2 Default Requirements for Control System Devices

Non-computer control system devices where Durability to Vulnerability Scanning requirements are not otherwise indicated in this Section are not required to respond to scans.

3.8 DEVICES WITH CONNECTION TO MULTIPLE IP NETWORKS

Except for Ethernet switches, do not use more than one physical connection to IP networks on the same device unless doing so is both required by the project specifications and the specific application is approved. If a device with multiple IP connections is required, provide a Multiple IP Connection Device Request using the Multiple IP Connection Device Request Schedule at http://www.wbdg.org/FFC/NAVGRAPH/graphtoc.pdf to request approval for each device.

3.9 SYSTEM AND COMMUNICATION PROTECTION

3.9.1 Denial of Service Protection, Process Isolation and Boundary Protection

{For Reference Only: This subpart (and its subparts) relates to SC-5, SC-39, SC-7(a); CCI-001093, CCI-002385, CCI-002386, CCI-002430, CCI-001097}

To the greatest extent practical, implement control logic in non-computer hardware and without reliance on the network.

3.10 SYSTEM AND INTEGRATION INTEGRITY

3.11 FIELD QUALITY CONTROL

3.11.1 Tests

In addition to testing and testing support required by other Sections, provide a minimum of 8 hours of technical support for cybersecurity testing of control systems.

-- End of Section --

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DIVISION 25 - INTEGRATED AUTOMATION

SECTION 25 05 11.01

CCI LIST HVAC

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-- End of Section Table of Contents --

Responsibility: Indicates who has responsibility for implementing the control.
One or more of:

DoD-Defined: Either the DoD has provided a value for the "organization selected" values, or the DoD implementation guidance states that the CCI is already met by existing policy or regulation. Note that definition or guidance provided may not be relevant for a control system – the organization definitions were determined from the perspective of a traditional information system, not for a control system.

Designer: The designer has a role to address for this CCI. Either the designer needs to provide design specifications to cover a requirement on the control system itself, or the designer must provide input to others regarding the implementation or lack of feasibility of the CCI (typically because the CCI was written with an IT system, not a control system, in mind).

Non-Designer: The CCI is beyond the responsibility of the designer, and is the responsibility of someone else – typically the System Owner (SO). This does not diminish the importance of these CCIs, but as these CCIs are not the responsibility of the designer they are beyond the scope of this UFC.

Platform Enclave: The CCI contains a requirement which is assumed to be implemented at the Platform Enclave and inherited by the control system, or is mostly implemented at the Platform Enclave but also needed within the field control system. Note that if there is no Platform Enclave, then CCIs listed in the "Platform Enclave" category are instead in the "Non-Designer" category.

Impractical: The CCI is impractical to fully implement in a control system, but may be applied in a limited manner to at least some part of the control system. Most often CCIs that can be applied to only part of the control system can be implemented at Level 4 of the architecture, but would be prohibitively difficult to implement at Levels 1 or 2. Note that "prohibitively" is a judgment based on a typical LOW control system – for a MODERATE or HIGH system, it may be worthwhile to implement these controls at all possible levels even if this adds significant cost and complexity.

Table H-4 Designer CCIs for LOW and MODERATE Impact Control Systems

CCI #	800-53 Control Text Indicator	CCI Definition	Responsibility	Guidance
CCI-000048	AC-8(a)	The information system displays an organization- defined system use notification message or banner before granting access to the system that provides privacy and security notices consistent with applicable federal laws, Executive Orders, directives, policies, regulations, standards, and guidance.	Enclave Designer Impractical	System Use Notification: Login banners must be implemented at user login to government computers – e.g. at the Platform Enclave, Level 4 and Level 2 computers. User interfaces at Levels 0, 1 and 2 (e.g. Local Display Panels (LDP)) generally won't support a login banner. Require login banners where practical according to best industry practice and indicate where implementation is not practical.
CCI-002247	AC-8(a)	The organization defines the use notification message or banner the information system displays to users before granting access to the system.	DoD-Defined Enclave Designer Impractical	System Use Notification: Login banners must be implemented at user login to government computers – e.g. at the Platform Enclave, Level 4 and Level 2 computers. User interfaces at Levels 0, 1 and 2 (e.g. Local Display Panels (LDP)) generally won't support a login banner. Require login banners where practical according to best industry practice and indicate where implementation is not practical.
CCI-002243	AC-8(a)(1)	The organization-defined information system use notification message or banner is to state that users are accessing a U.S. Government information system.	DoD-Defined Enclave Designer Impractical	System Use Notification: Login banners must be implemented at user login to government computers – e.g. at the Platform Enclave, Level 4 and Level 2 computers. User interfaces at Levels 0, 1 and 2 (e.g. Local Display Panels (LDP)) generally won't support a login banner. Require login banners where practical according to best industry practice and indicate where implementation is not practical.
CCI-002244	AC-8(a)(2)	The organization-defined information system use notification message or banner is to state that information system usage may be monitored, recorded, and subject to audit.	DoD-Defined Enclave Designer Impractical	System Use Notification: Login banners must be implemented at user login to government computers – e.g. at the Platform Enclave, Level 4 and Level 2 computers. User interfaces at Levels 0, 1 and 2 (e.g. Local Display Panels (LDP)) generally won't support a login banner. Require login banners where practical according to best industry practice and indicate where implementation is not practical.
CCI-002246	AC-8(a)(4)	The organization-defined information system use notification message or banner is to state that use of the information system indicates consent to monitoring and recording.	DoD-Defined Enclave Designer Impractical	System Use Notification: Login banners must be implemented at user login to government computers – e.g. at the Platform Enclave, Level 4 and Level 2 computers. User interfaces at Levels 0, 1 and 2 (e.g. Local Display Panels (LDP)) generally won't support a login banner. Require login banners where practical according to best industry practice and indicate where implementation is not practical.
CCI-000050	AC-8(b)	The information system retains the notification message or banner on the screen until users acknowledge the usage conditions and take explicit actions to log on to or further access.	Enclave Designer	System Use Notification: Login banners must be implemented at user login to government computers – e.g. at the Platform Enclave, Level 4 and Level 2 computers. User interfaces at Levels 0, 1 and 2 (e.g. Local Display Panels (LDP)) generally won't support a login banner. Require login banners where practical according to best industry practice and indicate where implementation is not practical.
CCI-002248	AC-8(c)(1)	The organization defines the conditions of use which are to be displayed to users of the information system before granting further access.	DoD-Defined Enclave Designer Impractical	System Use Notification: Login banners must be implemented at user login to government computers – e.g. at the Platform Enclave, Level 4 and Level 2 computers. User interfaces at Levels 0, 1 and 2 (e.g. Local Display Panels (LDP)) generally won't support a login banner. Require login banners where practical according to best industry practice and indicate where implementation is not practical.
CCI-000139	AU-5(a)	The information system alerts designated organization-defined personnel or roles in the event of an audit processing failure.	Enclave Designer Impractical	Response To Audit Processing Failures: Notifications and specific actions may only be possible at Level 4.
CCI-000140	AU-5(b)	The information system takes organization defined actions upon audit failure (e.g., shut down information system, overwrite oldest audit records, stop generating audit records).	Enclave Designer Impractical	Response To Audit Processing Failures: Notifications and specific actions may only be possible at Level 4.
CCI-001490	AU-5(b)	The organization defines actions to be taken by the information system upon audit failure (e.g., shut down information system, overwrite oldest audit records, stop generating audit records).	Enclave Designer Non-Designer Impractical	Response To Audit Processing Failures: Notifications and specific actions may only be possible at Level 4.
CCI-000550	CP-10	The organization provides for the recovery and reconstitution of the information system to a known state after a disruption.	Enclave Designer Non-Designer	Information System Recovery And Reconstitution: Designer should require submittals containing data, documentation and software sufficient to restore the system to its final accepted as built state. This must include custom programming and configuration for controllers or workstations.
CCI-000551	CP-10	The organization provides for the recovery and reconstitution of the information system to a known state after a compromise.	Enclave Designer Non-Designer	Information System Recovery And Reconstitution: Designer should require submittals containing data, documentation and software sufficient to restore the system to its final accepted as built state. This must include custom programming and configuration for controllers or workstations.

CCI-000552	CP-10	The organization provides for the recovery and reconstitution of the information system to a known state after a failure.	Enclave Designer Non-Designer	Information System Recovery And Reconstitution: Designer should require submittals containing data, documentation and software sufficient to restore the system to its final accepted as built state. This must include custom programming and configuration for controllers or workstations.
CCI-000764	IA-2	The information system uniquely identifies and authenticates organizational users (or processes acting on behalf of organizational users).	Enclave Designer Impractical	Identification And Authentication (Organizational Users): Much of this can only be met at Level 4, and much of it depends on the computer operating system. Designer should provide specifications where possible, and be prepared to justify non-implementation in the control system. Whenever possible, require that the control system (for access via a computer) support CAC (or similar) logins. Note that remote access is covered at the platform enclave.
CCI-000765	IA-2(1)	The information system implements multifactor authentication for network access to privileged accounts.	Enclave Designer Impractical	Identification And Authentication (Organizational Users): Much of this can only be met at Level 4, and much of it depends on the computer operating system. Designer should provide specifications where possible, and be prepared to justify non-implementation in the control system. Whenever possible, require that the control system (for access via a computer) support CAC (or similar) logins. Note that remote access is covered at the platform enclave.
CCI-001953	IA-2(12)	The information system accepts Personal Identity Verification (PIV) credentials.	Enclave Designer Impractical	Identification And Authentication (Organizational Users): Much of this can only be met at Level 4, and much of it depends on the computer operating system. Designer should provide specifications where possible, and be prepared to justify non-implementation in the control system. Whenever possible, require that the control system (for access via a computer) support CAC (or similar) logins. Note that remote access is covered at the platform enclave.
CCI-001954	IA-2(12)	The information system electronically verifies Personal Identity Verification (PIV) credentials.	Enclave Designer Impractical	Identification And Authentication (Organizational Users): Much of this can only be met at Level 4, and much of it depends on the computer operating system. Designer should provide specifications where possible, and be prepared to justify non-implementation in the control system. Whenever possible, require that the control system (for access via a computer) support CAC (or similar) logins. Note that remote access is covered at the platform enclave.
CCI-000777	IA-3	The organization defines a list of specific and/or types of devices for which identification and authentication is required before establishing a connection to the information system.	DoD-Defined Enclave Designer Impractical	Device Identification And Authentication: Much of this can only be met at Level 4, and much of it depends on the computer operating system. Typically, authentication between devices can be implemented between computers (Level 2 and 4) or between network hardware (Level 2, 3 or 4). Authentication may be supported between controllers, where not all controllers will support this capability and it will be more often supported at for LOW impact system, but may be required for MODERATE or HIGH systems.
CCI-000778	IA-3	The information system uniquely identifies an organization defined list of specific and/or types of devices before establishing a local, remote, or network connection.	Enclave Designer Impractical	Device Identification And Authentication: Much of this can only be met at Level 4, and much of it depends on the computer operating system. Typically, authentication between devices can be implemented between computers (Level 2 and 4) or between network hardware (Level 2, 3 or 4). Authentication may be supported between controllers, where not all controllers will support this capability and it will be more often supported at for LOW impact system, but may be required for MODERATE or HIGH systems.
CCI-001958	IA-3	The information system authenticates an organization defined list of specific and/or types of devices before establishing a local, remote, or network connection.	Enclave Designer Impractical	Device Identification And Authentication: Much of this can only be met at Level 4, and much of it depends on the computer operating system. Typically, authentication between devices can be implemented between computers (Level 2 and 4) or between network hardware (Level 2, 3 or 4). Authentication may be supported between controllers, where not all controllers will support this capability and it will be more often supported at for LOW impact system, but may be required for MODERATE or HIGH systems.
CCI-000192	IA-5(1)(a)	The information system enforces password complexity by the minimum number of upper case characters used.	Enclave Designer	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.
CCI-000193	IA-5(1)(a)	The information system enforces password complexity by the minimum number of lower case characters used.	Enclave Designer	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.

CCI-000194	IA-5(1)(a)	The information system enforces password complexity by the minimum number of numeric characters used.	Enclave Designer	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.
CCI-000205	IA-5(1)(a)	The information system enforces minimum password length.	Enclave Designer	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.
CCI-001619	IA-5(1)(a)	The information system enforces password complexity by the minimum number of special characters used.	Enclave Designer	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.
CCI-000195	IA-5(1)(b)	The information system, for password-based authentication, when new passwords are created, enforces that at least an organization-defined number of characters are changed.	Enclave Designer	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.
CCI-000196	IA-5(1)(c)	The information system, for password-based authentication, stores only cryptographically-protected passwords.	Enclave Designer Impractical	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.
CCI-000197	IA-5(1)(c)	The information system, for password-based authentication, transmits only cryptographically- protected passwords.	Enclave Designer	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.
CCI-000199	IA-5(1)(d)	The information system enforces maximum password lifetime restrictions.	Enclave Designer	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.
CCI-000200	IA-5(1)(e)	The information system prohibits password reuse for the organization defined number of generations.	Enclave Designer Non-Designer Impractical	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.
CCI-001618	IA-5(1)(e)	The organization defines the number of generations for which password reuse is prohibited.	DoD-Defined Enclave Designer Impractical	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.
CCI-002041	IA-5(1)(f)	The information system allows the use of a temporary password for system logons with an immediate change to a permanent password.	Enclave Designer Impractical	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.

CCI-002002	IA-5(11)	The organization defines the token quality requirements to be employed by the information system mechanisms for token-based authentication.	DoD-Defined Enclave Designer Impractical	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.
CCI-002003	IA-5(11)	The information system, for token-based authentication, employs mechanisms that satisfy organization-defined token quality requirements.	Enclave Designer Impractical	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.
CCI-000206	IA-6	The information system obscures feedback of authentication information during the authentication process to protect the information from possible exploitation/use by unauthorized individuals.	Enclave Designer Impractical	Authenticator Feedback and Cryptographic Module Authentication: Almost certainly Platform Enclave only and not supported below that level. Designer may need to provide input/justification for this. For devices that have STIGs or SRGs related to obscuring of authenticator feedback (CCI-000206), comply with the requirements of those STIGS/SRGs.
CCI-000803	IA-7	The information system implements mechanisms for authentication to a cryptographic module that meet the requirements of applicable federal laws, Executive Orders, directives, policies, regulations, standards, and guidance for such authentication.	Enclave Designer Impractical	Authenticator Feedback and Cryptographic Module Authentication: Almost certainly Platform Enclave only and not supported below that level. Designer may need to provide input/justification for this. For devices that have STIG/SRGs related to cryptographic module authentication (CCI-000803), comply with the requirements of those STIG/SRGs.
CCI-003051	PL-2(a)(2)	The organization's security plan for the information system explicitly defines the authorization boundary for the system.	Enclave Designer Non-Designer	System Security Plan: While the designer is not directly responsible for the system security plan itself, the design must provide information to be used in this plan. For example, the system architecture drawing is part of the definition of the authorization boundary. The designer may also provide input for the security categorization since they have the specific knowledge of the underlying mechanical/electrical systems and can help assess the
CCI-001054	RA-5(a)	The organization scans for vulnerabilities in the information system and hosted applications on an organization-defined frequency.	Enclave Designer Non-Designer	Vulnerability Scanning: Scanning can be performed at Levels 3 and 4, and scanning of the control system at this level should be performed by the Platform Enclave. Scanning below this level – and particularly at Level 1 - is problematic at best since typical control systems do not support scanning, and traditional IT-centric scanning tools will often completely fail when scanning a controller. Note that scanning tools should be within the organizations attempting to meet RA-5. See SC-7, SI-3
CCI-001055	RA-5(a)	The organization defines a frequency for scanning for vulnerabilities in the information system and hosted applications.	DoD-Defined Enclave Designer Impractical	Vulnerability Scanning: Scanning can be performed at Levels 3 and 4, and scanning of the control system at this level should be performed by the Platform Enclave. Scanning below this level – and particularly at Level 1 - is problematic at best since typical control systems do not support scanning, and traditional IT-centric scanning tools will often completely fail when scanning a controller. Note that scanning tools should be within the organizations attempting to meet RA-5. See SC-7, SI-3
CCI-001056	RA-5(a)	The organization scans for vulnerabilities in the information system and hosted applications when new vulnerabilities potentially affecting the system/applications are identified and reported.	Enclave Designer Non-Designer	Vulnerability Scanning: Scanning can be performed at Levels 3 and 4, and scanning of the control system at this level should be performed by the Platform Enclave. Scanning below this level – and particularly at Level 1 - is problematic at best since typical control systems do not support scanning, and traditional IT-centric scanning tools will often completely fail when scanning a controller. Note that scanning tools should be within the organizations attempting to meet RA-5. See SC-7, SI-3
CCI-001641	RA-5(a)	The organization defines the process for conducting random vulnerability scans on the information system and hosted applications.	Enclave Designer Non-Designer Impractical	Vulnerability Scanning: Scanning can be performed at Levels 3 and 4, and scanning of the control system at this level should be performed by the Platform Enclave. Scanning below this level – and particularly at Level 1 - is problematic at best since typical control systems do not support scanning, and traditional IT-centric scanning tools will often completely fail when scanning a controller. Note that scanning tools should be within the organizations attempting to meet RA-5. See SC-7, SI-3

CCI-001643	RA-5(a)	The organization scans for vulnerabilities in the information system and hosted applications in accordance with the organization-defined process for random scans.	Enclave Designer Non-Designer	Vulnerability Scanning: Scanning can be performed at Levels 3 and 4, and scanning of the control system at this level should be performed by the Platform Enclave. Scanning below this level – and particularly at Level 1 - is problematic at best since typical control systems do not support scanning, and traditional IT-centric scanning tools will often completely fail when scanning a controller. Note that scanning tools should be within the organizations attempting to meet RA-5. See SC-7, SI-3
CCI-001057	RA-5(b)	The organization employs vulnerability scanning tools and techniques that facilitate interoperability among tools and automate parts of the vulnerability management process by using standards for: enumerating platforms, software flaws, and improper configurations; formatting checklists and test procedures; and measuring vulnerability impact.	Enclave Designer Non-Designer Impractical	Vulnerability Scanning: Scanning can be performed at Levels 3 and 4, and scanning of the control system at this level should be performed by the Platform Enclave. Scanning below this level – and particularly at Level 1 - is problematic at best since typical control systems do not support scanning, and traditional IT-centric scanning tools will often completely fail when scanning a controller. Note that scanning tools should be within the organizations attempting to meet RA-5. See SC-7, SI-3
CCI-001058	RA-5(c)	The organization analyzes vulnerability scan reports and results from security control assessments.	Enclave Designer Non-Designer	Vulnerability Scanning: Scanning can be performed at Levels 3 and 4, and scanning of the control system at this level should be performed by the Platform Enclave. Scanning below this level – and particularly at Level 1 - is problematic at best since typical control systems do not support scanning, and traditional IT-centric scanning tools will often completely fail when scanning a controller. Note that scanning tools should be within the organizations attempting to meet RA-5. See SC-7, SI-3
CCI-001059	RA-5(d)	The organization remediates legitimate vulnerabilities in organization-defined response times in accordance with an organizational assessment risk.	Enclave Designer Non-Designer Impractical	Vulnerability Scanning: Scanning can be performed at Levels 3 and 4, and scanning of the control system at this level should be performed by the Platform Enclave. Scanning below this level – and particularly at Level 1 - is problematic at best since typical control systems do not support scanning, and traditional IT-centric scanning tools will often completely fail when scanning a controller. Note that scanning tools should be within the organizations attempting to meet RA-5. See SC-7, SI-3
CCI-003116	SA-4(10)	The organization employs only information technology products on the FIPS PUB 201-2-approved products list for Personal Identity Verification (PIV) capability implemented within organizational information systems.	Enclave Designer Impractical	Acquisition Process: SA-4 is at least partially met by the designer incorporating security-specific requirements in the design, including acceptance testing. Requirements for FIPS PUB 201-2 probably only apply at the Platform Enclave and designer may need to provide rationale for not meeting those requirement in the control system. Similarly, many of the requirements on the developer probably cannot be enforced on a COTS
CCI-001093	SC-5	The organization defines the types of denial of service attacks (or provides references to sources of current denial of service attacks) that can be addressed by the information system.	Enclave Designer	Denial Of Service Protection: Within the control system, denial of service attacks are mitigated by designing the system to not depend on the network. Otherwise, this is a Platform Enclave control.
CCI-002385	SC-5	The information system protects against or limits the effects of organization-defined types of denial of service attacks by employing organization-defined security safeguards.	Enclave Designer	Denial Of Service Protection: Within the control system, denial of service attacks are mitigated by designing the system to not depend on the network. Otherwise, this is a Platform Enclave control.
CCI-002386	SC-5	The organization defines the security safeguards to be employed to protect the information system against, or limit the effects of, denial of service attacks.	Enclave Designer Non-Designer	Denial Of Service Protection: Within the control system, denial of service attacks are mitigated by designing the system to not depend on the network. Otherwise, this is a Platform Enclave control.
CCI-001097	SC-7(a)	The information system monitors and controls communications at the external boundary of the system and at key internal boundaries within the system.	DoD-Defined Enclave Designer Impractical	Boundary Protection: Implementation at the external boundary should be the responsibility of the Platform Enclave. The Platform Enclave can perform monitoring/traffic control at Level 3, and perhaps key points near Level 4 assets. Aside from those locations, this control may be difficult to meet within the control system. Designer may need to provide justification for not monitoring or controlling traffic below Level 3. It may not be prudent equipment by taking out the boundary device. Control systems must continue to run independently when boundary devices are lost. See CP-12

CCI-002544	SC-41	The organization defines the information systems or information system components on which organization-defined connection ports or input/output devices are to be physically disabled or removed.	Enclave Designer Non-Designer	Port And I/O Device Access: See comments on CM-7 Least Functionality: The control system has a specific purpose (not a general one) and its functions (and limitations) are specified by the control system architecture and protocols. Specifications should require disabling any ports/protocols/services not specifically needed by the control system. Required software should be covered by specification; all other software should be prohibited. 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.
CCI-002545	SC-41	The organization defines the connection ports or input/output devices that are to be physically disabled or removed from organization-defined information systems or information system components.	Enclave Designer Non-Designer	Port And I/O Device Access: See comments on CM-7 Least Functionality: The control system has a specific purpose (not a general one) and its functions (and limitations) are specified by the control system architecture and protocols. Specifications should require disabling any ports/protocols/services not specifically needed by the control system. All other software should be prohibited. Required software should be covered by specification; all other software 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.
CCI-001241	SI-3(c)(1)	The organization configures malicious code protection mechanisms to perform periodic scans of the information system on an organization-defined frequency.	Enclave Designer Non-Designer	Malicious Code Protection: Should be implemented by the Platform Enclave at entry/exit points. Periodic scans within the control system may be difficult and the designer may need to justify their non-implementation. See RA-5, SC-7. For all computers installed under this project, install and configure malware protection software in accordance with the relevant STIGs.
CCI-002110	AC-2(a)	The organization defines the information system account types that support the organizational missions/business functions.	Designer	Account Management: Specify what account types provide which permissions in the control system (e.g. "view only", "acknowledge alarms", "change set-points", etc.). Note that designer may need to explain these roles to the ISSM / ISSO so they can perform their DoD-defined duties under this control. Note that "accounts" (and particularly "temporary" or "emergency" accounts) likely exist at Level 4 and may or may not exist at many utility control systems do). Designer may need to explain lack of "accounts" at Levels 1 and 2. Specifications should require that account Any device supporting user accounts (either FULLY or MINIMALLY) must limit access to the device according to specified limitations for each account. Install and configure any device having a STIG or SRG in accordance with that STIG or SRG.
CCI-000213	AC-3	The information system enforces approved authorizations for logical access to information and system resources in accordance with applicable access control policies.	Designer	Access Enforcement: AC-3 is met by requiring the contractor to configure any control system component which has a STIG or SRG in accordance with that STIG or SRG"
CCI-000043	AC-7(a)	The organization defines the maximum number of consecutive invalid logon attempts to the information system by a user during an organization-defined time period.	DoD-Defined Designer Impractical	Unsuccessful Logon Attempts: Note that a requirement for a HIGH availability at the front end may preclude locking out an account for failed login attempts. This control may be impractical below Level 3 and, even at Level 4, may only be implemented by login to the OS as a prerequisite for access to the control system. Designer needs to identify where this can be supported, and include requirements in the specification where this is
CCI-002237	AC-7(b)	The organization defines the delay algorithm to be employed by the information system to delay the next login prompt when the maximum number of unsuccessful attempts is exceeded.	DoD-Defined Designer Impractical	Unsuccessful Logon Attempts: Note that a requirement for a HIGH availability at the front end may preclude locking out an account for failed login attempts. This control may be impractical below Level 3 and, even at Level 4, may only be implemented by login to the OS as a prerequisite for access to the control system. Designer needs to identify where this can be supported, and include requirements in the specification where this is

CCI-002238	AC-7(b)	The information system automatically locks the account or node for either an organization-defined time period, until the locked account or node is released by an administrator, or delays the next login prompt according to the organization-defined delay algorithm when the maximum number of unsuccessful attempts is exceeded.	Designer Impractical	Unsuccessful Logon Attempts: Note that a requirement for a HIGH availability at the front end may preclude locking out an account for failed login attempts. This control may be impractical below Level 3 and, even at Level 4, may only be implemented by login to the OS as a prerequisite for access to the control system. Designer needs to identify where this can be supported, and include requirements in the specification where this is
CCI-000061	AC-14(a)	The organization identifies and defines organization- defined user actions that can be performed on the information system without identification or authentication consistent with organizational missions/business functions.	Designer	Permitted Actions Without Identification Or Authentication: At Level 4, all actions should require authentication to the (Windows) Operating System. User interfaces at Level 1 or 2 should be password protected. Note that this security control is specifically about user actions, not "processes acting for a user". In most cases, this is met by virtue of the user having logged into a computer. Physical security may be required to switches, room access control, people trap, and paper access logs. Some user access (local display panels, Hand-Off-Auto switches, etc.) may not support authentication and necessary physical security should be considered. When considering physical security of such devices, it is generally not beneficial to secure an interface which is co-located with the controlled equipment without also securing the controlled equipment, as the equipment would remain vulnerable.
CCI-000232	AC-14(b)	The organization documents and provides supporting rationale in the security plan for the information system, user actions not requiring identification and authentication.	Designer	Permitted Actions Without Identification Or Authentication: At Level 4, all actions should require authentication to the (Windows) Operating System. User interfaces at Level 1 or 2 should be password protected. Note that this security control is specifically about user actions, not "processes acting for a user". In most cases, this is met by virtue of the user having logged into a computer. Physical security may be required to switches, room access control, people trap, and paper access logs. Some user access (local display panels, Hand-Off-Auto switches, etc.) may not support authentication and necessary physical security should be considered. When considering physical security of such devices, it is generally not beneficial to secure an interface which is co-located with the controlled equipment without also securing the controlled equipment, as the equipment would remain vulnerable.
CCI-001438	AC-18(a)	The organization establishes usage restrictions for wireless access.	Designer Non-Designer	Wireless Access: Wireless at Level 4 should be provided by the appropriate IT organization. Avoid wireless to the greatest extent possible at Levels 1 and 2. Wireless may be considered for retrofits where running wires would be prohibitive, but other technologies (such as powerline carrier) should be considered first. When permitting wireless, require extremely limited range such that signals are not available beyond the
CCI-001439	AC-18(a)	The organization establishes implementation guidance for wireless access.	Designer Non-Designer	Wireless Access: Wireless at Level 4 should be provided by the appropriate IT organization. Avoid wireless to the greatest extent possible at Levels 1 and 2. Wireless may be considered for retrofits where running wires would be prohibitive, but other technologies (such as powerline carrier) should be considered first. When permitting wireless, require extremely limited range such that signals are not available beyond the
CCI-002323	AC-18(a)	The organization establishes configuration/connection requirements for wireless access.	Designer Non-Designer	Wireless Access: Wireless at Level 4 should be provided by the appropriate IT organization. Avoid wireless to the greatest extent possible at Levels 1 and 2. Wireless may be considered for retrofits where running wires would be prohibitive, but other technologies (such as powerline carrier) should be considered first. When permitting wireless, require extremely limited range such that signals are not available beyond the
CCI-001441	AC-18(b)	The organization authorizes wireless access to the information system prior to allowing such connections.	Designer Non-Designer	Wireless Access: Wireless at Level 4 should be provided by the appropriate IT organization. Avoid wireless to the greatest extent possible at Levels 1 and 2. Wireless may be considered for retrofits where running wires would be prohibitive, but other technologies (such as powerline carrier) should be considered first. When permitting wireless, require extremely limited range such that signals are not available beyond the
CCI-000123	AU-2(a)	The organization determines the information system must be capable of auditing an organization-defined list of auditable events.	Designer Non-Designer	Audit Events: No additional control-specific guidance. Use general control family guidance preceding this table for this control.

CCI-000125	AU-2(c)	The organization provides a rationale for why the list of auditable events is deemed to be adequate to support after-the-fact investigations of security incidents.	Designer Non-Designer	Audit Events: No additional control-specific guidance. Use general control family guidance preceding this table for this control.
CCI-001485	AU-2(d)	The organization defines the events which are to be audited on the information system on an organization-defined frequency of (or situation requiring) auditing for each identified event.	Designer Non-Designer	Audit Events: No additional control-specific guidance. Use general control family guidance preceding this table for this control.
CCI-000130	AU-3	The information system generates audit records containing information that establishes what type of event occurred.	Designer	Content Of Audit Records: Note that this – particularly the "user" portion - may only be possible at Level 4
CCI-000131	AU-3	The information system generates audit records containing information that establishes when an event occurred.	Designer	Content Of Audit Records: Note that this – particularly the "user" portion - may only be possible at Level 4
CCI-000132	AU-3	The information system generates audit records containing information that establishes where the event occurred.	Designer	Content Of Audit Records: Note that this – particularly the "user" portion - may only be possible at Level 4
CCI-000133	AU-3	The information system generates audit records containing information that establishes the source of the event.	Designer	Content Of Audit Records: Note that this – particularly the "user" portion - may only be possible at Level 4
CCI-000134	AU-3	The information system generates audit records containing information that establishes the outcome of the event.	Designer	Content Of Audit Records: Note that this – particularly the "user" portion - may only be possible at Level 4
CCI-001487	AU-3	The information system generates audit records containing information that establishes the identity of any individuals or subjects associated with the event.	Designer Impractical	Content Of Audit Records: Note that this – particularly the "user" portion - may only be possible at Level 4
CCI-001848	AU-4	The organization defines the audit record storage requirements.	Designer Non-Designer	Audit Storage Capacity: Long term audit storage will be at a computer at Level 4. Transfer from the control system to long term storage is likely a manual process, or perhaps scripted via by the computer operating system, but it is likely not an inherent feature of the control system. Designer needs to require that control system auditing can be accessed by operating system tools (e.g. control system supports or exports to standard. For devices that have STIG/SRGs related to audit storage capacity (CCI-001848 or CCI-001849) comply with the requirements of those STIG/SRGs.
CCI-001849	AU-4	The organization allocates audit record storage capacity in accordance with organization-defined audit record storage requirements.	Designer Non-Designer	Audit Storage Capacity: Long term audit storage will be at a computer at Level 4. Transfer from the control system to long term storage is likely a manual process, or perhaps scripted via by the computer operating system, but it is likely not an inherent feature of the control system. Designer needs to require that control system auditing can be accessed by operating system tools (e.g. control system supports or exports to standard For devices that have STIG/SRGs related to audit storage capacity (CCI-001848 or CCI-001849) comply with the requirements of those STIG/SRGs.
CCI-000159	AU-8(a)	The information system uses internal system clocks to generate time stamps for audit records.	Designer	Time Stamps: Typically, the timing requirement inherent in the control system will be sufficient.
CCI-001889	AU-8(b)	The information system records time stamps for audit records that meets organization-defined granularity of time measurement.	Designer	Time Stamps: Typically, the timing requirement inherent in the control system will be sufficient.
CCI-001890	AU-8(b)	The information system records time stamps for audit records that can be mapped to Coordinated Universal Time (UTC) or Greenwich Mean Time (GMT).	Designer	Time Stamps: Typically, the timing requirement inherent in the control system will be sufficient.
CCI-000169	AU-12(a)	The information system provides audit record generation capability for the auditable events defined in AU-2(a) at organization defined information system components.	Designer	Audit Generation: No additional control-specific guidance. Use general control family guidance preceding this table for this control.
CCI-001459	AU-12(a)	The organization defines information system components that provide audit record generation capability.	DoD-Defined Designer Impractical	Audit Generation: No additional control-specific guidance. Use general control family guidance preceding this table for this control.

CCI-000171	AU-12(b)	The information system allows organization-defined personnel or roles to select which auditable events are to be audited by specific components of the information system.	Designer Impractical	Audit Generation: No additional control-specific guidance. Use general control family guidance preceding this table for this control.
CCI-001910	AU-12(b)	The organization defines the personnel or roles allowed select which auditable events are to be audited by specific components of the information system.	DoD-Defined Designer Impractical	Audit Generation: No additional control-specific guidance. Use general control family guidance preceding this table for this control.
CCI-000172	AU-12(c)	The information system generates audit records for the events defined in AU-2(d) with the content defined in AU-3.	Designer	Audit Generation: No additional control-specific guidance. Use general control family guidance preceding this table for this control.
CCI-002102	CA-9(a)	The organization defines the information system components or classes of components that that are authorized internal connections to the information system.	Designer	Internal System Connections: The control system is a special purpose system. By design, only necessary connections should be allowed; typically this means use of a single specific protocol with limited capabilities. The specifications, points schedules, and network design document these controls.
CCI-002103	CA-9(b)	The organization documents, for each internal connection, the interface characteristics.	Designer	Internal System Connections: The control system is a special purpose system. By design, only necessary connections should be allowed; typically this means use of a single specific protocol with limited capabilities. The specifications, points schedules, and network design document these controls.
CCI-002104	CA-9(b)	The organization documents, for each internal connection, the security requirements.	Designer	Internal System Connections: The control system is a special purpose system. By design, only necessary connections should be allowed; typically this means use of a single specific protocol with limited capabilities. The specifications, points schedules, and network design document these controls.
CCI-000363	CM-6(a)	The organization defines security configuration checklists to be used to establish and document configuration settings for the information system technology products employed.	Designer	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.
CCI-000364	CM-6(a)	The organization establishes configuration settings for information technology products employed within the information system using organization-defined security configuration checklists.	Designer	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.
CCI-000365	CM-6(a)	The organization documents configuration settings for information technology products employed within the information system using organization-defined security configuration checklists that reflect the most restrictive mode consistent with operational requirements.	DoD-Defined Designer Non-Designer Impractical	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.
CCI-001588	CM-6(a)	The organization-defined security configuration checklists reflect the most restrictive mode consistent with operational requirements.	DoD-Defined Designer Non-Designer Impractical	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.
CCI-001755	CM-6(c)	The organization defines the information system components for which any deviation from the established configuration settings are to be identified, documented and approved.	DoD-Defined Designer Non-Designer Impractical	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.
CCI-000381	CM-7(a)	The organization configures the information system to provide only essential capabilities.	Designer	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.
CCI-000380	CM-7(b)	The organization defines for the information system prohibited or restricted functions, ports, protocols, and/or services.	Designer	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.
CCI-000382	CM-7(b)	The organization configures the information system to prohibit or restrict the use of organization-defined functions, ports, protocols, and/or services.	Designer	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.
CCI-001761	CM-7(1)(b)	The organization defines the functions, ports, protocols and services within the information system that are to be disabled when deemed unnecessary and/or non-secure.	Designer	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.

CCI-001762	CM-7(1)(b)	The organization disables organization-defined functions, ports, protocols, and services within the information system deemed to be unnecessary and/or non-secure.	Designer Impractical	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.
CCI-000389	CM-8(a)(1)	The organization develops and documents an inventory of information system components that accurately reflects the current information system.	Designer	Information System Component Inventory: Initial configuration is specified by as-built documentation. In most cases automated tools for component inventory below Level 3 do not currently exist for many systems, although new tools may be available for systems in the future and should be implemented once available.
CCI-000392	CM-8(a)(2)	The organization develops and documents an inventory of information system components that includes all components within the authorization boundary of the information system.	Designer	Information System Component Inventory: Initial configuration is specified by as-built documentation. In most cases automated tools for component inventory below Level 3 do not currently exist for many systems, although new tools may be available for systems in the future and should be implemented once available.
CCI-000398	CM-8(a)(4)	The organization defines information deemed necessary to achieve effective information system component accountability.	DoD-Defined Designer Non-Designer Impractical	Information System Component Inventory: Initial configuration is specified by as-built documentation. In most cases automated tools for component inventory below Level 3 do not currently exist for many systems, although new tools may be available for systems in the future and should be implemented once available.
CCI-002855	CP-12	The information system, when organization-defined conditions are detected, enters a safe mode of operation with organization-defined restrictions of safe mode of operation.	Designer	Safe Mode: The designer should determine, based on the criticality of the controlled equipment, what conditions to consider and which actions, if any, the control system should take when these conditions are true. This should all be specified in the control logic (e.g. sequence of operations), in particular by addressing normal/failed positions of output devices, and in the overall system design. Where high reliability is required, the analysis
CCI-002856	CP-12	The organization defines the conditions, that when detected, the information system enters a safe mode of operation with organization-defined restrictions of safe mode of operation.	Designer	Safe Mode: The designer should determine, based on the criticality of the controlled equipment, what conditions to consider and which actions, if any, the control system should take when these conditions are true. This should all be specified in the control logic (e.g. sequence of operations), in particular by addressing normal/failed positions of output devices, and in the overall system design. Where high reliability is required, the analysis
CCI-002857	CP-12	The organization defines the restrictions of safe mode of operation that the information system will enter when organization-defined conditions are detected.	Designer	Safe Mode: The designer should determine, based on the criticality of the controlled equipment, what conditions to consider and which actions, if any, the control system should take when these conditions are true. This should all be specified in the control logic (e.g. sequence of operations), in particular by addressing normal/failed positions of output devices, and in the overall system design. Where high reliability is required, the analysis
CCI-000176	IA-5(b)	The organization manages information system authenticators by establishing initial authenticator content for authenticators defined by the organization.	Designer Non-Designer	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.
CCI-001544	IA-5(c)	The organization manages information system authenticators by ensuring that authenticators have sufficient strength of mechanism for their intended use.	Designer Non-Designer Impractical	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.
CCI-001989	IA-5(e)	The organization manages information system authenticators by changing default content of authenticators prior to information system installation.	Designer	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.
CCI-000182	IA-5(g)	The organization manages information system authenticators by changing/refreshing authenticators in accordance with the organization defined time period by authenticator type.	DoD-Defined Designer Non-Designer Impractical	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.

CCI-001610	IA-5(g)	The organization defines the time period (by authenticator type) for changing/refreshing authenticators.	DoD-Defined Designer Non-Designer Impractical	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.
CCI-001611	IA-5(1)(a)	The organization defines the minimum number of special characters for password complexity enforcement.	DoD-Defined Designer Impractical	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.
CCI-001612	IA-5(1)(a)	The organization defines the minimum number of upper case characters for password complexity enforcement.	DoD-Defined Designer Impractical	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.
CCI-001613	IA-5(1)(a)	The organization defines the minimum number of lower case characters for password complexity enforcement.	DoD-Defined Designer Impractical	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.
CCI-001614	IA-5(1)(a)	The organization defines the minimum number of numeric characters for password complexity enforcement.	DoD-Defined Designer Impractical	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.
CCI-001615	IA-5(1)(b)	The organization defines the minimum number of characters that are changed when new passwords are created.	DoD-Defined Designer Impractical	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.
CCI-000198	IA-5(1)(d)	The information system enforces minimum password lifetime restrictions.	Designer Impractical	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.
CCI-001616	IA-5(1)(d)	The organization defines minimum password lifetime restrictions.	DoD-Defined Designer Impractical	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.
CCI-001617	IA-5(1)(d)	The organization defines maximum password lifetime restrictions.	DoD-Defined Designer Impractical	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.
CCI-003053	PL-2(a)(4)	The organization's security plan for the information system provides the security categorization of the information system including supporting rationale.	Designer Non-Designer	System Security Plan: While the designer is not directly responsible for the system security plan itself, the design must provide information to be used in this plan. For example, the system architecture drawing is part of the definition of the authorization boundary. The designer may also provide input for the security categorization since they have the specific knowledge of the underlying mechanical/electrical systems and can help assess the

CCI-003124	SA-5(a)(1)	The organization obtains administrator documentation for the information system, system component, or information system services that describes secure configuration of the system, component, or service.	Designer Non-Designer	Information System Documentation: Designer should require submittals providing the documentation which is required by these CCIs. Note that some of the required documentation may not be obtainable, particularly for a COTS system.
CCI-003125	SA-5(a)(1)	The organization obtains administrator documentation for the information system, system component, or information system services that describes secure installation of the system, component, or service.	Designer Non-Designer	Information System Documentation: Designer should require submittals providing the documentation which is required by these CCIs. Note that some of the required documentation may not be obtainable, particularly for a COTS system.
CCI-003127	SA-5(a)(2)	The organization obtains administrator documentation for the information system, system component, or information system services that describes effective use and maintenance of security functions/mechanisms.	Designer Non-Designer	Information System Documentation: Designer should require submittals providing the documentation which is required by these CCIs. Note that some of the required documentation may not be obtainable, particularly for a COTS system.
CCI-003128	SA-5(a)(3)	The organization obtains administrator documentation for the information system, system component, or information system services that describes known vulnerabilities regarding configuration and use of administrative (i.e., privileged) functions.	Designer Non-Designer	Information System Documentation: Designer should require submittals providing the documentation which is required by these CCIs. Note that some of the required documentation may not be obtainable, particularly for a COTS system.
CCI-003129	SA-5(b)(1)	The organization obtains user documentation for the information system, system component, or information system service that describes user-accessible security functions/mechanisms and how to effectively use those security functions/mechanisms.	Designer Non-Designer	Information System Documentation: Designer should require submittals providing the documentation which is required by these CCIs. Note that some of the required documentation may not be obtainable, particularly for a COTS system.
CCI-003130	SA-5(b)(2)	The organization obtains user documentation for the information system, system component or information system service that describes methods for user interaction which enables individuals to use the system, component, or service in a more secure manner.	Designer Non-Designer	Information System Documentation: Designer should require submittals providing the documentation which is required by these CCIs. Note that some of the required documentation may not be obtainable, particularly for a COTS system.
CCI-003131	SA-5(b)(3)	The organization obtains user documentation for the information system, system component or information system service that describes user responsibilities in maintaining the security of the system, component, or service.	Designer Non-Designer	Information System Documentation: Designer should require submittals providing the documentation which is required by these CCIs. Note that some of the required documentation may not be obtainable, particularly for a COTS system.
CCI-002546	SC-41	The organization physically disables or removes organization-defined connection ports or input/output devices on organization-defined information systems or information system components.	Designer Impractical	Port And I/O Device Access: See comments on CM-7 Least Functionality: The control system has a specific purpose (not a general one) and its functions (and limitations) are specified by the control system architecture and protocols. Specifications should require disabling any ports/protocols/services not specifically needed by the control system. Required software should be covered by specification; all other software should be prohibited. 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.
CCI-002623	SI-3(c)(1)	The organization defines the frequency for performing periodic scans of the information system for malicious code.	DoD-Defined Designer Impractical	Malicious Code Protection: Should be implemented by the Platform Enclave at entry/exit points. Periodic scans within the control system may be difficult and the designer may need to justify their non-implementation. See RA-5, SC-7. For all computers installed under this project, install and configure malware protection software in accordance with the relevant STIGs.

CCI-002773	SI-17	The organization defines the fail-safe procedures to be implemented by the information system when organization-defined failure conditions occur.	Designer	Fail-Safe Procedures: See SC-24 and CP-12 comments, where failure is one of the conditions to consider. SC-24: Fail In Known State: What is key here is the status of controlled equipment after a control system failure. Designer should specify this where necessary. Note that the DoD requirement of a "secure state" may not be applicable, and would be superseded by a "safe state", or by a "support the mission" state. Data preserved through a failure may be limited by the nature of the control system and designer should specify what is reasonable. Safe Mode: The designer should determine, based on the criticality of the controlled equipment, what conditions to consider and which actions, if any, the control system should take when these conditions are true. This should all be specified in the control logic (e.g. sequence of operations), in particular by addressing normal/failed positions of output devices, and in the overall system design. Where high reliability is required, the analysis should consider the addition of redundant equipment to the design.
CCI-002774	SI-17	The organization defines the failure conditions which, when they occur, will result in the information system implementing organization-defined fail-safe procedures.	Designer	Fail-Safe Procedures: See SC-24 and CP-12 comments, where failure is one of the conditions to consider. SC-24: Fail In Known State: What is key here is the status of controlled equipment after a control system failure. Designer should specify this where necessary. Note that the DoD requirement of a "secure state" may not be applicable, and would be superseded by a "safe state", or by a "support the mission" state. Data preserved through a failure may be limited by the nature of the control system and designer should specify what is reasonable. Safe Mode: The designer should determine, based on the criticality of the controlled equipment, what conditions to consider and which actions, if any, the control system should take when these conditions are true. This should all be specified in the control logic (e.g. sequence of operations), in particular by addressing normal/failed positions of output devices, and in the overall system design. Where high reliability is required, the analysis should consider the addition of redundant equipment to the design.
CCI-002775	SI-17	The information system implements organization- defined fail-safe procedures when organization- defined failure conditions occur.	Designer	Fail-Safe Procedures: See SC-24 and CP-12 comments, where failure is one of the conditions to consider. SC-24: Fail In Known State: What is key here is the status of controlled equipment after a control system failure. Designer should specify this where necessary. Note that the DoD requirement of a "secure state" may not be applicable, and would be superseded by a "safe state", or by a "support the mission" state. Data preserved through a failure may be limited by the nature of the control system and designer should specify what is reasonable. Safe Mode: The designer should determine, based on the criticality of the controlled equipment, what conditions to consider and which actions, if any, the control system should take when these conditions are true. This should all be specified in the control logic (e.g. sequence of operations), in particular by addressing normal/failed positions of output devices, and in the overall system design. Where high reliability is required, the analysis should consider the addition of redundant equipment to the design.

CCI-002953	PE-9(1)	The organization employs redundant power cabling paths that are physically separated by organization- defined distance.	Designer, Non-Designer	Power Equipment And Cabling: For systems requiring redundant power, designer should coordinate with electrical designer. Note that the weak link in reliability will often be the controlled equipment. For example, if a single backup generator is needed, a system with 2 generators - each with a single controller - will be more reliable than a single generator with redundant controllers.
CCI-002954	PE-9(1)	The organization defines the distance to physically separate redundant power cabling paths.	Designer, Non-Designer	Power Equipment And Cabling: For systems requiring redundant power, designer should coordinate with electrical designer. Note that the weak link in reliability will often be the controlled equipment. For example, if a single backup generator is needed, a system with 2 generators - each with a single controller - will be more reliable than a single generator with redundant controllers.
CCI-002955	PE-11	The organization provides a short-term uninterruptible power supply to facilitate an orderly shutdown of the information system and/or transition of the information system to long-term alternate power in the event of a primary power source loss.	Enclave Designer, Impractical	Emergency Power: Within the control system, require an uninterruptible power supply (UPS), either in the control system specification or by coordination with electrical specification, when backup power is required. At the front end, this could either be met by the Platform Enclave, or by control system specification requirements also. For the majority of LOW impact

CCI-000961	PE-11(1)	The organization provides a long-term alternate power supply for the information system that is capable of maintaining minimally required operational capability in the event of an extended loss of the primary power source.	Enclave Designer, Impractical	Emergency Power: Within the control system, require an uninterruptible power supply (UPS), either in the control system specification or by coordination with electrical specification, when backup power is required. At the front end, this could either be met by the Platform Enclave, or by control system specification requirements also. For the majority of LOW impact

Table H-6 Platform Enclave CCIs for LOW and MODERATE Impact Control Systems

CCI #	800-53 Control Text Indicator	CCI Definition	Guidance
CCI-000048	AC-8(a)	The information system displays an organization-defined system use notification message or banner before granting access to the system that provides privacy and security notices consistent with applicable federal laws, Executive Orders, directives, policies, regulations, standards, and guidance.	System Use Notification: Login banners must be implemented at user login to government computers – e.g. at the Platform Enclave, Level 4 and Level 2 computers. User interfaces at Levels 0, 1 and 2 (e.g. Local Display Panels (LDP)) generally won't support a login banner. Require login banners where practical according to best industry practice and indicate where implementation is not practical.
CCI-002247	AC-8(a)	The organization defines the use notification message or banner the information system displays to users before granting access to the system.	System Use Notification: Login banners must be implemented at user login to government computers – e.g. at the Platform Enclave, Level 4 and Level 2 computers. User interfaces at Levels 0, 1 and 2 (e.g. Local Display Panels (LDP)) generally won't support a login banner. Require login banners where practical according to best industry practice and indicate where implementation is not practical.
CCI-002243	AC-8(a)(1)	The organization-defined information system use notification message or banner is to state that users are accessing a U.S. Government information system.	System Use Notification: Login banners must be implemented at user login to government computers – e.g. at the Platform Enclave, Level 4 and Level 2 computers. User interfaces at Levels 0, 1 and 2 (e.g. Local Display Panels (LDP)) generally won't support a login banner. Require login banners where practical according to best industry practice and indicate where implementation is not practical.

Table H-6 Platform Enclave CCIs for LOW and MODERATE Impact Control Systems

CCI-002244	AC-8(a)(2)	The organization-defined information system use notification message or banner is to state that information system usage may be monitored, recorded, and subject to audit.	System Use Notification: Login banners must be implemented at user login to government computers – e.g. at the Platform Enclave, Level 4 and Level 2 computers. User interfaces at Levels 0, 1 and 2 (e.g. Local Display Panels (LDP)) generally won't support a login banner. Require login banners where practical according to best industry practice and indicate where implementation is not practical.
CCI-002246	AC-8(a)(4)	The organization-defined information system use notification message or banner is to state that use of the information system indicates consent to monitoring and recording.	System Use Notification: Login banners must be implemented at user login to government computers – e.g. at the Platform Enclave, Level 4 and Level 2 computers. User interfaces at Levels 0, 1 and 2 (e.g. Local Display Panels (LDP)) generally won't support a login banner. Require login banners where practical according to best industry practice and indicate where implementation is not practical.
CCI-000050	AC-8(b)	The information system retains the notification message or banner on the screen until users acknowledge the usage conditions and take explicit actions to log on to or further access.	System Use Notification: Login banners must be implemented at user login to government computers – e.g. at the Platform Enclave, Level 4 and Level 2 computers. User interfaces at Levels 0, 1 and 2 (e.g. Local Display Panels (LDP)) generally won't support a login banner. Require login banners where practical according to best industry practice and indicate where implementation is not practical.

Table H-6 Platform Enclave CCIs for LOW and MODERATE Impact Control Systems

CCI-002248	AC-8(c)(1)	The organization defines the conditions of use which are to be displayed to users of the information system before granting further access.	System Use Notification: Login banners must be implemented at user login to government computers – e.g. at the Platform Enclave, Level 4 and Level 2 computers. User interfaces at Levels 0, 1 and 2 (e.g. Local Display Panels (LDP)) generally won't support a login banner. Require login banners where practical according to best industry practice and indicate where implementation is not practical.
CCI-000139	AU-5(a)	The information system alerts designated organization-defined personnel or roles in the event of an audit processing failure.	Response To Audit Processing Failures: Notifications and specific actions may only be possible at Level 4.
CCI-000140	AU-5(b)	The information system takes organization defined actions upon audit failure (e.g., shut down information system, overwrite oldest audit records, stop generating audit records).	Response To Audit Processing Failures: Notifications and specific actions may only be possible at Level 4.
CCI-001490	AU-5(b)	The organization defines actions to be taken by the information system upon audit failure (e.g., shut down information system, overwrite oldest audit records, stop generating audit records).	Response To Audit Processing Failures: Notifications and specific actions may only be possible at Level 4.
CCI-000550	CP-10	The organization provides for the recovery and reconstitution of the information system to a known state after a disruption.	Information System Recovery And Reconstitution: Designer should require submittals containing data, documentation and software sufficient to restore the system to its final accepted as-built state. This must include custom programming and configuration for controllers or workstations.
CCI-000551	CP-10	The organization provides for the recovery and reconstitution of the information system to a known state after a compromise.	Information System Recovery And Reconstitution: Designer should require submittals containing data, documentation and software sufficient to restore the system to its final accepted as-built state. This must include custom programming and configuration for controllers or workstations.

Table H-6 Platform Enclave CCIs for LOW and MODERATE Impact Control Systems

CCI-000552	CP-10	The organization provides for the recovery and reconstitution of the information system to a known state after a failure.	Information System Recovery And Reconstitution: Designer should require submittals containing data, documentation and software sufficient to restore the system to its final accepted as-built state. This must include custom programming and configuration for controllers or workstations.
CCI-000764	IA-2	The information system uniquely identifies and authenticates organizational users (or processes acting on behalf of organizational users).	Identification And Authentication (Organizational Users): Much of this can only be met at Level 4, and much of it depends on the computer operating system. Designer should provide specifications where possible, and be prepared to justify non-implementation in the control system. Whenever possible, require that the control system (for access via a computer) support CAC (or similar) logins. Note that remote access is covered at the platform enclave.
CCI-000765	IA-2(1)	The information system implements multifactor authentication for network access to privileged accounts.	Identification And Authentication (Organizational Users): Much of this can only be met at Level 4, and much of it depends on the computer operating system. Designer should provide specifications where possible, and be prepared to justify non-implementation in the control system. Whenever possible, require that the control system (for access via a computer) support CAC (or similar) logins. Note that remote access is covered at the platform enclave.

Table H-6 Platform Enclave CCIs for LOW and MODERATE Impact Control Systems

CCI-001953	IA-2(12)	The information system accepts Personal Identity Verification (PIV) credentials.	Identification And Authentication (Organizational Users): Much of this can only be met at Level 4, and much of it depends on the computer operating system. Designer should provide specifications where possible, and be prepared to justify non-implementation in the control system. Whenever possible, require that the control system (for access via a computer) support CAC (or similar) logins. Note that remote access is covered at the platform enclave.
CCI-001954	IA-2(12)	The information system electronically verifies Personal Identity Verification (PIV) credentials.	Identification And Authentication (Organizational Users): Much of this can only be met at Level 4, and much of it depends on the computer operating system. Designer should provide specifications where possible, and be prepared to justify non-implementation in the control system. Whenever possible, require that the control system (for access via a computer) support CAC (or similar) logins. Note that remote access is covered at the platform enclave.
CCI-000777	IA-3	The organization defines a list of specific and/or types of devices for which identification and authentication is required before establishing a connection to the information system.	Device Identification And Authentication: Much of this can only be met at Level 4, and much of it depends on the computer operating system. Typically, authentication between devices can be implemented between computers (Level 2 and 4) or between network hardware (Level 2, 3 or 4). Authentication may be supported between controllers, where not all controllers will support this capability and it will be more often supported at for LOW impact system, but may be required for MODERATE or HIGH systems.

Table H-6 Platform Enclave CCIs for LOW and MODERATE Impact Control Systems

CCI-000778	IA-3	The information system uniquely identifies an organization defined list of specific and/or types of devices before establishing a local, remote, or network connection.	Device Identification And Authentication: Much of this can only be met at Level 4, and much of it depends on the computer operating system. Typically, authentication between devices can be implemented between computers (Level 2 and 4) or between network hardware (Level 2, 3 or 4). Authentication may be supported between controllers, where not all controllers will support this capability and it will be more often supported at for LOW impact system, but may be required for MODERATE or HIGH systems.
CCI-001958	IA-3	The information system authenticates an organization defined list of specific and/or types of devices before establishing a local, remote, or network connection.	Device Identification And Authentication: Much of this can only be met at Level 4, and much of it depends on the computer operating system. Typically, authentication between devices can be implemented between computers (Level 2 and 4) or between network hardware (Level 2, 3 or 4). Authentication may be supported between controllers, where not all controllers will support this capability and it will be more often supported at for LOW impact system, but may be required for MODERATE or HIGH systems.
CCI-000192	IA-5(1)(a)	The information system enforces password complexity by the minimum number of upper case characters used.	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.

Table H-6 Platform Enclave CCIs for LOW and MODERATE Impact Control Systems

CCI-000193	IA-5(1)(a)	The information system enforces password complexity by the minimum number of lower case characters used.	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.
CCI-000194	IA-5(1)(a)	The information system enforces password complexity by the minimum number of numeric characters used.	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.
CCI-000205	IA-5(1)(a)	The information system enforces minimum password length.	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.
CCI-001619	IA-5(1)(a)	The information system enforces password complexity by the minimum number of special characters used.	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.

Table H-6 Platform Enclave CCIs for LOW and MODERATE Impact Control Systems

CCI-000195	IA-5(1)(b)	The information system, for password-based authentication, when new passwords are created, enforces that at least an organization-defined number of characters are changed.	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.
CCI-000196	IA-5(1)(c)	The information system, for password-based authentication, stores only cryptographically-protected passwords.	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.
CCI-000197	IA-5(1)(c)	The information system, for password-based authentication, transmits only cryptographically-protected passwords.	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.
CCI-000199	IA-5(1)(d)	The information system enforces maximum password lifetime restrictions.	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.

Table H-6 Platform Enclave CCIs for LOW and MODERATE Impact Control Systems

CCI-000200	IA-5(1)(e)	The information system prohibits password reuse for the organization defined number of generations.	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.
CCI-001618	IA-5(1)(e)	The organization defines the number of generations for which password reuse is prohibited.	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.
CCI-002041	IA-5(1)(f)	The information system allows the use of a temporary password for system logons with an immediate change to a permanent password.	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.
CCI-002002	IA-5(11)	The organization defines the token quality requirements to be employed by the information system mechanisms for token-based authentication.	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.

Table H-6 Platform Enclave CCIs for LOW and MODERATE Impact Control Systems

CCI-002003	IA-5(11)	The information system, for token-based authentication, employs mechanisms that satisfy organization-defined token quality requirements.	Authenticator Management: The DoD-defined password complexity values may be impractical for control system components to meet. Specify password complexity at DoD-defined values where practical. Require that default passwords be changed from defaults, and that passwords are submitted in a secure manner.. For PKI systems, certificate paths should be provided by the Platform Enclave.
CCI-000206	IA-6	The information system obscures feedback of authentication information during the authentication process to protect the information from possible exploitation/use by unauthorized individuals.	Authenticator Feedback and Cryptographic Module Authentication: Almost certainly Platform Enclave only and not supported below that level. Designer may need to provide input/justification for this. For devices that have STIGs or SRGs related to obscuring of authenticator feedback (CCI-000206), comply with the requirements of those STIGS/SRGs
CCI-000803	IA-7	The information system implements mechanisms for authentication to a cryptographic module that meet the requirements of applicable federal laws, Executive Orders, directives, policies, regulations, standards, and guidance for such authentication.	Authenticator Feedback and Cryptographic Module Authentication: Almost certainly Platform Enclave only and not supported below that level. Designer may need to provide input/justification for this. For devices that have STIG/SRGs related to cryptographic module authentication (CCI-000803), comply with the requirements of those STIG/SRGs.
CCI-000965	PE-13	The organization employs and maintains fire suppression and detection devices/systems for the information system that are supported by an independent energy source.	
CCI-000971	PE-14(a)	The organization maintains temperature and humidity levels within the facility where the information system resides at organization-defined acceptable levels.	

Table H-6 Platform Enclave CCIs for LOW and MODERATE Impact Control Systems

CCI-000972	PE-14(a)	The organization defines acceptable temperature and humidity levels to be maintained within the facility where the information system resides.	
CCI-000973	PE-14(b)	The organization monitors temperature and humidity levels in accordance with organization-defined frequency.	
CCI-000974	PE-14(b)	The organization defines a frequency for monitoring temperature and humidity levels.	
CCI-000977	PE-15	The organization protects the information system from damage resulting from water leakage by providing master shutoff or isolation valves that are accessible.	
CCI-000978	PE-15	The organization protects the information system from damage resulting from water leakage by providing master shutoff or isolation valves that are working properly.	
CCI-000979	PE-15	Key personnel have knowledge of the master water shutoff or isolation valves.	
CCI-000981	PE-16	The organization authorizes organization-defined types of information system components entering and exiting the facility.	No additional control-specific guidance. Use general control family guidance preceding this table for this control.
CCI-000982	PE-16	The organization monitors organization-defined types of information system components entering and exiting the facility.	No additional control-specific guidance. Use general control family guidance preceding this table for this control.
CCI-000983	PE-16	The organization controls organization-defined types of information system components entering and exiting the facility.	No additional control-specific guidance. Use general control family guidance preceding this table for this control.
CCI-000984	PE-16	The organization maintains records of information system components entering and exiting the facility.	No additional control-specific guidance. Use general control family guidance preceding this table for this control.
CCI-002974	PE-16	The organization defines types of information system components to authorize, monitor, and control entering and exiting the facility and to maintain records.	No additional control-specific guidance. Use general control family guidance preceding this table for this control.

Table H-6 Platform Enclave CCIs for LOW and MODERATE Impact Control Systems

CCI-003051	PL-2(a)(2)	The organization's security plan for the information system explicitly defines the authorization boundary for the system.	
CCI-001054	RA-5(a)	The organization scans for vulnerabilities in the information system and hosted applications on an organization-defined frequency.	
CCI-001055	RA-5(a)	The organization defines a frequency for scanning for vulnerabilities in the information system and hosted applications.	
CCI-001056	RA-5(a)	The organization scans for vulnerabilities in the information system and hosted applications when new vulnerabilities potentially affecting the system/applications are identified and reported.	
CCI-001641	RA-5(a)	The organization defines the process for conducting random vulnerability scans on the information system and hosted applications.	
CCI-001643	RA-5(a)	The organization scans for vulnerabilities in the information system and hosted applications in accordance with the organization-defined process for random scans.	
CCI-001057	RA-5(b)	The organization employs vulnerability scanning tools and techniques that facilitate interoperability among tools and automate parts of the vulnerability	
CCI-001058	RA-5(c)	The organization analyzes vulnerability scan reports and results from security control assessments.	
CCI-001059	RA-5(d)	The organization remediates legitimate vulnerabilities in organization defined response times in accordance with an organizational assessment risk.	

Table H-6 Platform Enclave CCIs for LOW and MODERATE Impact Control Systems

CCI-003116	SA-4(10)	The organization employs only information technology products on the FIPS PUB 201-2-approved products list for Personal Identity Verification (PIV) capability implemented within organizational information systems.	
CCI-001093	SC-5	The organization defines the types of denial of service attacks (or provides references to sources of current denial of service attacks) that can be addressed by the information system.	
CCI-002385	SC-5	The information system protects against or limits the effects of organization-defined types of denial of service attacks by employing organization-defined security safeguards.	
CCI-002386	SC-5	The organization defines the security safeguards to be employed to protect the information system against, or limit the effects of, denial of service attacks.	
CCI-001097	SC-7(a)	The information system monitors and controls communications at the external boundary of the system and at key internal boundaries within the system.	
CCI-002430	SC-12	The organization defines the requirements for cryptographic key storage to be employed within the information system.	
CCI-002544	SC-41	The organization defines the information systems or information system components on which organization-defined connection ports or input/output devices are to be physically disabled or removed.	
CCI-002545	SC-41	The organization defines the connection ports or input/output devices that are to be physically disabled or removed from organization-defined information systems or information system components.	

Table H-6 Platform Enclave CCIs for LOW and MODERATE Impact Control Systems

CCI-001227	SI-2(a)	The organization corrects information system flaws.	
CCI-001241	SI-3(c)(1)	The organization configures malicious code protection mechanisms to perform periodic scans of the information system on an organization- defined frequency.	

Table H-7 Additional Platform Enclave CCIs for MODERATE Impact Control Systems

CCI #	800-53 Control Text Indicator	CCI Definition	Responsibility	Guidance
CCI-000956	PE-10(a)	The organization provides the capability of shutting off power to the information system or individual system components in emergency situations.	Platform Enclave	
CCI-000957	PE-10(b)	The organization places emergency shutoff switches or devices in an organization-defined location by information system or system component to facilitate safe and easy access for personnel.	Platform Enclave	
CCI-000958	PE-10(b)	The organization defines a location for emergency shutoff switches or devices by information system or system component.	Platform Enclave	
CCI-000959	PE-10(c)	The organization protects emergency power shutoff capability from unauthorized activation.	Platform Enclave	
CCI-002955	PE-11	The organization provides a short-term uninterruptible power supply to facilitate an orderly shutdown of the information system and/or transition of the information system to long-term alternate power in the event of a primary power source loss.	Platform Enclave	Emergency Power: Within the control system, require an uninterruptible power supply (UPS), either in the control system specification or by coordination with electrical specification, when backup power is required. At the front end, this could either be met by the Platform Enclave, or by control system specification requirements also. For the majority of LOW impact

CCI-000961	PE-11(1)	The organization provides a long-term alternate power supply for the information system that is capable of maintaining minimally required operational capability in the event of an extended loss of the primary power source.	Platform Enclave	Emergency Power: Within the control system, require an uninterruptible power supply (UPS), either in the control system specification or by coordination with electrical specification, when backup power is required. At the front end, this could either be met by the Platform Enclave, or by control system specification requirements also. For the majority of LOW impact
CCI-000968	PE-13(3)	The organization employs an automatic fire suppression capability for the information system when the facility is not staffed on a continuous basis.	Platform Enclave	
CCI-000985	PE-17(a)	The organization employs organization-defined security controls at alternate work sites.	Platform Enclave	Alternate Work Site: PE-17 can't be applied except at Level 4 – there is no possible "alternate work site" for PIT. This is all at the Platform Enclave.
CCI-002975	PE-17(a)	The organization defines security controls to employ at alternate work sites.	Platform Enclave	Alternate Work Site: PE-17 can't be applied except at Level 4 – there is no possible "alternate work site" for PIT. This is all at the Platform Enclave.
CCI-000987	PE-17(b)	The organization assesses as feasible, the effectiveness of security controls at alternate work sites.	Platform Enclave	Alternate Work Site: PE-17 can't be applied except at Level 4 – there is no possible "alternate work site" for PIT. This is all at the Platform Enclave.
CCI-000988	PE-17(c)	The organization provides a means for employees to communicate with information security personnel in case of security incidents or problems.	Platform Enclave	Alternate Work Site: PE-17 can't be applied except at Level 4 – there is no possible "alternate work site" for PIT. This is all at the Platform Enclave.

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CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS (FIRE ALARM ONLY)

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SECTION 25 05 11.02

CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS (FIRE ALARM ONLY)
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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 are available online at the Information Assurance Support Environment (IASE) website at http://iase.disa.mil/stigs/Pages/index.aspx. Not all control system components have applicable STIGs or SRGs.

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 Reporting/Mass Notification (Building Level Controls Only).

The components invovled are for the Fire Reporting System. There is no Operational or Traditional IT involved in this project. The installer should apply cybersecurity to the lowest point practical on the control system. Primary work will be conducted at Control System Levels 0 thru 1.

1.2 RELATED REQUIREMENTS

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.

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

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

1.4 DEFINITIONS

1.4.1 Computer

As used in this Section, 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 OS, where Android is considered separate from Linux

e. a device running a version of Apple iOS

1.4.2 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 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).

Any device that supports wireless communication is network connected, regardless of whether the device is communicating using wireless.

1.4.3 User Account Support Levels

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

1.4.3.1 FULLY Supported

Device supports configurable individual accounts. Accounts can be created, deleted, modified, etc. Privileges can be assigned to accounts.

1.4.3.2 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 "user name and password" structure).

1.4.3.3 NOT Supported

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

1.4.4 User Interface

Generally, a user interface is hardware on a device allowing user interaction with that device via input (buttons, switches, sliders, keyboard, touch screen, etc.) and a screen. There are three types of user interfaces defined in this Section: Limited Local User Interface, Full Local User Interface and Remote User Interface. In this Section, when the term "User Interface" is used without specifying which type, it refers only to Full Local User Interface and Remote User Interface (NOT to Limited Local User Interface).

1.4.4.1 Limited Local User Interface

A Limited Local User Interface is a user interface where the interaction is limited, fixed at the factory, and cannot be modified in the field. The user must be physically at the device to interact with it.

Examples of Limited Local User Interface include thermostats .

1.4.4.2 Full Local User Interface

A Full Local User Interface is a user interface where the interaction and displays are field-configurable.

Examples of a Full Local User Interface include local applications on a computer .

1.4.4.3 Remote User Interface

A Remote User Interface is a user interface on a Client device allowing user interaction with a different Server device. The user need not be physically at the Server device to interact with it.

Examples of Remote User Interfaces include web browsers.

1.5 ADMINISTRATIVE REQUIREMENTS

1.5.1 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 communication, the Wireless Communication Request submittal must be approved prior to control system device selection and integration.

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 integration.

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

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. 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, HTTP web server certificates must be obtained from the indicated contact for the project site.

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

1.6 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance with Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Wireless Communication Request; G

Device Account Lock Exception Request; G

Contractor Computer Cybersecurity Compliance Statements; G

Contractor Temporary Network Cybersecurity Compliance Statements; G

SD-02 Shop Drawings

User Interface Banner Schedule; G

Network Communication Report; G

Cybersecurity Riser Diagram; G

Control System Inventory Report; G

SD-03 Product Data

Control System Cybersecurity Documentation; G

SD-06 Test Reports

Wireless Communication Test Report; G

SD-07 Certificates

Software Licenses; G

SD-11 Closeout Submittals

Password Summary Report; G

Software Recovery And Reconstitution Images; G

Device Audit Record Upload Software; G

1.7 QUALITY CONTROL

1.7.1 Control System Cybersecurity Subject Matter Expert

The individual will oversee all work within this specification. This position requires that the individual currently meet Information Assurance Manager Level II Certification requirements in accordance with DoDI 8570 Information Workforce Improvement Program.

Individuals for this poistion should have experience securing DoD systems and with Risk Management Framework. Control System experience is highly desirable.

Resumes should be submitted to the Government within 14 days after notice to proceed. All certifications must be in effect prior to beginning work.

This position may serve across the contract for all control systems. There is no requirement to have one Cybersecurity SME per platform.

1.8 CYBERSECURITY DOCUMENTATION

1.8.1 Network Communication Report

{For Reference Only: This subpart (and its subparts) relates to CA-9; CCI-002102, CCI-002103, CCI-002104, CCI-002105 and also the submittal requirements associated with CM-6, CM-7 and SC-41}

Provide a network communication report. For each networked controller, document the communication characteristics of the controller including communication protocols, services used, and a general description of what information is communicated over the network. For each controller using IP, document all TCP and UDP ports 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.

1.8.2 Control System Inventory Report

{For Reference Only: This subpart (and its subparts) relates to CM-8(a), CP-12, SI-17, IA-3; CCI-000389, CCI-000392, CCI-000398, CCI-002855, CCI-002856, CCI-002857, 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 http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphic 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.

1.8.3 Software Recovery and Reconstitution Images

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

For each control system device on which software is installed under this project, provide a recovery image of the final as-built control device. 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 Government.

1.8.4 Cybersecurity Riser Diagram

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

Provide a cybersecurity riser diagram of the complete control system including all network and controller 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 overlayed on a facility schematic.

1.8.5 Control System Cybersecurity Documentation

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

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

1.8.5.1 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 reference only: relates to CCI-003124}

b. Documentation that describes secure installation of the device {for reference only: relates to CCI-003125}

c. Documentation that describes secure operation of the device {for reference only: relates to CCI-003124}

d. Documentation that describes effective use and maintenance of security functions or mechanisms for the device {for 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 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 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 reference only: relates to CCI-003130}

h. Documentation that describes user responsibilities in maintaining the security of the device {for reference only: relates to CCI-003131}

1.9 SOFTWARE UPDATE LICENSING

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

In addition to all other licensing requirements, all software licensing must include licensing of the following software updates for a period of no less than 5 years:

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 Reference Only: This subpart (and its subparts) relates to AC-18, SA-3, CCI-00258}

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. When used, contractor computers 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. All 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 all computers 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 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 http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphic 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 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 IP networks provided under this project or Government furnished IP networks provided for this purpose. Any and all network access 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 must not interfere with existing wireless network and must use WPA2 security. 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 http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphic 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 ACCESS CONTROL REQUIREMENTS

3.1.1 User Accounts

{For Reference Only: This subpart (and its subparts) relate to AC-2(a)and AC-3; CCI-002110, CCI-000213.}

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

3.1.1.1 Requirements for Control System Devices

For control system devices where User Account requirements are not otherwise indicated in this Section:

a. Devices with web interfaces must either at least MINIMALLY support user accounts or have their web interface disabled.

b. Field devices with full local user interfaces allowing modification of data must at least MINIMALLY support user accounts.

c. Field devices with read-only full local user interfaces must at least MINIMALLY support user accounts.

d. All devices must at least MINIMALLY support user accounts.

3.1.2 Unsuccessful Logon Attempts

{For Reference Only: This subpart (and its subparts) relate 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.

3.1.2.1 Devices MINIMALLY Supporting Accounts

Devices which MINIMALLY support accounts are not required to lock based on unsuccessful logon attempts.

3.1.2.2 Devices FULLY Supporting Accounts

Devices which FULLY support accounts must meet the following requirements. If a device cannot meet these requirements, document device capabilities to protect from subsequent unsuccessful logon attempts and propose alternate protections in a Device Account Lock Exception Request submittal. Do not implement alternate protection measures without explicit permission from the Government.

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.

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

3.1.2.3 High Availability Interfaces Exempt from Unsuccessful Logon Attempts Requirements

The following high availability interfaces are exempt from unsuccessful logon attempts requirements:

High Availability Interfaces Exempt from Unsuccessful Logon Attempts Requirements		
User Interface	**Location**	**Action to take in lieu of locking screen**
Fire Panel		None

3.1.3 System Use Notification

{For 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}

Web interfaces must display a warning banner meeting the requirements of DTM 08-060.

Devices which are connected to a network and have a user interface must display a warning banner meeting the requirements of DTM 08-060 if capable of doing so. Devices which are connected to a network and have a user interface but are not capable of displaying a banner must have a permanently affixed label displaying an approved banner from DTM 08-060.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 contract between font and background colors.

3.1.3.1 User Interface Banner Schedule

Provide a User Interface Schedule using the format indicated showing each user interface provided and how the information banner requirement has been implemented for each user interface.

User Interface Schedule Format (with sample entries)			
User Interface Description	**User Interface Location**	**Type of User Interface**	**Banner Implementation**
Sample 1	Room 1	Remote	DTM 08-060 Banner "A" Displayed at Logon
Sample 2	Room 2	Limited Local	DTM 08-060 Banner "B" on Affixed Label
Sample 3	Room 3	Full Local	DTM 08-060 Banner "B" Displayed on Screen

3.1.4 Permitted Actions Without Identification or Authentication

{For 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.

3.1.5 Wireless Access

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

Unless explicitly authorized by the Government, do not use any wireless communication. Any device with wireless communication capability is considered to be using wireless communication, regardless of whether or not the device is actively communicating wirelessly, except when wireless communication has been physically permanently disabled (such as through

the removal of the wireless transceiver).

3.1.5.1 Wireless IP Communications

Do not install wireless 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.

3.1.5.2 Non-IP Wireless Communication

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.

3.1.5.3 Wireless Communication Request

Provide a report documenting the proposed use of wireless communication prior to beginning construction using the Wireless Communication Request Schedule at http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphic

For each device proposed to use wireless 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, RF Frequency, Radiated Power in dBm (decibel with a milliwatt reference), free-space range, and the expected as-installed range.

3.1.5.4 Wireless Communication Testing

As part of Functional Performance Testing {FPT}, conduct testing of wireless communication for all devices indicated on the approved Wireless 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 CYBERSECURITY AUDITING

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

{For Reference Only: This subpart (and its subparts) relates to AU-2(a),(c),(d), AU-3, AU-12; CCI-000123, CCI-001571, CCI-000125, CCI-001485, CCI-000130, CCI-000131, CCI-000132, CCI-00133, CCI-000134, CCI-001487, CCI-000169, CCI-001459, CCI-000171, CCI-000172, CCI-001910}

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.

3.2.1.1 Requirements for Control System Devices

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

3.2.1.1.1 Devices Which FULLY Support Accounts

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

3.2.1.1.1.1 Audited Events

Configure each device 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)

a. Successful and unsuccessful logon attempts

b. Privileged activities or other system level access

c. Starting and ending time for user access to the system

d. Concurrent logons from different workstations

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

f. All kernel module load, unload, and restart

3.2.1.1.2 Devices Which Do Not FULLY Support Accounts

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

3.2.2 Audit Storage Capacity and Audit Upload

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

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 non-computer control system devices capable of generating audit records, provide 60 days worth of secure local storage, assuming 10 auditable events per day.

3.2.2.1 Device Audit Record Upload Software

For each non-computer device required to audit events, provide, and license to the Government, software implementing a secure mechanism of uploading audit records from the device to a computer and of exporting the uploaded audit records as a Microsoft Excel file Where different devices

use different software, provide software of each type required to upload audit logs from all devices.

Submit copies of device audit record upload software. If there are no non-computer devices requiring auditing, provide a document stating this in lieu of this submittal.

3.2.3 Time Stamps

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

3.2.3.1 Control System Devices

Devices generating audit records must have internal clocks capable of providing time with a resolution of 1 second. Clocks cannot drift more than 10 seconds per day. Configure the system so that each device generating audit records maintains accurate time to within 1 second.

3.2.3.2 Default Requirements for Control System Devices

For control system devices where Time Stamps requirements are not otherwise indicated in this Section: Devices generating audit records must have internal clocks capable of providing time with a resolution of 1 second. Clocks must not drift more than 10 seconds per day. Configure the system so that each device generating audit records maintains accurate time to within 1 second.

3.3 REQUIREMENTS FOR LEAST FUNCTIONALITY

{For Reference Only: This subpart (and its subparts), along with the network communication report submittal specified elsewhere in this section, relates to CM-6 (a), (c), CM-7, CM-7 (1)(b), SC-41; CCI-000363, CCI-000364, CCI-000365, CCI-001588, CCI-001755, CCI-000381, CCI-000380, CCI-00382, 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.

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

3.3.1 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, or use any protocol on ports other than those specified.

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

3.3.2 IP Control Networks

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.

3.4 SAFE MODE AND FAIL SAFE OPERATION

{For Reference Only: This subpart (and its subparts) relates to CP-12, SI-17; CCI-002855, CCI-002856, CCI-002857, 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.

3.5 IDENTIFICATION AND AUTHENTICATION

3.5.1 User Identification and Authentication

{For Reference Only: This subpart (and its subparts) relates to IA-2,(1),(12); CCI-000764, CCI-000765, CCI-001953, CCI-001954}

a. Devices that FULLY support accounts must uniquely identify and authenticate organizational users.

b. Devices which allow network access to privileged accounts must implement multifactor authentication for network access to privileged accounts.

3.5.1.1 Default Requirements for Control System Devices

For control system devices where User Identification and Authentication requirements are not otherwise indicated in this Section, User Identification and Authentication for network access to privileged accounts must be implemented by inheriting identification and authentication from the operating system.

3.5.2 Authenticator Management

{For Reference Only: This subpart (and its subparts) relates to IA-5 (b),(c),(e),(g),(1),(11); CCI-000176, 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}

3.5.2.1 Authentication Type

3.5.2.1.1 Requirements for Control System Devices

For control system devices where Authentication Type requirements are not otherwise indicated in this Section:

a. Other devices which FULLY support accounts must use either password-based authentication or hardware token-based authentication.

b. Devices MINIMALLY supporting accounts must use either password-based authentication or hardware token-based authentication.

3.5.2.2 Password-Based Authentication Requirements

3.5.2.2.1 Passwords for Non-Computer Devices FULLY Supporting Accounts

All non-computer devices 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.

f. Password must have a maximum lifetime of sixty (60) days. When passwords expire, prompt users to change passwords. Do no 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.

3.5.2.2.2 Passwords for Web Interfaces

Passwords for connecting to a web 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.

f. Password must have a maximum lifetime of 60 days. When passwords expire, prompt users to change passwords. Do no 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.

3.5.2.2.3 Passwords for Devices Minimally Supporting Accounts

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

3.5.2.2.4 Password Configuration and Reporting

For all devices with a password, change the password from the default

password. Coordinate selection of passwords with the Government. Do not use the same password for more than one device unless specifically instructed to do so. Provide a Password Summary Report documenting the password for each device and describing the procedure to change the password for each device.

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.

3.5.2.3 Hardware Token-Based Authentication Requirements

Devices supporting hardware token-based authentication must use Personal Identity Verification (PIV) credentials for the hardware token.

3.5.3 Authenticator Feedback

{For 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.

3.5.4 Device Identification and Authentication

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

3.5.4.1 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 using a web server certificate obtained from the Government Trusted Agent instead.

3.5.5 Cryptographic Module Authentication

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

For devices that have STIG/SRGs related to cryptographic module authentication (CCI-000803), comply with the requirements of those STIG/SRGs.

3.6 EMERGENCY POWER

{For Reference Only: This subpart (and its subparts) relates to PE-11,(1); CCI-02955, CCI-000961}

Emergency power is specified in the control system and equipment specifications.

3.7 DURABILITY TO VULNERABILITY SCANNING

{For Reference Only: This subpart (and its subparts) relates to RA-5

{(a),(b),(c),(d); CCI-001054, CCI-001055, CCI-0010156, 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.

For control system devices other than computers:

3.7.1 Control System Devices Other Than Computers

Fire Alarm control system devices are not required to respond to scans.

3.7.2 Default Requirements for Control System Devices

Non-computer control system devices where Durability to Vulnerability Scanning requirements are not otherwise indicated in this Section are not required to respond to scans.

3.8 DEVICES WITH CONNECTION TO MULTIPLE IP NETWORKS

Except for Ethernet switches, do not use more than one physical connection to IP networks on the same device unless doing so is both required by the project specifications and the specific application is approved. If a device with multiple IP connections is required, provide a Multiple IP Connection Device Request using the Multiple IP Connection Device Request Schedule at http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphic to request approval for each device.

3.9 SYSTEM AND COMMUNICATION PROTECTION

3.9.1 Denial of Service Protection, Process Isolation and Boundary Protection

{For Reference Only: This subpart (and its subparts) relates to SC-5, SC-39, SC-7(a); CCI-001093, CCI-002385, CCI-002386, CCI-002430, CCI-001097}

To the greatest extent practical, implement control logic in non-computer hardware and without reliance on the network.

3.9.2 Cryptographic Protection

{For Reference Only: This subpart (and its subparts) relates to SC-13; CCIs: CCI-002449, CCI-002450}

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

3.10 SYSTEM AND INTEGRATION INTEGRITY

3.11 FIELD QUALITY CONTROL

3.11.1 Tests

In addition to testing and testing support required by other Sections,

provide a minimum of 8 hours of technical support for cybersecurity testing of control systems.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 25 - INTEGRATED AUTOMATION

SECTION 25 05 11.02

CCI LIST FLS

07/20

-- End of Section Table of Contents --

Responsibility: Indicates who has responsibility for implementing the control.
One or more of:

DoD-Defined: Either the DoD has provided a value for the "organization selected" values, or the DoD implementation guidance states that the CCI is already met by existing policy or regulation. Note that definition or guidance provided may not be relevant for a control system – the organization definitions were determined from the perspective of a traditional information system, not for a control system.

Designer: The designer has a role to address for this CCI. Either the designer needs to provide design specifications to cover a requirement on the control system itself, or the designer must provide input to others regarding the implementation or lack of feasibility of the CCI (typically because the CCI was written with an IT system, not a control system, in mind).

Non-Designer: The CCI is beyond the responsibility of the designer, and is the responsibility of someone else – typically the System Owner (SO). This does not diminish the importance of these CCIs, but as these CCIs are not the responsibility of the designer they are beyond the scope of this UFC.

Platform Enclave: The CCI contains a requirement which is assumed to be implemented at the Platform Enclave and inherited by the control system, or is mostly implemented at the Platform Enclave but also needed within the field control system. Note that if there is no Platform Enclave, then CCIs listed in the "Platform Enclave" category are instead in the "Non-Designer" category.

Impractical: The CCI is impractical to fully implement in a control system, but may be applied in a limited manner to at least some part of the control system. Most often CCIs that can be applied to only part of the control system can be implemented at Level 4 of the architecture, but would be prohibitively difficult to implement at Levels 1 or 2. Note that "prohibitively" is a judgment based on a typical LOW control system – for a MODERATE or HIGH system, it may be worthwhile to implement these controls at all possible levels even if this adds significant cost and complexity.

FIRE LIFE SAFETY AND MASS NOTIFICATION SYSTEMS BUILDING LEVEL CONTROL, SECURITY CONTROLS

CCI #	800-53/82 Control Text Indicator	CCI Definition	Designer Implementation	Practicality
CCI-002110	AC-2 (a)	The organization defines the information system account types that support the organizational missions/business functions.	**FRONT END SERVERS AND WORKSTATIONS** will FULLY support accounts. Accounts and associated roles to gain access to the system through the Operating System (OS) are different than account and associated roles to gain access to the control system (CS) application. Users shall be given a unique username and assigned to a role reflecting the level of access that they are required to have. CS users should only require a general user account when authenticating to the front end server or workstation. In some cases, programmers and developers may need permissions at the local administrator level in order to execute CS tools. Users requiring administrator access to the system in order to execute special CS tools will have an administrator account and a general user account.	Impractical
			FIELD POINT OF CONNECTIONS (FPOC's) which consists of standard IT managed Ethernet switch's or IP routers will FULLY support accounts. FPOCS should only have a single role relegated to administration of the device. Also known as Building Point of Connections (BPOC).	
			FIELD CONTROL SYSTEM IP (FCS-IP) Network Controllers on an IP network shall FULLY support accounts on capable devices and WEAKLY support accounts on those with accounts that cannot be modified. Many building point of connections (BPOCS) support more than one account but are relegated to a single role utilizing administrator rights. Whether by web interface or direct connection each user requiring access shall have a unique username.	
			FIELD CONTROL SYSTEM NON-IP devices generally do NOT support any access enforcement therefore the concept of "account" is meaningless.	
			HUMAN MACHINE INTERFACES (HMI'S) and or GRAPHICAL USER INTERFACES (GUI'S) are NOT supported accounts. Aside from manufacturer's access for maintenance, devices generally do not support any access enforcement. If the HMI/GUI does support unique accounts and roles, then they SHALL be implemented.	
			CONTROL SYSTEM APPLICATIONS shall be FULLY support accounts. Roles for the CS application are generally broken down into the following types. **Operator**- The operator account has view-only access. **Operator with Control**- The operator with control account has a higher level of access usually with the ability to change set-points, and acknowledge alarms. **Control**	
			system admin-The control system with admin has full access rights to the CS application.	
CCI-001682	AC-2(2)	MODERATE The information system automatically removes or disables emergency accounts after an organization-defined time period for each type of account	The organization being inspected/assessed configures the information system to never automatically remove or disable emergency accounts. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1682. DoD has defined the time period as never. Recommended Compelling Evidence: 1.) Signed and dated documentation which defines how emergency accounts are never disabled or removed. 2.) Applicable STIG checks. 3.) Log trail of emergency accounts.	Impractical

CCI-001361	AC-2(2)	MODERATE The organization defines a time period after which temporary accounts are automatically terminated	DoD has defined the time period as 72 hours. The time period of 72 hours applies to temporary user accounts. Recommended Compelling Evidence: Automatically compliant	Impractical
CCI-001365	AC-2(2)	MODERATE The organization defines a time period after which emergency accounts are automatically terminated.	DoD has defined the time period as never. The time period of never applies to emergency admin accounts. Recommended Compelling Evidence: Automatically compliant	Impractical
CCI-000017	AC-2(3)	MODERATE The information system automatically disables inactive accounts after an organization-defined time period.	The organization being inspected/assessed configures the information system to disable inactive accounts after 35 days. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 000017. DoD has defined the time period as 35 days. Recommended Compelling Evidence: 1.) Access control policy which defines the process for disabling inactive accounts after 35 days. 2.) Applicable STIG/SRG checks.	Impractical
CCI-000217	AC-2(3)	MODERATE The organization defines a time period after which inactive accounts are automatically disabled.	DoD has defined the time period as 35 days. Recommended Compelling Evidence: Automatically compliant	Impractical
CCI-000018	AC-2(4)	MODERATE The information system automatically audits account creation actions.	The organization being inspected/assessed configures the information system to automatically audit account creation actions. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 18. Recommended Compelling Evidence: 1.) Audit trails of account creation. 2.) Applicable STIG/SRG checks.	Impractical
CCI-001403	AC-2(4)	MODERATE The information system automatically audits account modification actions.	The organization being inspected/assessed configures the information system to automatically audit account modification actions. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1403. Recommended Compelling Evidence: 1.) Audit trails of account modification. 2.) Applicable STIG/SRG checks.	Impractical
CCI-001404	AC-2(4)	MODERATE The information system automatically audits account disabling actions.	The organization being inspected/assessed configures the information system to automatically audit account disabling actions. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1404. Recommended Compelling Evidence: 1.) Audit trails of account disabling. 2.) Applicable STIG/SRG checks.	Impractical
CCI-001405	AC-2(4)	MODERATE	The organization being inspected/assessed configures the information system to automatically audit account removal actions. For information	Impractical

		The information system automatically audits account removal actions.	system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1405. Recommended Compelling Evidence: 1.) Audit trails of account removal. 2.) Applicable STIG/SRG checks.	
CCI-002130	AC-2(4)	MODERATE The information system automatically audits account enabling actions.	The organization being inspected/assessed configures the information system to automatically audit account enabling actions. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 2130. Recommended Compelling Evidence: 1.) Signed and dated documentation which defines who the personnel and roles are to receive account enabling notifications. 2.) Audit trail of account enabling actions. 3.) Applicable STIG/SRG checks.	Impractical
CCI-001683	AC-2(4)	MODERATE The information system notifies organization-defined personnel or roles for account creation actions.	The organization being inspected/assessed configures the information system to notify the system administrator and ISSO for account creation actions. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1683. DoD has defined the personnel or roles as the system administrator and ISSO. Recommended Compelling Evidence: 1.) Signed and dated documentation which defines the process for notifying the system administrator and ISSO of account creation actions. 2.) Applicable STIG/SRG checks.	Impractical
CCI-001684	AC-2(4)	MODERATE The information system notifies organization-defined personnel or roles for account modification actions.	The organization being inspected/assessed configures the information system to notify the system administrator and ISSO for account modification actions. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1684. DoD has defined the personnel or roles as the system administrator and ISSO. Recommended Compelling Evidence:	Impractical
			1.) Signed and dated documentation which defines the process for notifying the system administrator and ISSO of account modification actions. 2.) Applicable STIG/SRG checks.	
CCI-001685	AC-2(4)	MODERATE The information system notifies organization-defined personnel or roles for account disabling actions.	The organization being inspected/assessed configures the information system to notify the system administrator and ISSO for account disabling actions. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1685. DoD has defined the personnel or roles as the system administrator and ISSO. Recommended Compelling Evidence: 1.) Signed and dated documentation which defines the process for notifying the system administrator and ISSO of account disabling actions. 2.) Applicable STIG/SRG checks.	Impractical
CCI-001686	AC-2(4)	MODERATE The information system notifies organization-defined personnel or roles for account removal actions.	The organization being inspected/assessed configures the information system to notify the system administrator and ISSO for account removal actions. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1686. DoD has defined the personnel or roles as the system administrator and ISSO.	Impractical

			Recommended Compelling Evidence: 1.) Signed and dated documentation which defines the process for notifying the system administrator and ISSO of account removal actions. 2.) Applicable STIG/SRG checks.	
CCI-002132	AC-2(4)	MODERATE The information system notifies organization-defined personnel or roles for account enabling actions.	The organization being inspected/assessed configures the information system to notify the system administrator and ISSO for account enabling actions. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 2132. DoD has defined the personnel or roles as the system administrator and ISSO. Recommended Compelling Evidence: 1.) Audit trail of account enabling actions. 2.) Applicable STIG/SRG checks.	Impractical
CCI-000213	AC-3	The information system enforces approved authorizations for logical access to information and system resources in accordance with applicable access control policies.	Any device supporting accounts (either FULLY or WEAKLY) must limit access to the device according to specified limitations for each account. Install and configure any device having a Security Technical Implementation Guide (STIG) or Security Requirements Guide (SRG) in accordance with that STIG or SRG.	Impractical
CCI-001368	AC-4	MODERATE The information system enforces approved authorizations for controlling the flow of information within the system based on organization-defined information flow control policies.	The organization being inspected/assessed configures the information system to enforce approved authorizations for controlling the flow of information within the system based on information flow control policies defined in AC-4, CCI 1548. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1368. Recommended Compelling Evidence: 1.) Signed and dated access control policy. 2.) Signed and dated data flow diagram. 3.) Applicable STIG/SRG checks.	Impractical
CCI-001414	AC-4	MODERATE The information system enforces approved authorizations for controlling the flow of information between interconnected systems based on organization-defined information flow control policies	The organization being inspected/assessed configures the information system to enforce approved authorizations for controlling the flow of information between interconnected systems based on information flow control policies defined in AC- 4, CCI 1549. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1414. Recommended Compelling Evidence: 1.) Signed and dated access control policy. 2.) Signed and dated data flow diagram. 3.) Applicable STIG/SRG checks.	Impractical
CCI-001548	AC-4	MODERATE The organization defines the information flow control policies for controlling the flow	The organization being inspected/assessed defines and documents the information flow control policies for controlling the flow of information within the system. DoD has determined the information flow control policies are not appropriate to define at the Enterprise level. Recommended Compelling Evidence:	N/A
		of information within the system.	1.) Signed and dated access control policy. 2.) Signed and dated data flow diagram. 3.) Signed and dated documentation that defines the information flow control policies.	

CCI-001549	AC-4	MODERATE The organization defines the information flow control policies for controlling the flow of information between interconnected systems	The organization being inspected/assessed defines and documents the information flow control policies for controlling the flow of information between interconnected systems. DoD has determined the information flow control policies are not appropriate to define at the Enterprise level. Recommended Compelling Evidence: 1.) Signed and dated access control policy. 2.) Signed and dated data flow diagram. 3.) Signed and dated documentation that defines the information flow control policies.	N/A
CCI-001550	AC-4	MODERATE The organization defines approved authorizations for controlling the flow of information within the system	The organization being inspected/assessed defines and documents approved authorizations for controlling the flow of information within the system. Recommended Compelling Evidence: 1.) Signed and dated access control policy. 2.) Signed and dated data flow diagram. 3.) Signed and dated documentation that defines approved authorizations for controlling the flow of information	N/A
CCI-001551	AC-4	MODERATE The organization defines approved authorizations for controlling the flow of information between interconnected systems.	The organization being inspected/assessed defines and documents approved authorizations for controlling the flow of information between interconnected systems. Recommended Compelling Evidence: 1.) Signed and dated access control policy. 2.) Signed and dated data flow diagram. 3.) Signed and dated documentation that defines approved authorizations for controlling the flow of information 4.) Applicable STIG/SRG checks.	Impractical
CCI-001558	AC-6(1)	MODERATE The organization defines the security functions (deployed in hardware, software, and firmware) for which	DoD has defined the security functions as all functions not publicly accessible. Recommended Compelling Evidence: Automatically compliant	N/A
		access must be explicitly authorized		
CCI-002221	AC-6(1)	MODERATE The organization defines the security-relevant information for which access must be explicitly authorized.	DoD has defined the security-relevant information as all security-relevant information not publicly available. Recommended Compelling Evidence: Automatically compliant	N/A
CCI-002222	AC-6(1)	MODERATE The organization explicitly authorizes access to organization-defined security functions	The organization being inspected/assessed documents and implements a process to explicitly authorize access to all functions not publicly accessible. Explicit authorization can be in the form of an acceptable use policy signed by the user at the time of access being granted. DoD has defined the security functions as all functions not publicly accessible. Recommended Compelling Evidence: 1.) Signed and dated access control policy 2.) Signed and dated system security plan (SSP) 3.) Signed and dated documentation that defines the process to explicitly authorize access to all functions not publicly accessible	N/A

CCI-002223	AC-6(1)	MODERATE The organization explicitly authorizes access to organization-defined security-relevant information	The organization being inspected/assessed documents and implements a process to explicitly authorize access to all security-relevant information not publicly available. Explicit authorization can be in the form of an acceptable use policy signed by the user at the time of access being granted. DoD has defined the security-relevant information as all security-relevant information not publicly available. Recommended Compelling Evidence: 1.) Signed and dated access control policy 2.) Signed and dated system security plan (SSP) 3.) Signed and dated documentation that defines the process to explicitly authorize access to all security- relevant information not publicly available	N/A
CCI-000039	AC-6(2)	MODERATE The organization requires that users of information system accounts or roles,	The organization being inspected/assessed documents and implements a process to require that users of information system accounts or roles, with access to any privileged security functions or security-relevant information, use non-privileged accounts, or roles, when accessing nonsecurity	N/A
		with access to organization-defined security functions or security-relevant information, use non-privileged accounts, or roles, when accessing non-security functions.	functions. DoD has defined the security functions and security-relevant information as any privileged security functions or security-relevant information. Recommended Compelling Evidence: 1.) Signed and dated access control policy 2.) Signed and dated system security plan (SSP) 3.) Provide signed and dated documentation that defines the process to require that users of information system accounts or roles, with access to any privileged security functions or security- relevant information, use non-privileged accounts, or roles, when accessing non-security functions.	
CCI-001419	AC-6(2)	MODERATE The organization defines the security functions or security-relevant information to which users of information system accounts, or roles, have access	DoD has defined the security functions and security-relevant information as any privileged security functions or security-relevant information. Recommended Compelling Evidence: Automatically compliant	N/A
CCI-002234	AC-6(9)	MODERATE The information system audits the execution of privileged functions.	The organization being inspected/assessed configures the information system to audit the execution of privileged functions. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 2234 Recommended Compelling Evidence: 1.) Applicable STIG/SRG checks 2.) Documentation that shows the system is configured to audit the execution of privileged functions	Impractical
CCI-002235	AC-6(10)	MODERATE The information system prevents non-privileged users from executing privileged functions to include disabling, circumventing, or altering implemented security safeguards/counte rmeasures.	The organization conducting the inspection/assessment examines the information system to ensure the organization being inspected/assessed configures the information system to prevent non-privileged users from executing privileged functions to include disabling, circumventing, or altering implemented security safeguards/countermeasures. For information system components that have applicable STIGs or SRGs, the organization conducting the inspection/assessment evaluates the components to ensure that the organization being inspected/assessed has configured the information	Impractical
			system in compliance with the applicable STIGs and SRGs pertaining to CCI 2235.	

CCI-000043	AC-7(a)	The organization defines the maximum number of consecutive invalid logon attempts to the information system by a user during an organization-defined time period.	DOD policy requires the system to Lock the user account when **[3]** unsuccessful login attempts occur within a **[60 minute]** interval. BPOCs and other field devices without an applicable STIG or SRG shall implement these requirements to the greatest extent possible up to what is defined here. Document any device incapable of meeting the defined requirement and state actual implementation.	Impractical
CCI-000044	AC-7(a)	The information system enforces the organization-defined limit of consecutive invalid logon attempts by a user during the organization-defined time period.	The information system shall be set to Lock the user account when **[3]** unsuccessful login attempts occur within a **[60 minute]** interval. Devices which WEAKLY supports accounts shall implement the requirements of a FULLY support account when possible. If unsuccessful login attempts and accounts lockouts are not supported by the device, then physical access to the device should limited to only authorized personnel. Document any device incapable of meeting the defined requirement and state actual implementation.	Impractical
CCI-001423	AC-7(a)	The organization defines the time period in which the organization-defined maximum number of consecutive invalid logon attempts occurs.	DOD policy requires the system to Lock the user account when **[3]** unsuccessful login attempts occur within a **[60 minute]** interval.	Impractical
CCI-002236	AC-7(b)	The organization defines the time period the information system will automatically lock the account or node when the maximum number of unsuccessful attempts is exceeded.	DOD policy requires for systems that once an account is locked, the account must stay locked until unlocked by an administrator.	Impractical
CCI-002237	AC-7(b)	The organization defines the delay algorithm to be	DOD policy requires that once the indicated number of unsuccessful login attempts occurs, delay login prompts by **[5] seconds**. If the provided	Impractical
		employed by the information system to delay the next login prompt when the maximum number of unsuccessful attempts is exceeded.	software cannot meet these requirements, document software capabilities to protest from subsequent unsuccessful login attempts and propose alternate protections. Do not implement alternate protection measures without explicit permission from the Government	

CCI-002238	AC-7(b)	The information system automatically locks the account or node for either an organization-defined time period, until the locked account or node is released by an administrator, or delays the next login prompt according to the organization-defined delay algorithm when the maximum number of unsuccessful attempts is exceeded.	The information system shall be configured to automatically lock the account or node until the locked account is released by an administrator and delays the next login prompt for a minimum of 5 seconds when the maximum number of unsuccessful attempts is exceeded. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 2238. DoD has defined the delay algorithm as a minimum of **[5] seconds**. DoD has defined the time period as until released by an administrator. Devices which WEAKLY supports accounts shall implement the requirements of a FULLY support account when possible. If unsuccessful login attempts and accounts lockouts are not supported by the device, then physical access to the device should limited to only authorized personnel.	Impractical
CCI-000048	AC-8(a)	The information system displays an organization-defined system use notification message or banner before granting access to the system that provides privacy and security notices consistent with applicable federal laws, Executive Orders, directives, policies, regulations, standards, and guidance.	All devices (PC's, BPOCs, Network switches, etc…) with a user interface supporting the use of a password or PIN, and capable of displaying 50 or more alphanumeric characters shall be configured to display the DoD Information Systems – Standard Consent Banner and User Agreement before granting access to the system that provides privacy and security notices consistent with applicable federal laws, Executive Orders, directives, policies, regulations, standards, and guidance. For information system components that have applicable STIGs or SRGs, the organization must comply with the STIG/SRG guidance that pertains to CCI 48. The DOD Consent Banner can be found on the RMF Knowledge Service site at https://rmfks.osd.mil/rmf/Guidance/GoverningPolicy/Pages/ConsentBanner.aspx Devices connected to a network, with a user interface supporting use of a password or PIN, and **not capable** of displaying 50 or more alphanumeric characters must have a permanently affixed label	Impractical
			displaying an approved banner from the policy listed above.	
CCI-002247	AC-8(a)	The organization defines the use notification message or banner the information system displays to users before granting access to the system.	The DOD Consent Banner is defined on the RMF Knowledge service along with the Army Regulation 25-2 and can be found on the RMF Knowledge Service site at https://rmfks.osd.mil/rmf/Guidance/GoverningPolicy/Pages/ConsentBanner.aspx	Impractical
CCI-002243	AC-8(a)(1)	The organization-defined information system use notification message or banner is to state that users are accessing a U.S. Government information system.	The DOD Consent Banner is defined on the RMF Knowledge service along with the Army Regulation 25-2 and can be found on the RMF Knowledge Service site at https://rmfks.osd.mil/rmf/Guidance/GoverningPolicy/Pages/ConsentBanner.aspx	Impractical
CCI-002244	AC-8(a)(2)	The organization-defined information system use notification message or banner is to state that information system usage may be monitored, recorded, and subject to audit.	The DOD Consent Banner is defined on the RMF Knowledge service along with the Army Regulation 25-2 and can be found on the RMF Knowledge Service site at https://rmfks.osd.mil/rmf/Guidance/GoverningPolicy/Pages/ConsentBanner.aspx	Impractical

CCI-002245	AC-8(a)(3)	The organization-defined information system use notification message or banner is to state that unauthorized use of the information system is prohibited and subject to criminal and civil penalties.	The DOD Consent Banner is defined on the RMF Knowledge service along with the Army Regulation 25-2 and can be found on the RMF Knowledge Service site at https://rmfks.osd.mil/rmf/Guidance/GoverningPolicy/Pages/ConsentBanner.aspx	Impractical
CCI-002246	AC-8(a)(4)	The organization-defined information system use notification message or banner is to state that use of the information system indicates consent to monitoring and recording.	The DOD Consent Banner is defined on the RMF Knowledge service along with the Army Regulation 25-2 and can be found on the RMF Knowledge Service site at https://rmfks.osd.mil/rmf/Guidance/GoverningPolicy/Pages/ConsentBanner.aspx	Impractical
CCI-000050	AC-8(a)(4)	The information system retains the notification message or banner on the screen until users acknowledge the usage conditions and take explicit actions to log on to or further access.	Configure the information system to retain the notification message or banner on the screen until users acknowledge the usage conditions and take explicit actions to log on to or further access. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 50.	Impractical
CCI-002248	AC-8(C)(1)	The organization defines the conditions of use which are to be displayed to users of the information system before granting further access.	The DOD Consent Banner is defined on the RMF Knowledge service along with the Army Regulation 25-2 and can be found on the RMF Knowledge Service site at https://rmfks.osd.mil/rmf/Guidance/GoverningPolicy/Pages/ConsentBanner.aspx	Impractical
CCI-000058	AC-11(a)	MODERATE The information system provides the capability for users to directly initiate session lock mechanisms.	The organization being inspected/assessed configures the information system to provide the capability for users to directly initiate session lock mechanisms. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 58. Recommended Compelling Evidence: 1.) Applicable STIG/SRG checks 2.) Documentation that shows the system is configured to provide the capability for users to directly initiate session lock mechanisms	Impractical
CCI-000059	AC-11(a)	MODERATE The organization defines the time period of inactivity after which the information system initiates a session lock.	DoD has defined the time period as 15 minutes. Recommended Compelling Evidence: Automatically compliant	Impractical
CCI-000056	AC-11(b)	MODERATE The information system retains the session lock until the user reestablishes access using	The organization being inspected/assessed configures the information system to retain the session lock until the user reestablishes access using established identification and authentication procedures. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply	Impractical

		established identification and authentication procedures	with the STIG/SRG guidance that pertains to CCI 56. Recommended Compelling Evidence: 1.) Applicable STIG/SRG checks	
CCI-000060	AC-11(1)	MODERATE The information system conceals, via the session lock, information previously visible on the display with a publicly viewable image.	The organization being inspected/assessed configures the information system to conceal, via the session lock, information previously visible on the display with a publicly viewable image. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 60. Recommended Compelling Evidence: 1.) Signed and dated system security plan (SSP) 2.) Applicable STIG/SRG checks	Impractical
CCI-002360	AC-12	MODERATE The organization defines the conditions or trigger events requiring session disconnect to be employed by the information system when automatically terminating a user session.	The organization being inspected/assessed defines and documents the conditions or trigger events requiring session disconnect to be employed by the information system when automatically terminating a user session. DoD has determined the conditions or trigger events are not appropriate to define at the Enterprise level. Recommended Compelling Evidence: 1.) Signed and dated system security plan (SSP) 2.) Applicable STIG/SRG checks 3.) Signed and dated documentation that defines the conditions or trigger events requiring session disconnect to be employed by the information system when automatically terminating a user session.	Impractical
CCI-002361	AC-12	MODERATE The information system automatically terminates a user session after organization-defined conditions or trigger events requiring session disconnect.	The organization being inspected/assessed configures the information system to automatically terminate a user session after conditions or trigger events requiring session disconnect, as defined in AC-12, CCI 2360. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 2361. Recommended Compelling Evidence: 1.) Signed and dated system security plan (SSP) 2.) Applicable STIG/SRG checks 3.)	Impractical
CCI-000061	AC-14(a)	The organization identifies and defines organization-defined user actions that can be performed on the information system without identification or authentication consistent with organizational missions/business functions.	Workstations, Servers, Network Switches, etc., shall not allow any actions without identification or authentication. This is usually automatically met by authenticating (logging in) to a system. The control system must use identification and authentication except for the following: Read only access via a user interface from other than a PC and via other than a web interface. Interactions via devices other than user interfaces. Devices that do not support authentication should have physical security implemented by lockable enclosures, tamper switches, room access control, people trap, or paper access logs.	Impractical
CCI-000232	AC-14(b)	The organization documents and provides supporting rationale in the security plan for the information system, user actions not requiring identification and authentication	Workstations, Servers, Network Switches, etc., shall not allow any actions without identification or authentication. This is usually automatically met by authenticating (logging in) to a system. The control system must use identification and authentication except for the following: Read only access via a user interface from other than a PC and via other than a web interface. Interactions via devices other than user interfaces. Devices that do not support authentication should have physical security implemented by lockable enclosures, tamper switches, room access control, people trap, or paper access logs.	Applicable
CCI-001438	AC-18(a)	The organization establishes usage restrictions for wireless access.	Wireless policies, procedures and configuration guides need to be created for the use of wireless capability.	N/A

CCI-001439	AC-18(a)	The organization establishes implementation guidance for wireless access.	Wireless policies, procedures and configuration guides need to be created for the use of wireless capability.	N/A
CCI-002323	AC-18(a)	The organization establishes configuration/connection requirements for wireless access.	Wireless policies, procedures and configuration guides need to be created for the use of wireless capability.	N/A
CCI-001441	AC-18(b)	The organization authorizes wireless access to the information system prior to allowing such connections.	Wireless policies, procedures and configuration guides need to be created for the use of wireless capability.	N/A
CCI-001443	AC-18(1)	MODERATE The information system protects wireless access to the system using authentication of users and/or devices.	The organization being inspected/assessed configures the information system to protect wireless access to the system using authentication of users and/or devices. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1443. Recommended Compelling Evidence: 1.) Signed and dated system security plan (SSP) 2.) Signed and dated wireless access policy	N/A
CCI-001444	AC-18(1)	MODERATE The information system protects wireless access to the system using encryption.	The organization being inspected/assessed configures the information system to protect wireless access to the system using encryption. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1444. Recommended Compelling Evidence: 1.) Signed and dated system security plan (SSP) 2.) Signed and dated wireless access policy 3.) Applicable STIG/SRG checks	Impractical
CCI-000123	AU-2(a)	The organization determines the information system must be capable of auditing an organization-defined list of auditable events.	HW (workstations, servers, network switches/infrastructure, etc…) capable of auditing shall audit the following: □ Successful and unsuccessful logon attempts □ Privileged activities or other system level access □ Starting and ending time for user access to the system □ Concurrent logons from different workstations. □ Successful and unsuccessful accesses to objects □ All program initiators □ All direct access to the information system □ All account creations, modifications, disabling, and terminations □ All kernel module load, unload, and restart	Impractical
CCI-001571	AU-2(a)	The organization defines the information system auditable events.	DoD has defined the information system auditable events as successful and unsuccessful attempts to access, modify, or delete privileges, security objects, security levels, or categories of information (e.g. classification levels). Successful and unsuccessful logon attempts, Privileged activities or	Impractical
			other system level access, Starting and ending time for user access to the system, Concurrent logons from different workstations, Successful and unsuccessful accesses to objects, All program initiations, All direct access to the information system. All account creations, modifications, disabling, and terminations. All kernel module load, unload, and restart.	

CCI-000125	AU-2(c)	The organization provides a rationale for why the list of auditable events is deemed to be adequate to support after-the-fact investigations of security incidents.	The organization documents in the audit and accountability policy the list of auditable system events, the organization provides clearly stated rationale for the selection of each system event. The rationale will support any after-action investigations of security event.	N/A
CCI-001485	AU-2(d)	The organization defines the events which are to be audited on the information system on an organization-defined frequency of (or situation requiring) auditing for each identified	The organization being inspected/assessed defines and documents events which are to be audited on the information system. Events should be selected from the events the information system is capable of auditing as defined in AU-2 (a) and should be based on ongoing risk assessments of current threat information and environment. DoD has determined that the events are not appropriate to define at the Enterprise level. Recommended Compelling Evidence: 1.) Signed and dated audit and accountability policy and/or procedures	N/A
CCI-000130	AU-3	The information system generates audit records containing information that establishes what type of event occurred.	The information system shall be configured to generate audit records containing information that establishes what type of event occurred. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 130. Other IP devices (BPOCs, other field devices) may not be able to generate audit records. Document if these components are incapable of implementing the requirements set forth in policy.	Impractical
CCI-000131	AU-3	The information system generates audit records containing information that establishes when an event occurred.	The information system shall be configured to generate audit records containing information that establishes when an event occurred. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 131.	Impractical
			Other IP devices (BPOCs, other field devices) may not be able to generate audit records. Document if these components are incapable of implementing the requirements set forth in policy.	
CCI-000132	AU-3	The information system generates audit records containing information that establishes where the event occurred.	The information system shall be configured to generate audit records containing information that establishes where the event occurred. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 132. Other IP devices (BPOCs, other field devices) may not be able to generate audit records. Document if these components are incapable of implementing the requirements set forth in policy.	Impractical
CCI-000133	AU-3	The information system generates audit records containing information that establishes the source of the event.	The information system shall be configured to generate audit records containing information that establishes the source of the event. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 133. Other IP devices (BPOCs, other field devices) may not be able to generate audit records. Document if these components are incapable of implementing the requirements set forth in policy.	Impractical
CCI-000134	AU-3	The information system generates audit records containing information that establishes the outcome of the	The information system shall be configured to generate audit records containing information that establishes the outcome of the event. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 134.	Impractical

			Other IP devices (BPOCs, other field devices) may not be able to generate audit records. Document if these components are incapable of implementing the requirements set forth in policy.	
CCI-001487	AU-3	The information system generates audit records containing information that establishes the identity of any individuals or subjects associated with the event.	The information system shall be configured to generate audit records containing information that establishes the identity of any individuals or subjects associated with the event. For information system components that have applicable STIGs or SRGs, the organization must comply with the STIG/SRG guidance that pertains to CCI 1487. Other IP devices (BPOCs, other field devices) may not be able to generate audit records. Document if	Impractical
			these components are incapable of implementing the requirements set forth in policy.	
CCI-000135	AU-3(1)	MODERATE The information system generates audit records containing the organization-defined additional, more detailed information that is to be included in the audit records.	The organization being inspected/assessed configures the information system to generate audit records containing the organization defined additional, more detailed information as defined in AU-3 (1), CCI 1488 that is to be included in the audit records. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 135. Recommended Compelling Evidence: 1.) Sample of generated audit records 2.) Applicable STIG/SRG checks	Impractical
CCI-001488	AU-3(1)	MODERATE The organization defines additional, more detailed information to be included in the audit records.	The organization being inspected/assessed defines and documents additional, more detailed information to be included in the audit records. The additional information must include at a minimum, full-text recording of privileged commands or the individual identities of group account users. The additional information must provide sufficient detail to reconstruct events to determine cause of compromise and magnitude of damage, malfunction, or security violation. DoD has determined that additional, more detailed information must include, at a minimum, full-text recording of privileged commands or the individual identities of group account users. DoD has determined that all additional, more detailed information is not appropriate to define at the Enterprise level. Recommended Compelling Evidence: 1.) Signed and dated audit and accountability policy and/or procedures	N/A
CCI-001848	AU-4	The organization defines the audit record storage requirements	Devices that have STIG/SRGs must comply with the requirements of those STIG/SRGs. For BPOCs and field devices (not front end computers) capable of generating audit records, the front end server shall be configured to retrieve audit records from the devices. Provide a secure mechanism of uploading these audit records to a front end PC for storage and review.	Impractical
CCI-001849	AU-4	The organization allocates audit record storage capacity in accordance with organization-defined audit record storage requirements.	The organization allocates, and configures the information system to allocate audit record storage capacity as defined in AU-4, CCI 001848. For information system components that have applicable STIGs or SRGs, the organization must comply with the STIG/SRG guidance that pertains to CCI 001849. Provide a secure mechanism of uploading these audit records to a front end PC for storage and review.	Impractical

CCI-000139	AU-5(a)	The information system alerts designated organization-defined personnel or roles in the event of an audit processing failure.	If the front end server can be configured to automatically archive full logs or write audit logs to an audit server (from all connected audit capable devices), then this control shall be considered not- applicable (NA). Otherwise, if email services are available, configure the workstations and servers to alert at a minimum, the system administrator (SA) and or the designated Information System Security Officer/Manager in the event of an audit processing failure. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 139. If email services are not available then the workstations and servers shall configure the system to provide an alert on the screen in the event of an audit processing failure. For BPOCs and other field devices see CCI-001848.	Impractical
CCI-000140	AU-5(b)	The information system takes organization defined actions upon audit failure (e.g., shut down information system, overwrite oldest audit records, stop generating audit records).	In case of an audit failure, if possible, configure the system to continue to collect audit records by overwriting existing audit records starting with the oldest records first. Ideal configuration would be to configure the system to send audit records directly to an audit server, or automatically archive full logs and document as such with the ISSO. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 140.	Impractical
CCI-001490	AU-5(b)	The organization defines actions to be taken by the	The organization being inspected/assessed will define and document actions to be taken by the	N/A
		information system upon audit failure (e.g., shut down information system, overwrite oldest audit records, stop generating audit records).	information system upon audit failure as described in CCI-000139 and CCI-000140.	
CCI-001875	AU-7(a)	MODERATE The information system provides an audit reduction capability that supports on-demand audit review and analysis.	The organization being inspected/assessed must employ information systems that provide an audit reduction capability that support on-demand audit review and analysis (either natively or through the use of third-party tools). For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1875. Recommended Compelling Evidence: 1.) Audit reduction capability system logs	Impractical
CCI-001876	AU-7(a)	MODERATE The information system provides an audit reduction capability that supports on-demand reporting requirements.	The organization being inspected/assessed must employ information systems that provide an audit reduction capability that support on-demand reporting requirements (either natively or through the use of third-party tools). For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1876. Recommended Compelling Evidence: 1.) Audit reduction capability system logs	Impractical
CCI-001877	AU-7(a)	MODERATE The information system provides an audit reduction capability that supports after-the-fact investigations of security incidents.	The organization being inspected/assessed must employ information systems that provide an audit reduction capability that support after-the-fact investigations of security incidents (either natively or through the use of third-party tools). For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1877. Recommended Compelling Evidence: 1.) After action reports which include audit logs	Impractical

CCI-001878	AU-7(a)	MODERATE The information system provides a report generation capability that supports on-demand audit review and analysis.	The organization being inspected/assessed must employ information systems that provide a report generation capability that support on-demand audit review and analysis (either natively or through the use of third-party tools). For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1878. Recommended Compelling Evidence: 1.) Example of on-demand audit review and analysis	Impractical
CCI-001879	AU-7(a)	MODERATE The information system provides a report generation capability that supports on-demand reporting requirements.	The organization being inspected/assessed must employ information systems that provide a report generation capability that support on-demand reporting requirements (either natively or through the use of third-party tools). For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1879. Recommended Compelling Evidence: 1.) Example of on-demand audit review and analysis	Impractical
CCI-001880	AU-7(a)	MODERATE The information system provides a report generation capability that supports after-the-fact investigations of security incidents.	The organization being inspected/assessed must employ information systems that provide a report generation capability that support after-the-fact investigations of security incidents (either natively or through the use of third-party tools). For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1880. Recommended Compelling Evidence: 1.) After action reports which include audit logs	Impractical
CCI-001881	AU-7(b)	MODERATE The information system provides an audit reduction capability that does not alter original content or time ordering of audit records.	The organization being inspected/assessed must ensure that the audit reduction capability does not alter the original audit records. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1881. Recommended Compelling Evidence:	Impractical
			1.) Example of audit log before and after audit reduction capability	
CCI-001882	AU-7(b)	MODERATE The information system provides a report generation capability that does not alter original content or time ordering of audit records.	The organization being inspected/assessed must ensure that the report generation capability does not alter the original audit records. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1882. Recommended Compelling Evidence: 1.) Example of audit log before and after audit reduction capability	Impractical
CCI-00158	AU-7(1)	MODERATE The information system provides the capability to process audit records for events of interest based on organization-defined audit fields within audit records.	The organization being inspected/assessed must employ information systems that provide the capability to process audit records for events of interest based on audit fields within audit records defined in AU-7 (1), CCI 1883. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 158. Recommended Compelling Evidence: 1.) Example of audit log report based on events of interest	Impractical
CCI-000159	AU-8(a)	The information system uses internal system clocks to generate time stamps for audit records.	Workstations and servers on the domain shall be configured to synchronize with domain controllers. If an NTP server is configured it should synchronize with a secure, authorized source. If not on a domain or NTP server, workstations, server or other components that generate audit records, the timing requirement inherent in the control system will be sufficient. For information system components that	Applicable

			have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 159.	
CCI-001889	AU-8(b)	The information system records time stamps for audit records that meets organization-defined granularity of time measurement.	DoD has defined the granularity of time measurement as one second. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1889.	Applicable
CCI-001890	AU-8(b)	The information system records time stamps for audit records that can be mapped to Coordinated Universal Time (UTC) or Greenwich Mean Time (GMT).	All devices which provide audit capabilities, configure them to generate time stamps for audit records that contain time zones or time offsets that can be mapped to Coordinated Universal Time (UTC) or Greenwich Mean Time (GMT). For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1890.	Applicable
CCI-001891	AU-8(1)	MODERATE The information system compares internal information system clocks on an organization-defined frequency with an organization-defined authoritative time source.	The organization being inspected/assessed configures the information system to synchronize internal information system clocks every 24 hours for networked systems with an authoritative time server which is synchronized with redundant United States Naval Observatory (USNO) time servers as designated for the appropriate DoD network (NIPRNet / SIPRNet) and/or the Global Positioning System (GPS) when the time difference is greater than the difference defined in AU-8 (1), CCI 1892. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1891. DoD has defined the frequency as every 24 hours for networked systems. DoD has defined the authoritative time source as an authoritative time server which is synchronized with redundant United States Naval Observatory (USNO) time servers as designated for the appropriate DoD network (NIPRNet / SIPRNet) and/or the Global Positioning System (GPS). Recommended Compelling Evidence: 1.) Signed and dated audit and accountability policy	Impractical
CCI-001892	AU-8(1)	MODERATE The organization defines the time difference which, when exceeded, will require the information system to synchronize the internal information system clocks to the organization-defined authoritative time source.	The organization being inspected/assessed defines and documents the time difference, which, when exceeded, will require the information system to synchronize the internal information system clocks. DoD has determined the time difference is not appropriate to define at the Enterprise level. Recommended Compelling Evidence: 1.) Signed and dated audit and accountability policy	N/A

CCI-002046	AU-8(1)	MODERATE The information system synchronizes the internal system clocks to the authoritative time source when the time difference is greater than the organization-defined time period.	The organization being inspected/assessed configures the information system to synchronize the internal system clocks to the authoritative time source when the time difference is greater than the time period defined in AU-8 (1), CCI 1892. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 2046. Recommended Compelling Evidence: 1.) Signed and dated audit and accountability policy 2.) Example of how the information system synchronizes internal information system clocks at least hourly with a NIST Internet Time Service server	Applicable
CCI-000169	AU-12(a)	The information system provides audit record generation capability for the auditable events defined in AU-2(a) at organization defined information system components.	CCI-000123 defines auditable events for an information system. Level 4 devices (workstations, servers, network switches, routers, etc.) shall implement to the extent possible the requirements in CCI-000123 and AU-2(a). Requirements that cannot be implemented must be documented and justification provided. Other devices (non level 4) that provide auditing capabilities shall implement the requirements in CCI-000123 where the capability exists and the ISSM deems relevant. Example, for components. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance	Impractical
CCI-001459	AU-12(a)	The organization defines information system components that provide audit record generation capability.	DoD has defined the information system components as all information system and network components. Devices which ARE NOT capable of generating an audit log are exempt. System documentation should define which components are capable and are not capable of generating audit logs.	N/A
CCI-000171	AU-12(b)	The information system allows organization-defined personnel or roles to select which auditable events are to be audited by specific components of the information system	Configure all capable devices to ensure that only the ISSM or individuals appointed by the ISSM select which auditable events are to be audited by specific components of the information system. DoD has defined the personnel or roles as the ISSM or individuals appointed by the ISSM. System administrator personnel will inherently have the rights associated with their accounts to select auditable events, however, organizational policy shall only authorize the ISSM or individuals appointed by the ISSM to select and make those necessary changes.	N/A
CCI-001910	AU-12(b)	The organization defines the personnel or roles allowed select which auditable events are to be audited by specific components of the information system.	DoD has defined the personnel or roles as the ISSM or individuals appointed by the ISSM.	N/A
CCI-000172	AU-12(c)	The information system generates audit records for the events defined in AU-2(d) with the content defined in AU-3.	Audit record requirements are defined in CCI- 000130, CCI-000131, CCI-000132, CCI-000133, CCI-000134, CCI-001487 above. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 172.	Impractical
CCI-000258	CA-3(b)	The organization documents, for each interconnection, the interface characteristics.	Interconnections to other systems WILL NOT be implemented. Front end servers and workstations may reside on the local Network Enterprise Center's (NECs) network allowing a connection into the control system (CS) components.	N/A

CCI-002102	CA-9(a)	The organization defines the information system components or classes of components that that are authorized internal connections to the information system.	Define and document the information system components or classes of components that that are authorized internal connections to the information system. (e.g. Network Controllers, switches, routers, etc.…)	Applicable
CCI-002103	CA-9(b)	The organization documents, for each internal connection, the interface characteristics.	The organization documents, for each internal connection (network controllers, etc.…) the communication protocols used and a general description of what information is communicated over the network. This can be accomplished through a network communication report.	Applicable.
CCI-002104	CA-9(b)	The organization documents, for each internal connection, the security requirements.	The organization documents, for each internal connection, the security requirements.	Applicable
CCI-002105	CA-9(b)	The organization documents, for each internal connection, the nature of the	See CCI-002103	Applicable
		information communicated.		
CCI-000293	CM-2	The organization develops and documents a current baseline configuration of the information system.	Develop and document a current baseline configuration of the information system to include, drawings, software licenses, source code, hardware, etc…	Applicable
CCI-000298	CM-2(1)(c)	MODERATE The organization reviews and updates the baseline configuration of the information system as an integral part of information system component installations.	The organization being inspected/assessed reviews and updates the baseline configuration of the information system as an integral part of information system component installations. The organization must document each occurrence of the reviews and update actions as an audit trail. Recommended Compelling Evidence: 1.) Signed and dated configuration management policy referencing section with reviews and updates to baseline configuration	N/A
CCI-001737	CM-2(7)a	MODERATE The organization defines the information systems, system components, or devices that are to have organization-defined configurations applied when located in areas of significant risk.	The organization being inspected/assessed defines and documents, in the configuration management policy, the information systems, system components, or devices that are to have configurations defined in CM-2 (7), CCI 1738 applied when located in areas of significant risk. DoD has determined that this value is not appropriate to define at the Enterprise level. Recommended Compelling Evidence: 1.) Signed and dated network diagram	Applicable
CCI-001738	CM-2(7)a	MODERATE The organization defines the security configurations to be implemented on information systems, system components, or devices when they are located in areas of significant risk.	The organization being inspected/assessed defines and documents, in the configuration management policy, the security configurations to be implemented on information systems, system components, or devices when they are located in areas of significant risk. DoD has determined that this value is not appropriate to define at the Enterprise level. Recommended Compelling Evidence: 1.) Signed and dated network diagram	Applicable
CCI-000363	CM-6(a)	The organization defines security	DoD has defined the security configuration checklists as DoD security configuration or	Impractical

		configuration checklists to be used to establish and	implementation guidance (e.g. STIGs, SRGs, NSA configuration guides, CTOs, DTMs etc.).	
		document configuration settings for the information system technology products employed.	Document in the security plan, the configuration guidance (e.g. STIGs, SRGs, NSA configuration guides, CTOs, DTMs etc.) which apply to their information system components. Field Devices (BPOCs, etc…) that do not have STIGs, SRGs, etc…obtain vendor configuration guides.	
CCI-000364	CM-6(a)	The organization establishes configuration settings for information technology products employed within the information system using organization-defined security configuration checklists.	DoD security configuration or implementation guidance (e.g. STIGs, SRGs, NSA configuration guides, CTOs, DTMs etc.) meet the DoD requirement for establishing configuration settings. DoD Components are automatically compliant with this control because they are covered by the DoD level security configuration or implementation guidance (e.g. STIGs, SRGs, NSA configuration guides, CTOs, DTMs etc.).	Impractical
CCI-000365	CM-6(a)	The organization documents configuration settings for information technology products employed within the information system using organization-defined security configuration checklists that reflect the most restrictive mode consistent with operational requirements.	DoD security configuration or implementation guidance (e.g. STIGs, SRGs, NSA configuration guides, CTOs, DTMs etc.) meet the DoD requirement for documenting configuration settings. DoD Components are automatically compliant with this control because they are covered by the DoD level security configuration or implementation guidance (e.g. STIGs, SRGs, NSA configuration guides, CTOs, DTMs etc.). Vendor should provide secure configuration guides	Applicable
CCI-001588	CM-6(a)	The organization-defined security configuration checklists reflect the most restrictive mode consistent with operational requirements.	DoD security configuration or implementation guidance (e.g. STIGs, SRGs, NSA configuration guides, CTOs, DTMs etc.) meet the DoD requirement for ensuring security configuration checklists reflect the most restrictive mode consistent with operational requirements. DoD Components are automatically compliant with this control because they are covered by the DoD level security configuration or implementation guidance (e.g. STIGs, SRGs, NSA configuration guides, CTOs, DTMs etc.). Vendor should provide secure configuration guides	Applicable
CCI-001755	CM-6(c)	The organization defines the information system components for which any deviation from the established configuration settings are to be identified, documented and approved.	DoD has defined the information system components as all configurable information system components.	N/A
CCI-000381	CM-7(a)	The organization configures the information system to provide only essential capabilities.	Disable all ports, protocols and services not specifically needed by any device or component within the Control system (server, workstations, field devices, BPOCS, switches, etc…) Remove all software not specifically needed for use in the control system.	Applicable

CCI-000380	CM-7(b)	The organization defines for the information system prohibited or restricted functions, ports, protocols, and/or services.	Disable all ports, protocols and services not specifically needed by any device or component within the Control system (server, workstations, field devices, BPOCS, switches, etc…) Remove all software not specifically needed for use in the control system.	Applicable
CCI-000382	CM-7(b)	The organization configures the information system to prohibit or restrict the use of organization-defined functions, ports, protocols, and/or services.	Disable all ports, protocols and services not specifically needed by any device or component within the Control system (server, workstations, field devices, BPOCS, switches, etc…) Remove all software not specifically needed for use in the control system.	Applicable
CCI-001761	CM-7(1)(b)	The organization defines the functions, ports, protocols and services within the information system that are to be disabled when deemed unnecessary and/or non-secure.	Define and document in the system security plan, the functions, ports, protocols and services within the control system that are to be disabled when deemed unnecessary.	Applicable
CCI-001762	CM-7(1)(b)	The organization disables organization-defined functions, ports, protocols, and services within the information system deemed to be	Disable functions, ports, protocols, and services within the control system deemed to be unnecessary and/or nonsecure, nonsecure functions, ports, protocols, and services.	Applicable
		unnecessary and/or non-secure.		
CCI-001592	CM-7(2)	MODERATE The organization defines the rules authorizing the terms and conditions of software program usage on the information system.	The organization being inspected/assessed defines and documents their rules for approval of software program usage. For network capable software programs, the organization being inspected/assessed complies with DoDI 8551.01. DoD has determined that the rules authorizing the terms and conditions of software program usage on the information system are not appropriate to define at the Enterprise level. Recommended Compelling Evidence: 1.) Approved software list 2.) Rules for approval of software program usage	N/A
CCI-001763	CM-7(2)	MODERATE The organization defines the policies regarding software program usage and restrictions.	The organization being inspected/assessed defines and documents their rules for approval of software program usage. For network capable software programs, the organization being inspected/assessed complies with DoDI 8551.01. DoD has determined that the rules authorizing the terms and conditions of software program usage on the information system are not appropriate to define at the Enterprise level. Recommended Compelling Evidence: 1.) Approved software list 2.) Rules for approval of software program usage	N/A

CCI-001764	CM-7(2)	MODERATE The information system prevents program execution in accordance with organization-defined policies regarding software program usage and restrictions, and/or rules authorizing the terms and conditions of software program usage.	The organization being inspected/assessed configures the information system to prevent the execution of programs not authorized in accordance with CM-7 (2) CCIs 1592 and 1763. Recommended Compelling Evidence: 1.) Applicable STIG/SRG checks	Impractical
CCI-001772	CM-7(5)a	MODERATE The organization defines the software	The organization being inspected/assessed must define and document software programs that are authorized to execute on the information system.	Applicable
		programs authorized to execute on the information system.	DoD has determined that a comprehensive list of unauthorized software programs is not appropriate to define at the Enterprise level. Recommended Compelling Evidence: 1.) Approved software list 2.) Rules for approval of software program usage	
CCI-001773	CM-7(5)a	MODERATE The organization identifies the organization-defined software programs authorized to execute on the information system.	The organization being inspected/assessed must define and document software programs that are authorized to execute on the information system. Recommended Compelling Evidence: 1.) Approved software list 2.) Rules for approval of software program usage	Applicable
CCI-001774	CM-7(5)b	MODERATE The organization employs a deny-all, permit-by-exception policy to allow the execution of authorized software programs on the information system.	The organization being inspected/assessed configures the information system to deny-all and only permit by exception the execution of authorized software programs on the information system. Recommended Compelling Evidence: 1.) Signed and dated system security plan (SSP)	Impractical
CCI-000389	CM-8(a)(1)	The organization develops and documents an inventory of information system components that accurately reflects the current information system.	Provide a Control System inventory report covering all networked, including network infrastructure devices. Provide the following information (where applicable): □ If the device has (in other project documentation) a unique identifier □ Description, make, mode, serial number, location □ Software/firmware version Network information: protocol, network address	Applicable
CCI-000392	CM-8(a)(2)	The organization develops and documents an inventory of information system components that includes all components within the authorization boundary of the information system.	See CCI-000389	Applicable
CCI-000398	CM-8(a)(4)	The organization defines information deemed necessary to achieve effective information system component accountability.	DoD has defined the information as hardware inventory specifications (manufacturer, type, model, serial number, physical location), software license information, information system/component owner, and for a networked component/device, the machine name.	Applicable

CCI-000550	CP-10	The organization provides for the recovery and reconstitution of the information system to a known state after a disruption.	The organization must develop a contingency plan (CP) addressing recovery and reconstitution of the control system to a known state after a disruption In essence, restoring the system to the appropriate operational state. The CP will be site specific and should be developed in conjunction with stakeholders of the system. Copies of required software, backup data, hardware list and baseline configurations should be identified in the CP. NOTE- known state shall also include the accepted "as-built" documentation and include any custom programming and configuration for controllers or workstations.	Applicable
CCI-000551	CP-10	The organization provides for the recovery and reconstitution of the information system to a known state after a compromise.	The organization shall provide automated mechanisms or manual procedures, or a combination of the two, for the recovery and reconstitution of its information system to a known state after a compromise. The organization must identify the selected method in the contingency plan. See also CCI-000550	Applicable
CCI-000552	CP-10	The organization provides for the recovery and reconstitution of the information system to a known state after a failure.	The organization shall provide automated mechanisms or manual procedures, or a combination of the two, for the recovery and reconstitution of its information system to a known state after a failure. The organization must identify the selected method in the contingency plan. See also CCI-000550	Applicable
CCI-002855	CP-12	The information system, when organization-defined conditions are detected, enters a safe mode of operation with organization-defined restrictions of safe mode of operation.	Configure the information system to enter a safe mode of operation with restrictions of safe mode of operation defined in CP-12, CCI 002857 when conditions defined in CP-12, CCI 2856 are detected. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 2855.	Impractical
CCI-002856	CP-12	The organization defines the conditions, that when detected, the information system enters a safe mode of operation with	When the following conditions are detected, the control system shall enter a safe mode of operation. □ Commercial Power Loss □ Fire □ Water	Impractical
		organization-defined restrictions of safe mode of operation.		
CCI-002857	CP-12	The organization defines the restrictions of safe mode of operation that the information system will enter when organization-defined conditions are detected.	**Commercial Power Failure:** Upon loss of commercial power, the control system will switch to Generator power and only Mission Critical Infrastructure (deemed by the organization) will received continued control system service. All other infrastructure/areas services will cease until commercial power is restored. **Fire:** The system shall be integrated with fire detectors. Upon detection of fire, the system will ensure dampers and air handlers are shut down to prevent the propagation of smoke, gasses and fire through the system. The system shall remain in a shutdown/closed state until manually restarted/rebooted by organization personnel. **Water:** Upon detection of water (sprinkler system), the servers shall perform a graceful shutdown in order to minimize component failure due to water.	Impractical
CCI-000764	IA-2	The information system uniquely identifies and authenticates organizational users (or processes acting on behalf of	All components capable of user accounts will be configured to uniquely identify and authenticate users (or processes acting on behalf of organizational users). For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains	Impractical

		organizational users).	to CCI 764.	
CCI-000765	IA-2(1)	The information system implements multifactor authentication for network access to privileged accounts.	Multifactor authentication shall be implemented for users that require privileged level accounts to servers and workstations residing on the network (not standalone or private VLAN segregated systems). Multifactor authentication can be implemented with through common access card (CAC) authentication. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 765.	Impractical
CCI-001953	IA-2(12)	The information system accepts Personal Identity Verification (PIV) credentials.	This control enhancement applies to organizations implementing logical access control systems (LACS) and physical access control systems (PACS). For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1953	Impractical
CCI-001954	IA-2(12)	The information system electronically verifies Personal Identity Verification (PIV) credentials.	This control enhancement applies to organizations implementing logical access control systems (LACS) and physical access control systems (PACS). For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1954.	Impractical
CCI-000777	IA-3	The organization defines a list of specific and/or types of devices for which identification and authentication is required before establishing a connection to the information system.	All network connected endpoint devices (including but not limited to: workstations, printers, servers) shall be identified and authenticated before establishing a connection to the information system. Any device incapable of being authenticated to the system shall be documented.	Impractical
CCI-000778	IA-3	The information system uniquely identifies an organization defined list of specific and/or types of devices before establishing a local, remote, or network connection.	Configure the network infrastructure to identify all network connected endpoint devices (including but not limited to: workstations, printers, servers) before establishing a local, remote, network connection. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 778. See CCI-000777	Impractical
CCI-001958	IA-3	The information system authenticates an organization defined list of specific and/or types of devices before establishing a local, remote, or network connection.	Configure the network infrastructure to authenticate all network connected endpoint devices (including but not limited to: workstations, printers, servers) before establishing a local, remote, network connection. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1958. See CCI-000777	Impractical
CCI-001959	IA-3(1)	MODERATE The organization defines the specific devices and/or type of devices the information system is to authenticate before establishing a connection.	DoD has defined the value as all network connected endpoint devices (including but not limited to: workstations, printers, servers (outside a datacenter), VoIP Phones, VTC CODECs). Recommended Compelling Evidence: Automatically Compliant	Impractical
CCI-001967	IA-3(1)	MODERATE	The organization being inspected/assessed configures the information system to use cryptographically based bidirectional	Impractical

		The information system authenticates organization-defined devices and/or types of devices before establishing a local, remote and/or network connection using bidirectional authentication that is cryptographically based.	authentication. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1967. Recommended Compelling Evidence: 1.) Signed and dated documentation for use of cryptographically based bidirectional authentication. 2.) Applicable STIG/SRG checks.	
CCI-000176	IA-5(b)	The organization manages information system authenticators by establishing initial authenticator content for authenticators defined by the organization.	The ISSM/O or designee will manage the password generation, issuance, and control process. If used, generate passwords in accordance with the BBP for Army Password Standards. The authenticators (passwords) will follow format and complexity as defined in the BBP for Army Password Standards and be changed immediately upon initial login. Control system component that are not capable of implementing the complexity requirements shall implement password strength to the greatest extent possible. Physical security mechanisms can be implemented as a layered defense to further protect access to non-conforming components. For information system components that have applicable STIGs or SRGs, the organization must comply with the STIG/SRG guidance.	Impractical
CCI-001544	IA-5(c)	The organization manages information system authenticators by ensuring that authenticators have sufficient strength of mechanism for their intended use.	For information system components that have applicable STIGs or SRGs, the organization must comply with the STIG/SRG guidance. Components which do not have an applicable STIG or SRG will configure (to the extent possible) them to comply with the complexity requirements set forth in the BBP for Army Password Standards.	Applicable
CCI-001989	IA-5(e)	The organization manages information system authenticators by changing default content of authenticators prior to information system installation.	Document and implement procedures to change default authenticators (passwords, etc.) or apply authenticators to all capable components prior to system installation.	Applicable
CCI-000182	IA-5(g)	The organization manages information system authenticators by	Document and implement procedures for changing/refreshing authenticators.	Applicable
		changing/refreshing authenticators in accordance with the organization defined time period by authenticator type.		
CCI-001610	IA-5(g)	The organization defines the time period (by authenticator type) for changing/refreshing authenticators.	DoD has defined the time period as CAC - every 3 years, or 1 year from term of contract. Password: 60 days. Biometrics: every 3 years.	Applicable

CCI-000192	IA-5(1)(a)	The information system enforces password complexity by the minimum number of upper case characters used.	For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 192. All other components will be configured to implement and enforce the minimum number of upper case characters used as defined in the BBP for Army Password Standards.	Impractical
CCI-000193	IA-5(1)(a)	The information system enforces password complexity by the minimum number of lower case characters used.	For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 193. All other components will be configured to implement and enforce the minimum number of lower case characters used as defined in the BBP for Army Password Standards.	Impractical
CCI-000194	IA-5(1)(a)	The information system enforces password complexity by the minimum number of numeric characters used.	For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 192. All other components will be configured to implement and enforce the minimum number of numeric characters used as defined in the BBP for Army Password Standards.	Impractical
CCI-000205	IA-5(1)(a)	The information system enforces minimum password length.	For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 205. All other components will be configured to implement and enforce the minimum password length as defined in the BBP for Army Password Standards.	Impractical
CCI-001611	IA-5(1)(a)	The organization defines the minimum number of special characters for password complexity enforcement.	The BBP for Army Password Standards defines the minimum number of special characters to be 2.	Impractical
CCI-001612	IA-5(1)(a)	The organization defines the minimum number of upper case characters for password complexity enforcement.	The BBP for Army Password Standards defines the minimum number of upper case characters to be 2.	Impractical
CCI-001613	IA-5(1)(a)	The organization defines the minimum number of lower case characters for password complexity enforcement.	The BBP for Army Password Standards defines the minimum number of special characters to be 2.	Impractical
CCI-001614	IA-5(1)(a)	The organization defines the minimum number of numeric characters for password complexity enforcement.	The BBP for Army Password Standards defines the minimum number of numeric characters to be 2.	Impractical
CCI-001619	IA-5(1)(a)	The information system enforces password complexity by the minimum number of special characters used.	For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1619. All other components will be configured to implement and enforce the minimum password length as defined in the BBP for Army Password Standards.	Impractical

CCI-000195	IA-5(1)(b)	The information system, for password-based authentication, when new passwords are created, enforces that at least an organization-defined number of characters are changed.	For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 195.	Impractical
CCI-001615	IA-5(1)(b)	The organization defines the minimum number of characters that are changed when new passwords are created.	For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 195. DoD has defined the minimum number of characters as 50% of the minimum password length.	Impractical
CCI-000196	IA-5(1)(c)	The information system, for password-based authentication,	Configure the information system to store only encrypted representations of passwords. For information system components that have applicable STIGs or SRGs, the organization being	Impractical
		stores only cryptographically-protected passwords.	inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 196.	
CCI-000197	IA-5(1)(c)	The information system, for password-based authentication, transmits only cryptographically-protected passwords.	Configure the information system to transmit only encrypted representations of passwords. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 197.	Impractical
CCI-000198	IA-5(1)(d)	The information system, for password-based authentication, transmits only cryptographically-protected passwords.	Configure the information system to enforce minimum password lifetime restrictions. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 198.	Impractical
CCI-000199	IA-5(1)(d)	The information system enforces maximum password lifetime restrictions.	Configure the information system to enforce maximum password lifetime restrictions. For capable components, set maximum password age to 60 days or less (excluding “0”). For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 199.	Impractical
CCI-001616	IA-5(1)(d)	The organization defines minimum password lifetime restrictions.	DoD has defined the minimum password lifetime restrictions as 24 hours.	Impractical
CCI-001617	IA-5(1)(d)	The organization defines maximum password lifetime restrictions.	DoD has defined the maximum password lifetime restrictions as 60 days and not being “0”.	Impractical
CCI-000200	IA-5(1)(e)	The information system prohibits password reuse for the organization defined number of generations.	For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 200. All other components utilizing passwords, the password reuse should be set to 24. If the components are incapable of being set to 24 then implement the maximum possible.	Applicable
CCI-001618	IA-5(1)(e)	The organization defines the number of generations for which password reuse is prohibited.	Per the STIGs for Windows based systems, the DOD has defined this to be set at a minimum of 24.	Applicable

CCI-002041	IA-5(1)(f)	The information system allows the use of a temporary password for system logons with an	Configure the information system to allow the use of a temporary password for system logons with an immediate change to a permanent password. For information system components that have applicable STIGs or SRGs, the organization being	Applicable
		immediate change to a permanent password.	inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 2041. For components that cannot technically require password change upon initial login, document in organizational policy as a requirement for personnel logging in with a temporary password to immediately change the password to the standards defined in the BBP for Army Password Standards.	
CCI-000185	IA-5(2)(a)	MODERATE The information system, for PKI-based authentication validates certifications by constructing and verifying a certification path to an accepted trust anchor including checking certificate status information.	The information system performing hardware token-based authentication must be configured to validate DoD-approved PKI credentials in accordance with RFC 5280. The information system must be configured to perform a revocation check as part of the certificate validation process. Revocation checking may be performed using certificate revocation lists (CRLs) published by the issuing PKI or Online Certificate Status Protocol (OCSP) services. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 185. Recommended Compelling Evidence: 1.) Signed and dated SOP/TTP documenting the use of a validated DoD-approved PKI credentials in accordance with RFC 5280 2.) Applicable STIG/SRG checks	Impractical
CCI-000186	IA-5(2)(b)	MODERATE The information system, for PKI-based authentication enforces authorized access to the corresponding private key.	Information systems must not have access to users' private keys. The cryptographic container in which the private keys are stored (e.g. smart card or software module) implements access controls and protections to ensure that only the authorized user can activate the private key. DoD users agree to protect their PKI credentials in accordance with the DD-2842 agreement that is executed for each credential. They are reminded of these responsibilities in annual IA training. The private key identifying the information system must be stored in a cryptographic container that is FIPS 140- 2 validated. Only authorized information system operators should have access to activation data (e.g. password or PIN) for the private key. Recommended Compelling Evidence: 1.) Signed and dated SOP/TTP, referencing section on private key access 2.) Applicable STIG/SRG checks	Impractical
CCI-000187	IA-5(2)(c)	MODERATE The information system, for PKI-based authentication, maps the authenticated identity to the account of the individual or group.	The information system performing PKI-based authentication must be configured to map the authenticated PKI credential to a corresponding network or information system account or role in accordance with DoDI 8520.03. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 187. Recommended Compelling Evidence: 1.) Signed and dated SOP/TTP for configuring the information system mapping of the authenticated PKI credentials to a corresponding network or information system account or role in accordance with DoDI 8520.03. 2.) Applicable STIG/SRG checks	Impractical

CCI-001991	IA-5(2)(D)	MODERATE The information system, for PKI-based authentication, implements a local cache of revocation data to support path discovery and validation in case of inability to access revocation information via the network.	The information system must be configured to locally cache revocation data to support path discovery and validation in case of inability to access revocation information via the network. The information system may meet this requirement by locally caching certificate revocation lists (CRLs), Online Certificate Status Protocol (OCSP) responses, or a combination thereof. Cached revocation data must include revocation information from all PKIs serving known or anticipated users of the information system. Cached data must be refreshed with a frequency shorter than the life of the data (e.g. if a CRL is valid for 7 days, a new CRL must be retrieved and cached more frequently than every 7 days) to ensure that cached data is valid and not expired. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1991. Recommended Compelling Evidence: 1.) Signed and dated SOP/TTP configuring the information system to locally cache revocation data to support path discovery and validation in case of inability to access revocation information via the network. 2.) Applicable STIG/SRG checks	Impractical
CCI-002002	IA-5(11)	The organization defines the token quality requirements to be employed by the information	DoDI 8520.03 defines types of authentication credentials that are acceptable for authentication to different systems based on the systems' information sensitivity levels and the users' access environments. The definitions for credential	Impractical
		system mechanisms for token-based authentication.	strengths D, E and H found in DoDI 8520.03 Enclosure 3, Section 3 specifically deal with acceptable types of hardware PKI credentials. DoD Components are automatically compliant with this control because they are covered by the DoD-level policy, DoDI 8520.03.	
CCI-002003	IA-5(11)	The information system, for token-based authentication, employs mechanisms that satisfy organization- defined token quality requirements.	The information system performing hardware token-based authentication must be configured to accept only DoD-approved PKI credentials in accordance with DoDI 8520.02 and DoDI 8520.03. For unclassified systems, DoD-approved PKI credentials include DoD PKI credentials, External Certification Authority (ECA) PKI credentials, and DoD-approved external PKI credentials. If the information system accepts DoD-approved external PKI credentials, the information system must be configured to accept only certificates at approved assurance levels, as represented by the Certificate Policy Object Identifiers (OIDs) asserted in the certificate. The current list of DoD-approved external PKIs and acceptable Object Identifiers (OIDs) for each approved external PKI is available at http://iase.disa.mil/pki-pke/interoperability. Windows based control systems on the network, utilizing CAC authentication and configured with the Army Gold Master (AGM) should automatically be compliant with this.	Impractical
CCI-000206	IA-6	The information system obscures feedback of authentication information during the authentication process to protect the information from possible exploitation/use by unauthorized individuals.	Configure the information system to obscure feedback of authentication information during the authentication process to protect the information from possible exploitation/use by unauthorized individuals. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 206. Applicable to networked devices. Does not apply to devices that have NO feedback during password/PIN entry.	Impractical

			Devices shall 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 CCI-000206, comply with the requirements of those STIGS/SRGs.	
CCI-000803	IA-7	The information system implements mechanisms for authentication to a cryptographic module that meet the requirements of applicable federal laws, Executive Orders, directives, policies, regulations, standards, and guidance for such authentication.	For devices that have STIG/SRGs related to CCI- 000803, comply with the requirements of those STIG/SRGs.	Impractical
CCI-000865	MA-3	MODERATE The organization approves information system maintenance tools.	The organization being inspected/assessed documents the approved maintenance tools within the Security Plan. Recommended Compelling Evidence: 1.) Signed and dated System Security Plan (SSP), including a list of approved maintenance tools	N/A
CCI-000936	PE-4	MODERATE The organization controls physical access to organization-defined information system distribution and transmission lines within organizational facilities using organization-defined security safeguards.	The organization being inspected/assessed controls physical access to information system distribution and transmission lines defined in PE-4, CCI 2930 within organizational facilities using security safeguards defined in PE-4, CCI 2931. Recommended Compelling Evidence: 1.) Facility access policy and procedures 2.) Locked Cabinets/Closets/Key Control etc.	Applicable
CCI-002930	PE-4	MODERATE The organization defines information system distribution and transmission lines within organizational facilities to control physical access using organization-defined security safeguards.	The organization being inspected/assessed defines and documents information system distribution and transmission lines within organizational facilities to control physical access using organization-defined security safeguards. If transmission lines carry classified information, a protected distribution system (PDS) must be used to transmit unencrypted classified information through an area of lesser classification or control. For additional information, see NSTISSI No. 7003. DoD has determined the information system distribution and transmission lines are not appropriate to define at the Enterprise level.	Applicable
			Recommended Compelling Evidence: 2.) Facility access policy and procedures	
CCI-002931	PE-4	MODERATE The organization defines security safeguards to control physical access to organization-defined information system distribution and transmission lines within organizational facilities.	The organization being inspected/assessed defines and documents security safeguards to control physical access to organization-defined information system distribution and transmission lines within organizational facilities. DoD has determined the security safeguards are not appropriate to define at the Enterprise level. Recommended Compelling Evidence: 1.) Facility access policy and procedures 2.) Access audit records for areas that include transmission or distribution lines 3.) Lines must be secured from tampering	Applicable
CCI-000937	PE-5	MODERATE	Physical Security should be applied where applicable and does not violate life safety.	Applicable

		The organization controls physical access to information system output devices to prevent unauthorized individuals from obtaining the output.		
CCI-000952	PE-9	MODERATE The organization protects power equipment and power cabling for the information system from damage and destruction.	The organization being inspected/assessed provides a list of protective measures in place to prevent damage and/or destruction of power equipment and power cabling for their information system environment, IAW CP-2 (1), CCI 469. Recommended Compelling Evidence: 1.) List of protective measures to prevent damage to the system 2.) Verify devices are secure.	Applicable
CCI-002953	PE-9(1)	MODERATE The organization employs redundant power cabling paths that are physically separated by organization-defined distance.	Apply and use redundant cable where practical, within code and cost effective.	Impractical
CCI-002954	PE-9(1)	MODERATE The organization defines the distance to physically separate redundant power cabling paths.	Installed in accordance with code.	Impractical
CCI-003051	PL-2(a)(2)	The organization's security plan for the information system explicitly defines the authorization boundary for the system.	Develop a diagram and explain within the system security plan (SSP) the authorization boundary for the complete control system including all networked devices and controller hardware.	N/A
CCI-003053	PL-2(a)(4)	The organization's security plan for the information system provides the security categorization of the information system including supporting rationale.	The recommended Security Category = {(confidentiality, Low), (integrity, Moderate), (availability, Moderate)} Therefore the system shall be categorized as a LOW-MOD-MOD system.	N/A
CCI-003071	PL-7(a)	MODERATE The organization develops a security Concept of Operations (CONOPS) for the information system containing at a minimum, how the organization intends to operate the system from the perspective of information security.	The organization conducting the inspection/assessment obtains and examines the security CONOPS to ensure the organization being inspected/assessed develops a security CONOPS for the information system containing at a minimum, how the organization intends to operate the system from the perspective of information security.	N/A
CCI-003072	PL-8(a)	MODERATE The organization develops an information security architecture for the information system.	The organization being inspected/assessed develops and documents an information security architecture for the information system. Recommended Compelling Evidence: 1.) Current documented information security architecture which includes information security implementation and safeguards, both externally and internally facing. 2). Architectural drawings should be provided	Applicable

CCI-003073	PL-8(a)(1)	MODERATE The organization's information security architecture for the information system describes the overall philosophy, requirements, and approach to be taken with regard to protecting the confidentiality, integrity, and availability of organizational information.	The organization being inspected/assessed describes within the information security architecture for the information system, the overall philosophy, requirements, and approach to be taken with regard to protecting the confidentiality, integrity, and availability of organizational information. Recommended Compelling Evidence: 1.) Current documented information security architecture which includes the overall philosophy, requirements, and approach to protect the confidentiality, integrity, and availability of organizational information.	Applicable
CCI-003075	PL-8(a)(3)	MODERATE The organization's information security architecture for the information system describes any information security assumptions about, and dependencies on, external services.	The organization being inspected/assessed describes within the information security architecture for the information system, any information security assumptions about, and dependencies on, external services. Recommended Compelling Evidence: 1.) Current documented information security architecture which identifies any information security assumptions about, and dependencies on, external services.	Applicable
CCI-000207	PM-5	The organization develops and maintains an inventory of its information systems.	Initial inventory is provided by as-built bill of materials. Army requires any system utilizing IT dollars to be registered in the Army Portfolio Management System (APMS). This would be a requirement of the system owner (SO). 1.) Vendor to provide needed information 2.) System Owner responsible for registration in APMS	Applicable
CCI-000236	PM-11(b)	The organization determines information protection needs arising from the defined mission/business processes and revises the processes as necessary, until an achievable set of	No additional protection needs are needed aside from what the network provider supplies. Control system components (not including servers and workstations) would generally be on a private VLAN without public access thereby further segregating the components from the cyber domain.	N/A
		protection needs are obtained.		
CCI-001048	RA-3(a)	The organization conducts an assessment of risk of the information system and the information it processes, stores, or transmits that includes the likelihood and magnitude of harm from the unauthorized access, use, disclosure, disruption, modification, or destruction.	The conducting of a Risk Assessment will most likely be site specific. The owning organization will need to conduct an assessment of risk of the information system and the information it processes, stores, or transmits that includes the likelihood and magnitude of harm from the unauthorized access, use, disclosure, disruption, modification, or destruction. The Designer can assist in identifying risk to the owing organization in order to complete the risk assessment.	Applicable

CCI-001054	RA-5(a)	The organization scans for vulnerabilities in the information system and hosted applications on an organization-defined frequency.	Servers, workstations and network infrastructure on the network will be scanned for vulnerabilities by the network provider. All other IP devices associated with the system (whether on the public or private side of the network) 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. The owning organization will need a service level agreement (SLA) with the network provider to perform scanning of IP devices on a private VLAN or dark fiber network, or have in-house personnel assigned to perform the vulnerability scanning. DoD has defined the frequency as every 30 days or as directed by an authoritative source (e.g. IAVM, CTOs, DTMs, STIGs).	Impractical
CCI-001055	RA-5(a)	The organization defines a frequency for scanning for vulnerabilities in the information system and hosted applications.	DoD has defined the frequency as every 30 days or as directed by an authoritative source (e.g. IAVM, CTOs, DTMs, STIGs).	Impractical
CCI-001056	RA-5(a)	The organization scans for vulnerabilities in the information system and hosted applications when new vulnerabilities potentially affecting	Conduct vulnerability scans of the information system and hosted applications when new vulnerabilities potentially affecting the system/applications are identified and reported via authoritative sources (e.g., IAVM, CTO, DTM, STIG, product vendor).	Impractical
		the system/applications are identified and reported.		
CCI-001641	RA-5(a)	The organization defines the process for conducting random vulnerability scans on the information system and hosted applications.	DoD has defined the requirement for vulnerability scanning periodicity of every 30 days. If the organization has determined a requirement for random scanning they must document that process. DoD has defined the frequency as every 30 days or as directed by an authoritative source (e.g. IAVM, CTOs, DTMs, STIGs).	Impractical
CCI-001643	RA-5(a)	The organization scans for vulnerabilities in the information system and hosted applications in accordance with the organization-defined process for random scans.	Servers, workstations and network infrastructure on the network will follow the process for random scans as defined by the Network Provider. The organization will conduct random vulnerability scans every 30 days or as directed by an authoritative source (e.g. IAVM, CTOs, DTMs, STIGs) for all other control system components on a private VLAN or the portion not scannable by the Network Provider.. The organization will document the vulnerability scans as an audit trail for future reference. The audit trail must be maintained IAW DoD, CYBERCOM, or component policies. DoD has defined the frequency as every 30 days or as directed by an authoritative source (e.g. IAVM, CTOs, DTMs, STIGs).	Impractical

CCI-001057	RA-5(b)	The organization employs vulnerability scanning tools and techniques that facilitate interoperability among tools and automate parts of the vulnerability management process by using standards for: enumerating platforms, software flaws, and improper configurations; formatting checklists and test procedures; and measuring vulnerability impact.	The organization whether through the Network Provider or otherwise, employs the DoD Enterprise scanning tool.	Impractical
CCI-001058	RA-5(c)	The organization analyzes vulnerability scan reports and results	The organization analyzes vulnerability scan reports and security control assessment results with the intent of identifying legitimate vulnerabilities	Impractical
		from security control assessments.	and the relationship between vulnerabilities and security controls.	
CCI-001059	RA-5(d)	The organization remediates legitimate vulnerabilities in organization-defined response times in accordance with an organizational assessment risk.	The organization being inspected/assessed takes corrective actions as appropriate on legitimate vulnerabilities identified in RA-5, CCI 001058 IAW an authoritative source (e.g. IAVM, CTOs, DTMs, STIGs). Audit records of actions must be maintained IAW applicable DoD, CYBERCOM, and/or component policies. DoD has defined the response times as IAW an authoritative source (e.g. IAVM, CTOs, DTMs, STIGs).	Impractical
CCI-001062	RA-5(1)	MODERATE The organization employs vulnerability scanning tools that include the capability to readily update the information system vulnerabilities to be scanned.	The organization being inspected/assessed will employ scanning tools that maintain currency with industry standard information system vulnerabilities to ensure that scanning activities are conducted with the most up to date list of known vulnerabilities to include USCYBERCOM issued IAVMs. DoD has provided an enterprise scanning tool that fully meets this requirement. Organizations that choose not to use the enterprise scanning tool must identify which scanning tool they are using and ensure that it meets these requirements. Recommended Compelling Evidence: 1.) Documentation that scanning tool being used can be updated.	Impractical
CCI-001067	RA-5(5)	MODERATE The information system implements privileged access authorization to organization- identified information system components for selected organization-defined vulnerability scanning activities.	The organization being inspected/assessed configures the information system to implement privileged access authorization to all information systems and infrastructure components for selected vulnerability scanning activities defined in RA-5 (5), CCI 2906. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1067. DoD has defined the information system components as all information systems and infrastructure components. Recommended Compelling Evidence: 1.) System security plan (SSP). 2.) Reference to system security plan (SSP) section pertaining to the roles and responsibilities of vulnerability scanning.	Impractical

CCI-001645	RA-5(5)	MODERATE The organization identifies the information system components to which privileged access is authorized for selected organization-defined vulnerability scanning activities.	DoD has defined the information system components as all information systems and infrastructure components. Recommended Compelling Evidence: Automatically compliant.	Impractical
CCI-002906	RA-5(5)	MODERATE The organization defines the vulnerability scanning activities in which the information system implements privileged access authorization to organization-identified information system components.	The organization being inspected/assessed defines and documents the vulnerability scanning activities in which the information system implements privileged access authorization to organization- identified information system components. DoD has determined the vulnerability scanning activities are not appropriate to define at the Enterprise level. Recommended Compelling Evidence: 1.) System security plan (SSP). 2.) Reference to system security plan (SSP) section pertaining to the roles and responsibilities of vulnerability scanning.	Impractical
CCI-000623	SA-4(1)	MODERATE The organization requires the developer of the information system, system component, or information system service to provide a description of the functional properties of the security controls to be employed.	DoDI 8510.01 system categorization meets the DoD requirement for providing a description of the functional properties of the security controls to be employed. DoD Components are automatically compliant with this CCI because they are covered by the DoD level policy, DoDI 8510.01. Recommended Compelling Evidence: Automatically compliant per DoDI 8510.01.	N/A
CCI-003101	SA-4(2)	MODERATE The organization requires the developer of the information system, system component, or information	The organization being inspected/assessed defines and documents in contracts/agreements, the design information for the security controls that the developer will employ in the information system to include security-relevant external system interfaces, high-level design, low-level design, source code, hardware schematics and/or design/information defined in SA-4 (2), CCI 3103	Impractical
		system service to provide design information for the security controls to be employed that includes security-relevant external system interfaces, high-level design, low-level design, source code, hardware schematics and/or organization-defined design/information at organization- defined level of detail.	at the level of detail defined in SA-4 (2), CCI 3105. Recommended Compelling Evidence: 1.) System security plan (SSP). 2.) System development life cycle (SDLC) documentation includes design information by the system developer. 3.) Security control documentation includes security-relevant external system interfaces, high- level design, low-level design, source code, hardware schematics and organization defined design/information level of detail.	

CCI-003102	SA-4(2)	MODERATE The organization requires the developer of the information system, system component, or information system service to provide implementation information for the security controls to be employed that includes security-relevant external system interfaces, high-level design, low-level design, source code and/or hardware schematics organization-defined implementation information at organization-defined level of detail.	The organization being inspected/assessed defines and documents in contracts/agreements, the implementation information for the security controls that the developer will employ in the information system to include security-relevant external system interfaces, high-level design, low- level design, source code and/or hardware schematics and/or implementation information defined in SA-4 (2), CCI 3104 at the level of detail defined in SA-4 (2), CCI 3106. Recommended Compelling Evidence: 1.) System security plan (SSP). 2.) System development life cycle (SDLC) documentation includes implementation information by the system developer. 3.) Security control documentation includes security-relevant external system interfaces, high- level design, low-level design, source code, hardware schematics and organization defined design/information level of detail.	Impractical
CCI-003103	SA-4(2)	MODERATE The organization defines the design information that the developer of the	The organization being inspected/assessed defines and documents the design information that the developer of the information system, system component, or information system service is required to provide for the security controls to be employed. DoD has determined the design	Impractical
		information system, system component, or information system service is required to provide for the security controls to be employed.	information is not appropriate to define at the Enterprise level. Recommended Compelling Evidence: 1.) System security plan (SSP). 2.) System development life cycle (SDLC) documentation includes design information by the system developer, as it related to security controls to be employed.	
CCI-003104	SA-4(2)	MODERATE The organization defines the implementation information that the developer of the information system, system component, or information system service is required to provide for the security controls to be employed.	The organization being inspected/assessed defines and documents the implementation information that the developer of the information system, system component, or information system service is required to provide for the security controls to be employed. DoD has determined the implementation information is not appropriate to define at the Enterprise level. Recommended Compelling Evidence: 1.) System security plan (SSP). 2.) System development life cycle (SDLC) documentation includes implementation information by the system developer, as it related to security controls to be employed.	Impractical
CCI-003105	SA-4(2)	MODERATE The organization defines the level of detail the design information of the security controls is required to be provided by the developer of the information system, system component, or information system services.	The organization being inspected/assessed defines and documents the level of detail the design information of the security controls is required to be provided by the developer of the information system, system component, or information system services. DoD has determined the level of detail is not appropriate to define at the Enterprise level. Recommended Compelling Evidence: 1.) System security plan (SSP) defines level of detail required in design information of all security controls, to be provided by developer of information system, component, or service.	Impractical
CCI-003106	SA-4(2)	MODERATE The organization defines the level of	The organization being inspected/assessed defines and documents the level of detail the implementation information of the security controls is required to be provided by the developer of the	Impractical

		detail the implementation information of the security controls is required to be provided by the developer of the information system, system component, or information system services.	information system, system component, or information system services. DoD has determined the level of detail is not appropriate to define at the Enterprise level. Recommended Compelling Evidence: 1.) System security plan (SSP) defines level of detail required in design information of all security controls, to be provided by developer of information system, component, or service.	
CCI-003114	SA-4(9)	MODERATE The organization requires the developer of the information system, system component, or information system service to identify early in the system development life cycle, the functions, ports, protocols, and services intended for organizational use.	The organization being inspected/assessed documents within contracts/agreements, the requirement that the developer of the information system, system component, or information system service identify early in the system development life cycle, the functions, ports, protocols, and services intended for organizational use. Ports identified shall be assessed and planned for in light of DISA's PPSM requirements. Recommended Compelling Evidence: 1.) System security plan (SSP). 2.) System development life cycle (SDLC) documentation identifies functions, ports, protocols and services intended for use.	Impractical
CCI-003116	SA-4(10)	The organization employs only information technology products on the FIPS PUB 201-2-approved products list for Personal Identity Verification (PIV) capability implemented within organizational information systems.	Servers and workstations on the network (Network Provider) and configured with the Army Gold Master (AGM) will be compliant with CCI-003116. Devices on the Network Provider will be compliant with FIPS 201-2 approved products list. Components not CAC enabled (those on private side, or private VLAN) will not implement PKI or a PIV capability.	Impractical
CCI-003124	SA-5(a)(1)	The organization obtains administrator documentation for the information system, system component, or information system	Document within contracts/agreements, requirements that the developer provide administrator documentation for the information system, system component or information system service that describe secure configuration of the system, component, or service.	Applicable
		services that describes secure configuration of the system, component, or service.	To the extent possible this should also apply to Control System software applications. This generally would not apply to physical servers and workstations on the network since they will be configured to Army requirements.	
CCI-003125	SA-5(a)(1)	The organization obtains administrator documentation for the information system, system component, or information system services that describes secure installation of the system, component, or service.	Document within contracts/agreements, requirements that the developer provide administrator documentation for the information system, system component or information system service that describe secure installation of the system, component, or service. To the extent possible this should also apply to Control System software applications. This generally would not apply to physical servers and workstations on the network since they will be configured to Army requirements.	Applicable

CCI-003126	SA-5(a)(1)	The organization obtains administrator documentation for the information system, system component, or information system services that describes secure operation of the system, component, or service.	Document within contracts/agreements, requirements that the developer provide administrator documentation for the information system, system component or information system service that describe secure operation of the system, component, or service. To the extent possible this should also apply to Control System software applications. This generally would not apply to physical servers and workstations on the network since they will be configured to Army requirements.	Applicable
CCI-003127	SA-5(a)(2)	The organization obtains administrator documentation for the information system, system component, or information system services that describes effective use and maintenance of security functions/mechanis ms.	Document within contracts/agreements, requirements that the developer provide administrator documentation for the information system, system component or information system service that describe effective use and maintenance of the system, component, or service. To the extent possible this should also apply to Control System software applications.	Applicable
CCI-003128	SA-5(a)(3)	The organization obtains administrator documentation for the information	Document within contracts/agreements, requirements that the developer provide administrator documentation for the information system, system component or information system	Applicable
		system, system component, or information system services that describes known vulnerabilities regarding configuration and use of administrative (i.e., privileged) functions.	service that describe known vulnerabilities of the system, component, or service. To the extent possible this should also apply to Control System software applications.	
CCI-003129	SA-5(b)(1)	The organization obtains user documentation for the information system, system component, or information system service that describes user-accessible security functions/mechanis ms and how to effectively use those security functions/mechanis ms.	Document within contracts/agreements, requirements that the developer provide administrator documentation for the information system, system component or information system service that describe user-accessible security functions/mechanisms and how to effectively use those security functions/mechanisms. To the extent possible this should also apply to Control System software applications.	Applicable
CCI-003130	SA-5(b)(2)	The organization obtains user documentation for the information system, system component or information system service that describes methods for user interaction which enables individuals to use the system, component, or service in a more secure manner.	Document within contracts/agreements, requirements that the developer provide user documentation for the information system, system component or information system service that describes methods for user interaction which enables individuals to use the system, component, or service in a more secure manner. To the extent possible this should also apply to Control System software applications.	Applicable

CCI-003131	SA-5(b)(3)	The organization obtains user documentation for the information system, system component or information system service that describes user responsibilities in	Document within contracts/agreements, requirements that the developer provide user documentation for the information system, system component or information system service that describes user responsibilities in maintaining the security of the system, component, or service. To the extent possible this should also apply to Control System software applications.	Applicable
		maintaining the security of the system, component, or service.		
CCI-003155	SA-10(A)	MODERATE The organization requires the developer of the information system, system component, or information system service to perform configuration management during system, component or service design, development, implementation and/or operation.	The organization being inspected/assessed requires within contracts/agreements that the developer of the information system, system component, or information system service perform configuration management during system, component or service design, development, implementation and/or operation. The configuration management process applies to: 1. Documentation developed or used in the lifecycle, including requirements and interface specifications; 2. Elements including design libraries; 3. Tools including design tools and test tools; 4. Technical data including test data; and 5. Information on element and system lifecycle processes Recommended Compelling Evidence: 1.) System security plan (SSP). 2.) System development life cycle (SDLC) documentation. 3.) Continuous monitoring plan must require developer to perform configuration management during system, component or service design, development, implementation, and/or operation.	N/A
CCI-003156	SA-10(b)	MODERATE The organization requires the developer of the information system, system component, or information system service to document the integrity of changes to organization- defined configuration items under configuration management.	The organization being inspected/assessed requires within contracts/agreements that the developer of the information system, system component, or information system service document the integrity of changes to configuration items under configuration management defined in SA-10, CCI 3159. Recommended Compelling Evidence: 1.) System security plan (SSP). 2.) System development life cycle (SDLC) documentation. 3.) Continuous monitoring plan must require developer to perform configuration management during system, component or service design, development, implementation, and/or operation.	N/A
CCI-003157	SA-10(b)	MODERATE The organization requires the	The organization being inspected/assessed requires within contracts/agreements the requirement that the developer of the information system, system component, or information system service manage	N/A
		developer of the information system, system component, or information system service to manage the integrity of changes to organization-defined configuration items under configuration management.	the integrity of changes to configuration items under configuration management defined in SA-10, CCI 3159. Recommended Compelling Evidence: 1.) System security plan (SSP). 2.) System development life cycle (SDLC) documentation. 3.) Continuous monitoring plan must require developer to perform configuration management during system, component or service design, development, implementation, and/or operation.	

CCI-003158	SA-10(b)	MODERATE The organization requires the developer of the information system, system component, or information system service to control the integrity of changes to organization-defined configuration items under configuration management.	The organization being inspected/assessed requires within contracts/agreements that the developer of the information system, system component, or information system service control the integrity of changes to configuration items under configuration management defined in SA-10, CCI 3159. Recommended Compelling Evidence: 1.) System security plan (SSP). 2.) System development life cycle (SDLC) documentation. 3.) Continuous monitoring plan must require developer to perform configuration management during system, component or service design, development, implementation, and/or operation.	N/A
CCI-003159	SA-10(b)	MODERATE The organization defines the configuration items under configuration management that require the integrity of changes to be documented, managed and controlled.	The organization being inspected/assessed defines and documents the configuration items under configuration management that require the integrity of changes to be documented, managed and controlled. DoD has determined the configuration items are not appropriate to define at the Enterprise level. Recommended Compelling Evidence: 1.) System security plan (SSP). 2.) System development life cycle (SDLC) documentation. 3.) Continuous monitoring plan must define configuration items under configuration management that require integrity of changes to be documented, managed and controlled.	N/A
CCI-000692	SA-10(c)	MODERATE The organization requires the developer of the information system,	The organization being inspected/assessed requires within contracts/agreements that the developer of the information system, system component, or information system service implement only organization-approved changes to the system, component, or service throughout its life cycle.	N/A
		system component, or information system service to implement only organization- approved changes to the system, component, or service.	Recommended Compelling Evidence: 1.) System security plan (SSP). 2.) System development life cycle (SDLC) documentation. 3.) Continuous monitoring plan must require that only organization-approved changes are implemented.	
CCI-000694	SA-10(d)	MODERATE The organization requires the developer of the information system, system component, or information system service to document approved changes to the system, component, or service.	The organization being inspected/assessed requires within contracts/agreements that the developer of the information system, system component, or information system service document approved changes to the system, component, or service. Recommended Compelling Evidence: 1.) System security plan (SSP). 2.) System development life cycle (SDLC) documentation. 3.) Continuous monitoring plan must require that only organization-approved changes are implemented, and documented.	N/A
CCI-003160	SA-10(d)	MODERATE The organization requires the developer of the information system, system component, or information system service to document the potential security impacts of approved changes to the system, component, or service.	The organization being inspected/assessed requires within contracts/agreements that the developer of the information system, system component, or information system service document the potential security impacts of approved changes to the system, component, or service. Recommended Compelling Evidence: 1.) System security plan (SSP). 2.) System development life cycle (SDLC) documentation. 3.) Continuous monitoring plan must document developer evaluated assessments of potential security impacts of approved changes.	N/A

CCI-003161	SA-10(e)	MODERATE The organization requires the developer of the information system, system component, or information system service to track security flaws within the system,	The organization being inspected/assessed requires within contracts/agreements that the developer of the information system, system component, or information system service track security flaws within the system, component, or service. Recommended Compelling Evidence: 1.) System security plan (SSP). 2.) System development life cycle (SDLC) documentation. 3.) Continuous monitoring plan must document developer flaw tracking.	N/A
		component, or service.		
CCI-003162	SA-10(e)	MODERATE The organization requires the developer of the information system, system component, or information system service to track flaw resolution within the system, component, or service.	The organization being inspected/assessed requires within contracts/agreements that the developer of the information system, system component, or information system service track flaw resolution within the system, component, or service. Recommended Compelling Evidence: 1.) System security plan (SSP). 2.) System development life cycle (SDLC) documentation. 3.) Continuous monitoring plan must document developer flaw tracking, and resolution.	N/A
CCI-003163	SA-10(e)	MODERATE The organization requires the developer of the information system, system component, or information system service to report security flaws and flaw resolution within the system, component, or service findings to organization-defined personnel.	The organization being inspected/assessed requires within contracts/agreements that the developer of the information system, system component, or information system service report security flaws and flaw resolution within the system, component, or service findings to at a minimum, the ISSO and ISSM. DoD has defined the personnel as at a minimum, the ISSO and ISSM. Recommended Compelling Evidence: 1.) System security plan (SSP). 2.) System development life cycle (SDLC) documentation. 3.) Continuous monitoring plan must document developer flaw tracking, and resolution.	N/A
CCI-003171	SA-11(a)	MODERATE The organization requires the developer of the information system, system component, or information system service to create a security assessment plan.	The organization being inspected/assessed requires that the developer create and document a security assessment plan that includes: 1. The types of analyses, testing, evaluation, and reviews of software and firmware components; 2. The degree of rigor to be applied; and 3. The types of artifacts produced during those processes. Recommended Compelling Evidence: 1.) System security plan (SSP). 2.) System development life cycle (SDLC) documentation must contain developer-created Security Assessment Plan.	N/A
CCI-003172	SA-11(a)	MODERATE The organization requires the developer of the information system, system component, or information system service to implement a security assessment plan.	The organization being inspected/assessed requires that the developer implement the security assessment plan developed in SA-11, CCI 003171. Recommended Compelling Evidence: 1.) System security plan (SSP). 2.) System development life cycle (SDLC) documentation must require implementation of developer-created Security Assessment Plan.	N/A

CCI-003173	SA-11(b)	MODERATE The organization requires the developer of the information system, system component, or information system service to perform unit, integration, system, and/or regression testing/evaluation at organization-defined depth and coverage.	The organization being inspected/assessed documents within the contracts/agreements, the requirement that the developer of the information system, system component, or information system service perform unit, integration, system, and/or regression testing/evaluation at depth and coverage defined in SA-11, CCI 3174. Recommended Compelling Evidence: 1.) System security plan (SSP). 2.) System development life cycle (SDLC) documentation must require developer to perform unit, integration, system, and/or regression testing at organization defined depth and coverage.	N/A
CCI-003174	SA-11(b)	MODERATE The organization defines the depth and coverage to perform unit, integration, system, and/or regression testing/evaluation.	The organization being inspected/assessed defines and documents the depth and coverage to perform unit, integration, system, and/or regression testing/evaluation. Examples of approaches or tool types that could be required are: 1. Approaches such as static analyses, dynamic analyses, binary analysis, or a hybrid of the three approaches; and 2. Tools such as web-based application scanners, static analysis tools, binary analyzers. DoD has determined the depth and coverage are not appropriate to define at the Enterprise level. Recommended Compelling Evidence: 1.) System security plan (SSP). 2.) System development life cycle (SDLC) documentation must define organization depth and coverage of unit, integration, system, and/or regression testing for developer to perform.	N/A
CCI-003175	SA-11(c)	MODERATE The organization requires the developer of the information system, system component, or information system service to produce evidence of the execution of the security assessment plan.	The organization being inspected/assessed requires the developer to produce and provide evidence of the execution of the security assessment plan. Recommended Compelling Evidence: 1.) System security plan (SSP). 2.) System development life cycle (SDLC) documentation must require execution of developer-created Security Assessment Plan.	N/A
CCI-003176	SA-11(c)	MODERATE The organization requires the developer of the information system, system component, or information system service to produce the results of the security testing/evaluation.	The organization being inspected/assessed requires the developer to produce and provide results of the security testing/evaluation. Recommended Compelling Evidence: 1.) System security plan (SSP). 2.) System development life cycle (SDLC) documentation must require developer results of security testing/evaluation.	N/A
CCI-003177	SA-11(d)	MODERATE The organization requires the developer of the information system, system component, or information system service to implement a verifiable flaw remediation process.	The organization being inspected/assessed requires the developer to implement a verifiable flaw remediation process. Recommended Compelling Evidence: 1.) System security plan (SSP). 2.) System development life cycle (SDLC) documentation must require developer to implement verifiable flaw remediation process.	N/A

CCI-003178	SA-11(e)	MODERATE The organization requires the developer of the information system, system component, or information system service to correct flaws identified during	The organization being inspected/assessed requires the developer to correct flaws identified during security testing/evaluation and to document and provide evidence that the flaws were corrected. Recommended Compelling Evidence: 1.) System security plan (SSP). 2.) System development life cycle (SDLC) documentation must require developer correct flaws identified during security testing/evaluation process.	N/A
		security testing/evaluation.		
CCI-001082	SC-2	MODERATE The information system separates user functionality (including user interface services) from information system management functionality.	The organization being inspected/assessed configures the information system to separate user functionality (including user interface services) from information system management functionality. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1082. Recommended Compelling Evidence: 1.) Data flow diagram. 2.) Applicable STIG/SRG checks.	N/A
CCI-001093	SC-5	The organization defines the types of denial of service attacks (or provides references to sources of current denial of service attacks) that can be addressed by the information system.	Definition of the types of denial of service attacks will be defined at the Network Provider level.	Impractical
CCI-002385	SC-5	The information system protects against or limits the effects of organization-defined types of denial of service attacks by employing organization-defined security safeguards.	For information system components that have applicable STIGs or SRGs, the organization must comply with the STIG/SRG guidance that pertains to CCI 2385. To the greatest extent practical, the hardware performs control logic without reliance on the network.	Impractical
CCI-002386	SC-5	The organization defines the security safeguards to be employed to protect the information system against, or limit the effects of, denial of service attacks.	Definition of the security safeguard to be employed to protect the information system will be defined at the Network Provider level for all devices on the Network Provider. To the greatest extent practical, the hardware performs control logic without reliance on the network.	Impractical
CCI-001097	SC-7(a)	The information system monitors and controls communications at the external	Monitoring and the controlling of communications at the external boundary of the system will be the responsibility of the Network Provider. The control system shall not be publicly accessible.	N/A
		boundary of the system and at key internal boundaries within the system.		
CCI-001109	SC-7(5)	MODERATE		Impractical

		The information system at managed interfaces denies network communications traffic by default and allows network communications traffic by exception (i.e., deny all, permit by exception	The organization being inspected/assessed configures the information system to deny network communications traffic at managed interfaces by default and allows network communications traffic by exception (i.e., deny all, permit by exception). For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1109. Recommended Compelling Evidence: 1.) Current Network diagram. 2.) Applicable firewall rule set. 3.) Applicable firewall logs. 4.) Applicable STIG/SRG checks.	
CCI-001126	SC-7(18)	MODERATE The information system fails securely in the event of an operational failure of a boundary protection device.	The organization conducting the inspection/assessment examines the information system to ensure the organization being inspected/assessed configures the information system to fail securely in the event of an operational failure of a boundary protection device. For information system components that have applicable STIGs or SRGs, the organization conducting the inspection/assessment evaluates the components to ensure that the organization being inspected/assessed has configured the information system in compliance with the applicable STIGs and SRGs pertaining to CCI 1126.	Impractical
CCI-002418	SC-8	MODERATE The information system protects the confidentiality and/or integrity of transmitted information.	The organization being inspected/assessed configures the information system to protect the confidentiality and/or integrity of transmitted information. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 2418. Recommended Compelling Evidence: 1.) Current Network diagram. 2.) Applicable STIG/SRG checks pertaining to CCI 2418.	Impractical
CCI-002419	SC-8(1)	MODERATE	DoD has defined the alternative physical safeguards as Protected Distribution System (PDS).	Impractical
		The organization defines the alternative physical safeguards to be employed when cryptographic mechanisms are not implemented to protect information during transmission.	Recommended Compelling Evidence: Automatically compliant.	
CCI-002421	SC-8(1)	MODERATE The information system implements cryptographic mechanisms to prevent unauthorized disclosure of information and/or detect changes to information during transmission unless otherwise protected by organization- defined alternative physical safeguards.	The organization being inspected/assessed configures the information system to implement cryptographic mechanisms to prevent unauthorized disclosure of information and detect changes to information during transmission unless otherwise protected by Protected Distribution System (PDS). For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 2421. DoD has defined the selection as both prevention of unauthorized disclosure and detection of changes to information. DoD has defined the alternative physical safeguards as Protected Distribution System (PDS). Recommended Compelling Evidence: 1.) Current Network diagram. 2.) Signed and dated System Security Plan (SSP). 3.) Applicable STIG/SRG checks.	Applicable – Documents Only

CCI-001133	SC-10	MODERATE The information system terminates the network connection associated with a communications session at the end of the session or after an organization-defined time period of inactivity.	The organization being inspected/assessed configures the information system to terminate the network connection associated with a communications session at the end of the session or after 10 minutes in band management and 15 minutes for user sessions. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1133. DoD has defined the time period as 10 minutes in band management and 15 minutes for user sessions. Recommended Compelling Evidence: 1.) Applicable STIG/SRG pertaining to CCI 1133.	Impractical
CCI-001134	SC-10	MODERATE The organization defines the time period of inactivity after which the information system terminates a network connection associated with a communications session.	DoD has defined the time period as 10 minutes in band management and 15 minutes for user sessions. Recommended Compelling Evidence: Automatically compliant.	Impractical
CCI-001160	SC-18(a)	MODERATE The organization defines acceptable and unacceptable mobile code and mobile code technologies.	The organization being inspected/assessed defines and documents acceptable and unacceptable mobile code and mobile code technologies IAW the Protection Profile for Web Browsers and Application SRG. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must define IAW the STIG/SRG guidance that pertains to CCI 1160. Recommended Compelling Evidence: 1.) Signed an dated system and communications protection policy (reference mobile code section). 2.) Applicable STIG/SRG checks pertaining to CCI 1160.	N/A
CCI-001161	SC-18(b)	MODERATE The organization establishes usage restrictions for acceptable mobile code and mobile code technologies.	The organization being inspected/assessed documents usage restrictions for acceptable mobile code and mobile code technologies IAW the Protection Profile for Web Browsers and Application SRG. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must establish IAW the STIG/SRG guidance that pertains to CCI 1161. Recommended Compelling Evidence: 1.) Signed and dated system and communications protection policy (reference mobile code section). 2.) Applicable STIG/SRG checks pertaining to CCI 1161.	Impractical
CCI-001162	SC-18(b)	MODERATE The organization establishes implementation guidance for acceptable mobile code and mobile code technologies.	The Protection Profile for Web Browsers and Application SRG meet the DoD requirement to establish implementation guidance for acceptable mobile code and mobile code technologies.	Impractical
			DoD Components are automatically compliant with this CCI because they are covered by the Protection Profile for Web Browsers and Application SRG. Recommended Compelling Evidence: Automatically compliant.	
CCI-001163	SC-18(c)	MODERATE The organization authorizes the use of mobile code within the information system.	The organization being inspected/assessed documents mobile code which is authorized for use within the information system. Recommended Compelling Evidence: 1.) Signed and dated system and communications protection policy (reference mobile code section). 2. Software list to be provided	N/A
CCI-001164	SC-18(c)	MODERATE The organization monitors the use of mobile code within the information system.	The organization being inspected/assessed documents and implements a process to monitor the use of mobile code within the information system. Recommended Compelling Evidence: 1.) Signed and dated system and communications protection policy (reference mobile code section).	N/A

CCI-001165	SC-18(c)	MODERATE The organization controls the use of mobile code within the information system.	The organization being inspected/assessed documents and implements a process to control the use of mobile code within the information system. Recommended Compelling Evidence: 1.) Signed and dated system and communications protection policy (reference mobile code section).	N/A
CCI-001184	SC-23	MODERATE The information system protects the authenticity of communications sessions.	The organization being inspected/assessed configures the information system to protect the authenticity of communications sessions. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1184. Recommended Compelling Evidence: 1.) Applicable STIG/SRG checks pertaining to CCI 1184.	Impractical
CCI-001190	SC-24	MODERATE The information system fails to an organization-defined	The organization conducting the inspection/assessment examines the information system to ensure the organization being inspected/assessed configures the information system to fail to a secure state for failures during	Applicable
		known-state for organization-defined types of failures.	system initialization, shutdown, and aborts. For information system components that have applicable STIGs or SRGs, the organization conducting the inspection/assessment evaluates the components to ensure that the organization being inspected/assessed has configured the information system in compliance with the applicable STIGs and SRGs pertaining to CCI 1190. DoD has defined the known state as secure state. DoD has defined the types of failures as failures during system initialization, shutdown, and aborts.	
CCI-001191	SC-24	MODERATE The organization defines the known states the information system should fail to in the event of an organization-defined system failure.	The organization being inspected/assessed is automatically compliant with this CCI because they are covered at the DoD level. DoD has defined the known state as secure state	Applicable
CCI-001192	SC-24	MODERATE The organization defines types of failures for which the information system should fail to an organization- defined known state.	The organization being inspected/assessed is automatically compliant with this CCI because they are covered at the DoD level. DoD has defined the types of failures as failures during system initialization, shutdown, and aborts.	N/A
CCI-001193	SC-24	MODERATE The organization defines system state information that should be preserved in the event of a system failure.	The organization being inspected/assessed is automatically compliant with this CCI because they are covered at the DoD level. DoD has defined system state information as information necessary to determine cause of failure and to return to operations with least disruption to mission/ business processes	Applicable
CCI-001665	SC-24	MODERATE The information system preserves organization-defined system state information in the event of a system failure.	The organization conducting the inspection/assessment examines the information system to ensure the organization being inspected/assessed configures the information system to preserve information necessary to determine cause of failure and to return to operations with least disruption to mission/ business processes in the event of a system failure. For information system components that have applicable STIGs or SRGs, the organization	Applicable
			conducting the inspection/assessment evaluates the components to ensure that the organization being inspected/assessed has configured the information system in compliance with the applicable STIGs and SRGs pertaining to CCI 1665. DoD has defined	

CCI-001199	SC-28	MODERATE The information system protects the confidentiality and/or integrity of organization-defined information at rest.	The organization being inspected/assessed configures the information system to protect the confidentiality and/or integrity of organization- defined information at rest. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1199. Recommended Compelling Evidence: 1.) Documentation that identifies which information at rest must be protected. 2.) Applicable STIG/SRG checks pertaining to CCI 1199.	Impractical
CC-002472	SC-28	MODERATE The organization defines the information at rest that is to be protected by the information system.	The organization being inspected/assessed defines and documents the information at rest that is to be protected by the information system which must include, at a minimum, PII and classified information. DoD has determined the information at rest is not appropriate to define at the Enterprise level. Recommended Compelling Evidence: 1.) Signed and dated System Security Plan (SSP) should define the information at rest that is to be protected by the information system.	Impractical
CCI-002530	SC-39	The information system maintains a separate execution domain for each executing process.	To the greatest extent practical, the hardware performs control sequences without reliance on the network.	Impractical
CCI-002544	SC-41	The organization defines the information systems or information system components on which organization-defined connection ports or input/output devices are to be physically disabled or removed.	Define and document the information systems or information system components on which organization-defined connection ports or input/output devices are to be physically disabled or removed. The control system has a specific purpose (not a general one) and its function (and limitations) are specified by the control system architecture and protocols. Specifications should require disabling any ports/protocols/services not specifically needed by the control system. Required software should be	Impractical
			covered by specification, all other software should be prohibited.	
CCI-002545	SC-41	The organization defines the connection ports or input/output devices that are to be physically disabled or removed from organization-defined information systems or information system components.	Document the connection ports or input/output devices that are to be physically disabled or removed from organization-defined information systems or information system components. The control system has a specific purpose (not a general one) and its function (and limitations) are specified by the control system architecture and protocols. Specifications should require disabling any ports/protocols/services not specifically needed by the control system. Required software should be covered by specification, all other software should be prohibited.	Applicable
CCI-002546	SC-41	The organization physically disables or removes organization-defined connection ports or input/output devices on organization- defined information systems or information system components.	Physically disable or remove connection ports or input/output devices defined in SC-41, CCI 2545 on information systems or information system components defined in SC-41, CCI 2544.	Applicable

CCI-001241	SI-3(c)(1)	The organization configures malicious code protection mechanisms to perform periodic scans of the information system on an organization-defined frequency.	The Network Provider will implement/configure security scanning for servers and workstations on their network. Servers and workstations installed under this project that are on a private VLAN, the owning organization must install and configure malware protection software. Configure software to perform a full system scan every 7 days. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1241. DoD has defined the frequency as every 7 days.	Impractical
CCI-002623	SI-3(c)(1)	The organization defines the frequency for performing periodic scans of the information system for malicious code.	DoD has defined the frequency as every 7 days.	Impractical
CCI-001253	SI-4(a)(1)	The organization defines the objectives of monitoring for	DoD has defined the monitoring objectives as sensor placement and monitoring requirements within CJCSI 6510.01F.	Impractical
		attacks and indicators of potential attacks on the information system.		
CCI-002645	SI-4(b)	The organization defines the techniques and methods to be used to identify unauthorized use of the information system.	Network monitoring is conducted by the network provider for control system components on non- private (VLAN) side. Network monitoring cannot be implemented for field devices/components on the private network (VLAN).	Impractical
CCI-002703	SI-7	MODERATE The organization defines the software, firmware, and information which will be subjected to integrity verification tools to detect unauthorized changes.	The organization being inspected/assessed defines and documents the software, firmware, and information which will be subjected to integrity verification tools to detect unauthorized changes. DoD has determined the software, firmware, and information are not appropriate to define at the Enterprise level. Recommended Compelling Evidence: 1.) Signed and dated System security plan defines the software, firmware and information which will be subjected to integrity verification tools to check for unauthorized changes. 2.) Implementation documentation of integrity verification tools that will check for those unauthorized changes.	Impractical
CCI-002705	SI-7(1)	MODERATE The organization defines the software on which integrity checks will be performed.	The organization being inspected/assessed defines and documents the software on which integrity checks will be performed. DoD has determined the software is not appropriate to define at the Enterprise level. Recommended Compelling Evidence: 1.) Signed and dated System security plan defines the software which will be subjected to integrity verification tools to check for unauthorized changes. 2.) Implementation documentation of integrity verification tools that will check the firmware for unauthorized changes.	Impractical
CCI-002706	SI-7(1)	MODERATE The organization defines the firmware on which integrity	The organization being inspected/assessed defines and documents the firmware on which integrity checks will be performed. DoD has determined the firmware is not appropriate to define at the Enterprise level.	Impractical

		checks will be performed.	Recommended Compelling Evidence: 1.) Signed and dated System security plan defines the firmware which will be subjected to integrity verification tools to check for unauthorized changes. 2.) Implementation documentation of integrity verification tools that will check the firmware for unauthorized changes.	
CCI-002707	SI-7(1)	MODERATE The organization defines the information on which integrity checks will be performed.	The organization being inspected/assessed defines and documents the information on which integrity checks will be performed. DoD has determined the information is not appropriate to define at the Enterprise level. Recommended Compelling Evidence: 1.) Signed and dated System security plan defines the information on which integrity checks will be performed. 2.) Implementation documentation of integrity verification tools that will subjected to integrity verification tools to check for unauthorized changes.	Impractical
CCI-002710	SI-7(1)	MODERATE The information system performs an integrity check of organization-defined software at startup, at organization- defined transitional states or security- relevant events, or on organization- defined frequency.	The organization being inspected/assessed configures the information system to perform an integrity check of software defined in SI-7 (1), CCI 2705 at startup, at transitional states or security- relevant events defined in SI-7 (1), CCI 2708, or annually. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 2710. DoD has defined the frequency as annually. Recommended Compelling Evidence: 1.) Signed and dated System security plan lists the organization-defined frequency at which integrity verification is performed on software. 2.) Trail of records (containing valid date/time stamps) to confirm frequency of integrity validation.	Impractical
CCI-002711	SI-7(1)	MODERATE The information system performs an integrity check of organization-defined firmware at startup, at organization-defined transitional	The organization being inspected/assessed configures the information system to perform an integrity check of firmware defined in SI-7 (1), CCI 2706 at startup, at transitional states or security- relevant events defined in SI-7 (1), CCI 2708, or annually. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 2711.	Impractical
		states or security-relevant events, or on organization-defined frequency.	DoD has defined the frequency as annually. Recommended Compelling Evidence: 1.) Signed and dated System security plan lists the organization-defined frequency at which integrity verification is performed on software. 2.) Trail of records (containing valid date/time stamps) to confirm frequency of integrity validation.	
CCI-002712	SI-7(1)	MODERATE The information system performs an integrity check of organization-defined information at startup, at organization-defined transitional states or security-relevant events, or on organization-defined frequency.	The organization being inspected/assessed configures the information system to perform an integrity check of information defined in SI-7 (1), CCI 2707 at startup, at transitional states or security-relevant events defined in SI-7 (1), CCI 2708, or annually. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 2712. DoD has defined the frequency as annually. Recommended Compelling Evidence: 1.) Signed and dated System security plan lists the organization-defined frequency at which integrity verification is performed on software. 2.) Trail of records (containing valid date/time stamps) to confirm frequency of integrity validation.	Impractical

CCI-001310	SI-10	MODERATE The information system checks the validity of organization-defined inputs.	The organization being inspected/assessed configures the information system to check the validity of all inputs except those identified specifically by the organization. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1310. DoD has defined the information inputs as all inputs except those identified specifically by the organization. Recommended Compelling Evidence: 1.) Signed and dated System security plan documents how validity of organization-defined inputs or check. 2.) Integrity logs.	Applicable
CCI-002744	SI-10	MODERATE The organization defines the inputs the information system	The organization being inspected/assessed defines and documents specific inputs which do not require validity checks. DoD has defined the information inputs as all inputs except those identified specifically by the organization.	N/A
		is to conduct validity checks.	Recommended Compelling Evidence: 1.) Signed and dated System security plan defines the organization inputs.	
CCI-001312	SI-11(a)	MODERATE The information system generates error messages that provide information necessary for corrective actions without revealing information that could be exploited by adversaries.	The organization being inspected/assessed configures the information system to generate error messages that provide information necessary for corrective actions without revealing information that could be exploited by adversaries. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to CCI 1312. Recommended Compelling Evidence: 1.) Signed and dated System security plan documents that how error messages will be formulated to provide data for corrective action without revealing sensitive information. 2.) Protection software configuration documentation that states useable information is in error messages without providing sensitive information.	Impractical
CCI-002773	SI-17	The organization defines the fail-safe procedures to be implemented by the information system when organization-defined failure conditions occur.	See **CCI-002857** for procedures relating to fire, water and power loss. In many cases standard control system design of sequences and alarm requirements address these CCIs without any additional design requirements Communication failure: BPOC's and other field devices should continue to operate/control components in the event of communications loss with the front end. Component failure: Front end server failure should not affect local operation of field devices (BPOCs, etc…) In the event of field device failure, the downline components should continue to operate according to default values.	N/A
CCI-002774	SI-17	The organization defines the failure conditions which, when they occur, will result in the information system implementing organization-defined fail-safe procedures.	See **CCI-002856**. Other failure conditions likely to be experienced by control system components are **component failure** and **communications failure to components.** See **CCI-002775** for implementation of fail-safe procedures.	Impractical
CCI-002775	SI-17	The information system implements organization-defined fail-safe procedures when organization- defined failure conditions occur.	Configure the information system to implement fail-safe procedures defined in **SI-17**, **CCI 002773** when failure conditions defined in **SI-17**, **CCI 002774** occur. For information system components that have applicable STIGs or SRGs, the organization being inspected/assessed must comply with the STIG/SRG guidance that pertains to **CCI 002775**.	Impractical

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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 D709	(2017) Standard Specification for Laminated Thermosetting Materials

ELECTRONIC INDUSTRIES ALLIANCE (EIA)

EIA 480	(1981) Toggle Switches

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL CODE COUNCIL (ICC)

ICC/ANSI A117.1	(2009) Accessible and Usable Buildings and Facilities

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2017; Errata 2017) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C80.1	(2005) American National Standard for Electrical Rigid Steel Conduit (ERSC)
ANSI C80.3	(2015) American National Standard for Electrical Metallic Tubing (EMT)
ANSI Z535.1	(2017) Safety Colors
ANSI/NEMA OS 1	(2013) Sheet-Steel Outlet Boxes, Device

	Boxes, Covers, and Box Supports
NEMA 250	(2018) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA AB 3	(2013) Molded Case Circuit Breakers and Their Application
NEMA FB 1	(2014) Standard for Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable
NEMA FU 1	(2012) Low Voltage Cartridge Fuses
NEMA ICS 1	(2000; R 2015) Standard for Industrial Control and Systems: General Requirements
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 PB 1	(2011) Panelboards
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	(2013) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 3	(2016) Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing
NEMA VE 1	(2017) Metal Cable Tray Systems
NEMA WD 1	(1999; R 2015) Standard for General Color Requirements for Wiring Devices
NEMA WD 6	(2016) Wiring Devices Dimensions Specifications

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2017; ERTA 1-2 2017; TIA 17-1; TIA 17-2; TIA 17-3; TIA 17-4; TIA 17-5; TIA 17-6; TIA 17-7; TIA 17-8; TIA 17-9; TIA 17-10; TIA 17-11; TIA 17-12; TIA 17-13; TIA 17-14; TIA 17-15; TIA 17-16; TIA 17-17) National Electrical Code
NFPA 70E	(2018; TIA 18-1; TIA 81-2) Standard for Electrical Safety in the Workplace

UNDERWRITERS LABORATORIES (UL)

UL 1	(2005; Reprint Aug 2017) UL Standard for Safety Flexible Metal Conduit
UL 5	(2016) UL Standard for Safety Surface Metal Raceways and Fittings
UL 5A	(2015) Nonmetallic Surface Raceways and Fittings
UL 6	(2007; Reprint Sep 2019) UL Standard for Safety Electrical Rigid Metal Conduit-Steel
UL 20	(2010; Reprint Feb 2012) General-Use Snap Switches
UL 44	(2018) UL Standard for Safety Thermoset-Insulated Wires and Cables
UL 50	(2015) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations
UL 67	(2018; Reprint Mar 2019) UL Standard for Safety Panelboards
UL 83	(2017) UL Standard for Safety Thermoplastic-Insulated Wires and Cables
UL 198M	(2018) UL Standard for Mine-Duty Fuses
UL 360	(2013; Reprint Nov 2018) UL Standard for Safety Liquid-Tight Flexible Metal Conduit
UL 486A-486B	(2018) UL Standard for Safety Wire Connectors
UL 486C	(2018) UL Standard for Safety Splicing Wire Connectors
UL 489	(2016) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 498	(2017; Reprint Dec 2018) UL Standard for Safety Attachment Plugs and Receptacles
UL 506	(2017) UL Standard for Safety Specialty Transformers
UL 514A	(2013; Reprint Aug 2017) UL Standard for Safety Metallic Outlet Boxes
UL 514B	(2012; Reprint Nov 2014) Conduit, Tubing and Cable Fittings
UL 514C	(2014; Reprint Nov 2018) UL Standard for Safety Nonmetallic Outlet Boxes,

	Flush-Device Boxes, and Covers
UL 651	(2011; Reprint Nov 2018) UL Standard for Safety Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings
UL 797	(2007; Reprint Mar 2017) UL Standard for Safety Electrical Metallic Tubing -- Steel
UL 817	(2015; Reprint May 2017) UL Standard for Safety Cord Sets and Power-Supply Cords
UL 869A	(2006) Reference Standard for Service Equipment
UL 870	(2016; Reprint Mar 2019) UL Standard for Safety Wireways, Auxiliary Gutters, and Associated Fittings
UL 943	(2016; Reprint Feb 2018) UL Standard for Safety Ground-Fault Circuit-Interrupters
UL 1242	(2006; Reprint Mar 2014) Standard for Electrical Intermediate Metal Conduit -- Steel
UL 1449	(2014; Reprint Jul 2017) UL Standard for Safety Surge Protective Devices
UL 1561	(2011; Reprint Jun 2015) Dry-Type General Purpose and Power Transformers
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

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. The technical sections referred to herein are those specification sections that describe products, installation procedures, and equipment operations and that refer to this section for detailed description of submittal types.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Marking Strips; G

SD-03 Product Data

Conduits and Raceways; G

Wire and Cable; G

Splices and Connectors; G

Switches; G

Receptacles; G

Outlet Boxes, Pull Boxes and Junction Boxes; G

Circuit Breakers; G

Panelboards; G

Dry-Type Distribution Transformers; G

Device Plates; G

SD-06 Test Reports

Continuity Test; G

Phase-Rotation Tests; G

Insulation Resistance Test; G

600-Volt Wiring Test; G

Transformer Tests; G

Ground-Fault Receptacle Test; G

Insulation-Resistance Test; G

SD-08 Manufacturer's Instructions

Manufacturer's Instructions

1.4 QUALITY CONTROL

1.4.1 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. Ensure equipment, materials, installation, and workmanship are in accordance with the mandatory and advisory provisions of NFPA 70, IEEE C2 unless more stringent requirements are specified or indicated.

1.4.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Provide products which have been in satisfactory commercial or industrial use for 2 years prior to bid opening. Ensure the 2-year period includes applications of equipment and materials under similar circumstances and of similar size. Ensure the product has been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer.

PART 2 PRODUCTS

2.1 EQUIPMENT

Provide the standard cataloged materials and equipment of manufacturers regularly engaged in the manufacture of the products. For material, equipment, and fixture lists submittals, show manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site.

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

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

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

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

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

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

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

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

2.1.1 Conduits and Raceways

2.1.1.1 Rigid Steel Conduit

Provide hot dipped galvanized rigid steel conduit complying with NEMA RN 1, ANSI C80.1, UL 6 and UL 5 as applicable. Except where installed underground, or in corrosive areas, provide polyvinylchloride (PVC), or protect from corrosion by painting with bitumastic coating or wrapping with corrosion inhibiting tape..

Use threaded fittings for rigid steel conduit.

Use solid gaskets. Ensure conduit fittings with blank covers have gaskets, except in clean, dry areas or at the lowest point of a conduit run where drainage is required.

Provide covers with captive screws and are accessible after the work has been completed.

2.1.1.2 Electrical Metallic Tubing (EMT)

Ensure EMT is in accordance with UL 797, UL 5, and ANSI C80.3 and is zinc coated steel. Provide zinc-coated couplings and connectors that are raintight, compression type with insulated throat. Crimp, spring, or setscrew type fittings are not acceptable.

2.1.1.3 Flexible Metallic Conduit

Ensure flexible metallic conduit is galvanized steel and complies with UL 1 and UL 360.

Ensure fittings for flexible metallic conduit are specifically designed for such conduit.

Provide liquidtight flexible metallic conduit with a protective jacket of PVC extruded over a flexible interlocked galvanized steel core to protect wiring against moisture, oil, chemicals, and corrosive fumes.

Ensure fittings for liquidtight flexible metallic conduit are specifically designed for such conduit.

2.1.1.4 Intermediate Metal Conduit

Ensure intermediate metal conduit is galvanized steel and complies with UL 1242, NEMA RN 1, ANSI C80.1, UL 6 and UL 5 as applicable.

2.1.1.5 Rigid Nonmetallic Conduit

Ensure rigid nonmetallic conduit complies with NEMA TC 2, NEMA TC 3, and UL 651 as applicable with a wall thickness not less than Schedule 40.

2.1.1.6 Surface Nonmetallic Raceway

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

2.1.2 Wireways

Ensure wireways and auxiliary gutters are a minimum 4 by 4-inch trade size conforming to UL 870.

UL 870. Material: steel epoxy painted 16 gauge for heights and depths up to 6 by 6 inches, and 14 gauge for heights and depths up to 12 by 12 inches. Provide in length required for the application with hinged-cover NEMA 1, 3R, or 12 enclosure per NEMA ICS 6 required for the application.

2.1.3 Cable Trays

NEMA VE 1. Provide the following:

a. Cable trays: form a wireway system, with a nominal depth as indicated.

b. Cable trays: constructed of aluminum or 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 inches as indicated.

Provide basket-type cable trays size as indicated with maximum wire mesh spacing of 2 by 4 inch.

Provide cable runway size as indicated with maximum rung spacing of 9 inches.

2.1.4 Outlet Boxes, Pull Boxes and Junction Boxes

Ensure outlet boxes for use with conduit systems are in accordance with NEMA FB 1 UL 514A, UL 514B, UL 514C and ANSI/NEMA OS 1 and are not less than 1-1/2 inches deep. Furnish all pull and junction boxes with screw-fastened covers.

2.1.5 Panelboards

Provide panelboards in accordance with NEMA PB 1, UL 67, and UL 50. Ensure panelboards for use as service equipment are also in accordance with UL 869A. Ensure panelboards have current rating, number of phases, and number of wires as indicated or specified herein. Ensure panelboards are rated for 120/208-volt, three-phase and 277/480-volt, three-phase, 60-hertz. Ensure each panelboard, as a complete unit, has a short-circuit current rating equal to or greater than the integrated equipment rating indicated, but in no case less than 10,000 amperes symmetrical.

Provide panelboards with bolt-on circuit breakers only. Use of plug-in style breaker is not permitted. Ensure panelboards are designed such that individual breakers can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as means of obtaining required clearance. Provide main lugs or main circuit breakers mounted "above" or "below" branch breakers with current ratings as indicated. Use of sub-feed breakers is not acceptable unless specifically indicated otherwise. Where "space only" is indicated, make provisions for future installation of breakers.

Submit detail drawings and manufacturer's standard product data for panelboards. Detail drawings consist of fabrication and assembly drawings for all parts of the work in sufficient detail to verify conformity with all requirements. Ensure drawings for panelboards indicate details of bus layout, overall physical features, dimensions, ratings, service

requirements, and weights of equipment.

Provide copper buses of the rating indicated, with main lugs or main circuit breaker. Provide all panelboards for use on grounded ac systems with a separate grounding bus in accordance with UL 67 bonded to the panelboard enclosure. Ensure grounding bus is a solid bus bar of rectangular cross section equipped with binding screws for the connection of equipment grounding conductors. Provide three-phase, four-wire and single-phase, three-wire panelboards with an isolated full-capacity bus providing spaces for single-pole circuit breaker switches and spaces indicated as spare.

Provide bus bar connections to the branch circuit breakers that are the "distributed phase" or "phase sequence" type. Ensure single-phase, three-wire panelboard busing is such that when any two adjacent single-pole breakers are connected to opposite phases, two-pole breakers can be installed in any location. Ensure that three-phase, four-wire panelboard busing is such that when any three adjacent single-pole breakers are individually connected to each of the three different phases, two- or three-pole breakers can be installed at any location. Ensure current-carrying parts of the bus assembly are plated.

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.

2.1.5.1 Circuit Breakers

Provide circuit breakers that conform to UL 489 and NEMA AB 3 with frame a trip ratings as indicated.

Provide bolt-on type, molded-case, manually operated, trip-free circuit breakers, with inverse-time thermal-overload protection and instantaneous magnetic short-circuit protection. Completely enclose circuit breakers in a molded case, with a factory-sealed, calibrated sensing element to prevent tampering. Plug-in type, tandem, and half-size circuit breakers are not permitted.

Provide inverse-time-delay thermal-overload protection and instantaneous magnetic short-circuit protection. Provide an instantaneous thermal-magnetic tripping element that is adjustable and accessible from the front of the breaker on frame sizes larger than 250 ampere.

Provide sufficient interrupting capacity of the panel and lighting branch circuit breakers to successfully interrupt the maximum short-circuit current imposed on the circuit at the breaker terminals. Provide circuit breaker interrupting capacities with a minimum of 10,000 A and that conform to NEMA AB 3. Series rating of circuit breakers or overcurrent protective devices to achieve indicated interrupt rating is not permitted.

Provide the common-trip-type multipole circuit breakers having a single operating handle and a two-position on/off indication. Provide circuit breakers with temperature compensation for operation in an ambient temperature of 104 degrees F. Provide circuit breakers that have root mean square (rms) symmetrical interrupting ratings sufficient to protect the circuit being supplied. Interrupting ratings may have selective-type tripping (time delay, magnetic, thermal, or ground fault).

Provide a phenolic-composition breaker body capable of having such

accessories as handle-extension, handle-locking, and padlocking devices attached where required to meet lock-out/tag-out requirements of NFPA 70E.

2.1.6 Dry-Type Distribution Transformers

2.1.6.1 General Requirements

Ensure that general purpose dry-type transformers with windings 600 volts or less are two-winding, 60 hertz, and self-cooled in accordance with UL 506 and UL 1561. Ensure windings have a minimum of two 2-1/2-percent taps above and below nominal voltage.

Provide transformers in NEMA 1 enclosure.

Transformer insulation system:

a. 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.

b. 180 degrees C insulation for transformers rated 10 kVA and less, with temperature rise not exceeding 115 degrees C under full-rated load in maximum ambient of 40 degrees C.

2.1.6.2 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.

2.2 MATERIALS

2.2.1 Wire And Cable

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.

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.

Ensure connectors used in wire systems comply with UL 486A-486B and UL 486C as applicable.

Ensure conductors installed in plenums are marked plenum rated.

2.2.1.1 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 lighting fixtures require 90-degree Centigrade (C) conductors, provide only conductors with 90-degree C insulation or better.

2.2.1.2 Cable Tray Cable or Power Limited Tray Cable

UL listed; type TC or PLTC.

2.2.1.3 Cord Sets and Power-Supply Cords

UL 817.

2.2.2 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 or brushed-finish aluminum, 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 be permitted.

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

2.2.3 Switches

2.2.3.1 Safety Switches

Ensure safety switches comply with NEMA KS 1, and are the heavy-duty type with enclosure, voltage, current rating, number of poles, and fusing as indicated on the drawings. Ensure fused switch fuse holders comply with UL 4248-1. Ensure switch construction is such that, when the switch handle in the "ON" position, the cover or door cannot be opened. Cover release device is coinproof and so constructed that an external tool is used to open the cover. Make provisions to lock the handle in the "OFF" position. Ensure the switch is not capable of being locked in the "ON" position.

Provide switches of the quick-make, quick-break type and terminal lugs for use with copper conductors.

Ensure safety color coding for identification of safety switches conforms to ANSI Z535.1.

2.2.3.2 Toggle Switches

Ensure toggle switches comply with EIA 480, NEMA WD 1, and UL 20 control Light Emitting Diode (LED) lighting fixtures and are the heavy duty, general purpose, noninterchangeable flush-type.

Provide commercial grade toggle switches, single, double-pole, three-way and four-way two-position devices rated 20 amperes at 120/277 volts, 60 hertz alternating current (ac) only.

Ensure all toggle switches are products of the same manufacturer.

2.2.4 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.

2.2.4.1 Fuseholders

Provide in accordance with UL 4248-1.

2.2.4.2 Cartridge, Current Limiting Type (Class R)

UL 198M, Class RK-1 and RK-5 time-delay type as required. Provide only Class R associated fuseholders in accordance with UL 4248-12.

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

UL 198M, Class J for zero to 600 amperes, Class L for 601 to 6,000 amperes, and Class CC for zero to 30 amperes.

2.2.4.4 Cartridge Fuses, Current Limiting Type (Class T)

UL 198M, Class T for zero to 1,200 amperes, 300 volts; and zero to 800 amperes, 600 volts.

2.2.5 Receptacles

Provide the following:

a. UL 498, hard use (also designated heavy-duty), grounding-type.

b. Ratings and configurations: as indicated.

c. Bodies: white 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.

2.2.5.1 Switched Duplex Receptacles

Provide separate terminals for each ungrounded pole. Top receptacle: switched when installed.

2.2.5.2 Weatherproof Receptacles

Provide receptacles, UL listed for use in "wet locations." Include cast metal box with gasketed, hinged, lockable and weatherproof while-in-use, polycarbonate, UV resistant/stabilized cover plate.

2.2.5.3 Ground-Fault Circuit Interrupter Receptacles

UL 943, duplex type for mounting in standard outlet box. Provide device capable of detecting current leak of 6 milliamperes or greater 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.

2.2.5.4 Special Purpose Receptacles

Receptacles serving special equipment indicated on plans are special purpose. Provide in ratings indicated.

2.2.5.5 Plugs

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

2.2.5.6 Tamper-Resistant Receptacles

Provide duplex receptacle with mechanical sliding shutters that prevent the insertion of small objects into its contact slots.

2.2.6 Manufacturer's Nameplate

Ensure each item of equipment has 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 is not acceptable.

2.2.7 Firestopping Materials

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

2.2.8 Metering

ANSI C12.1.

2.2.9 Surge Protective Devices

Provide parallel type surge protective devices (SPD) which comply with UL 1449 at the service entrance and panelboards. Provide surge protectors in a NEMA 1 enclosure per NEMA ICS 6. Use Type 1 or Type 2 SPD and connect on the load side of a dedicated circuit breaker.

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

600V 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
1,200V for 480Y/277V, three phase system

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

PART 3 EXECUTION

3.1 PREPARATION

Submit manufacturer's instructions including special provisions required to install equipment components and system packages. Special provisions include impedances, hazards and safety precautions.

Clean and paint conduit, supports, fittings, cabinets, pull boxes, and racks as specified in Section 09 90 00 PAINTS AND COATINGS.

Protect metallic materials against corrosion. Provide equipment enclosures with the standard finish by the manufacturer when used for most indoor installations. For harsh indoor environments (any area subjected to chemical and abrasive action), and all outdoor installations, refer to Section 09 90 00 PAINTS AND COATINGS. Do not use aluminum when in contact with earth or concrete and, where connected to dissimilar metal, protect by using approved fittings and treatment. Except where other equivalent protective treatment is specifically approved in writing, provide hot-dip galvanized ferrous metals for items such as, anchors, bolts, braces, boxes, bodies, clamps, fittings, guards, nuts, pins, rods, shims, thimbles, washers, and miscellaneous items not made of corrosion-resistant steel.

3.2 INSTALLATION

3.2.1 Underground Service

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

3.2.2 Hazardous Locations

Perform work in hazardous locations, as defined by NFPA 70, in strict accordance with NFPA 70 for particular "Class," "Division," and "Group" of hazardous locations involved. Provide conduit and cable seals where required by NFPA 70. Provide conduit with tapered threads.

3.2.3 Service Entrance Identification

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

3.2.4 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.

3.2.5 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. Shared neutral, or multi-wire branch circuits, are not permitted with arc-fault circuit interrupters. Minimum conduit size: 1/2 inch in diameter for low voltage lighting and power circuits. Vertical distribution in multiple story buildings: made with metal conduit in fire-rated shafts, with metal conduit extending through shafts for minimum distance of 6 inches. Firestop conduit which penetrates fire-rated walls, fire-rated partitions, or fire-rated floors in accordance with Section 07 84 00, FIRESTOPPING.

3.2.5.1 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.

3.2.6 Conduits, Raceways and Fittings

Ensure that conduit runs between outlet and outlet, between fitting and fitting, or between outlet and fitting does not contain more than the

equivalent of three 90-degree bends, including those bends located immediately at the outlet or fitting.

Do not install crushed or deformed conduit. Avoid trapped conduit runs where possible. Take care to prevent the lodgment of foreign material in the conduit, boxes, fittings, and equipment during the course of construction. Clear any clogged conduit of obstructions or replace conduit.

Conduit and raceway runs concealed in or behind walls, above ceilings, or exposed on walls and ceilings 5 feet or more above finished floors and not subject to mechanical damage may be electrical metallic tubing (EMT).

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.

3.2.6.1 Rigid Steel Conduit

Make field-made bends and offsets with approved Hickey bending tool or conduit bending machine. Use long radius conduit for elbows larger than 2-1/2 inches.

Provide a flush coupling for all conduit stubbed-up through concrete floors for connections to free-standing equipment with the exception of motor-control centers, cubicles, and other such items of equipment, when the floor slab is of sufficient thickness. Otherwise, provide a floor box set flush with the finished floor. For conduits installed for future use, terminate with a coupling and plug; set flush with the floor.

3.2.6.2 Electrical Metallic Tubing (EMT)

Ground EMT in accordance with NFPA 70, using pressure grounding connectors especially designed for EMT.

3.2.6.3 Flexible Metallic Conduit

Use flexible metallic conduit to connect recessed fixtures from outlet boxes in ceilings, transformers, and other approved assemblies.

Use bonding wires in flexible conduit as specified in NFPA 70, for all circuits. Flexible conduit is not considered a ground conductor.

Make electrical connections to vibration-isolated equipment with flexible metallic conduit.

Use liquidtight flexible metallic conduit in wet and oily locations and to complete the connection to motor-driven equipment.

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 liquidtight flexible nonmetallic conduit in wet and damp locations for equipment subject to vibration, noise transmission, movement or motors. Provide separate ground conductor across flexible

connections.

3.2.6.4 Intermediate Conduit

Make all field-made bends and offsets with approved Hickey bending tool or conduit bending machine. Use intermediate metal conduit only for indoor installations.

3.2.6.5 Rigid Nonmetallic Conduit

Install a green insulated copper grounding conductor in conduit with conductors and solidly connect to ground at each end. Size grounding wires in accordance with NFPA 70.

3.2.6.6 Underground Conduit

Plastic-coated rigid steel; plastic-coated steel IMC; PVC, Type EPC-40 Plastic coating: extend minimum 6 inches above floor.

3.2.6.7 Conduit for Circuits Rated Greater Than 600 Volts

Rigid metal conduit or IMC only.

3.2.6.8 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.

3.2.6.9 Conduit Installed Through Floor Slabs

Where conduits rise through floor slabs, do not allow curved portion of bends to be visible above finished slab.

3.2.6.10 Conduit Installed in Concrete Floor Slabs

Rigid steel; steel IMC; or PVC, Type EPC-40. Locate so as not to adversely affect structural strength of slabs. Install conduit within middle one-third of concrete slab. Do not stack conduits. Space conduits horizontally not closer than three diameters, except at cabinet locations. Curved portions of bends must not be visible above finish slab. Increase slab thickness as necessary to provide minimum one inch cover over conduit. Where embedded conduits cross building and/or expansion joints, provide suitable watertight expansion/deflection fittings and bonding jumpers. Expansion/deflection fittings must allow horizontal and vertical movement of raceway. Conduit larger than one inch trade size: installed parallel with or at right angles to main reinforcement; when at right angles to reinforcement, install conduit close to one of supports of slab.

3.2.6.11 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.

3.2.6.12 Conduit Support

Support conduit by pipe straps, wall brackets, threaded rod conduit hangers, or ceiling trapeze. 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. Support exposed risers in wire shafts of multistory buildings by U-clamp hangers at each floor level and at 10 foot maximum intervals. Where conduit crosses building expansion joints, provide suitable expansion fitting that maintains conduit electrical continuity by bonding jumpers or other means. For conduits greater than 2 1/2 inches inside diameter, provide supports to resist forces of 0.5 times the equipment weight in any direction and 1.5 times the equipment weight in the downward direction.

3.2.6.13 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.

3.2.6.14 Wireway and Auxiliary Gutter

Bolt together straight sections and fittings to provide a rigid, mechanical connection and electrical continuity. Close dead ends of wireways and auxiliary gutters. Plug all unused conduit openings.

Support wireways for overhead distribution and control circuits at maximum 5-foot intervals.

Ensure auxiliary gutters used to supplement wiring spaces for equipment not contained in a single enclosure contains no switches, overcurrent devices, appliances, or apparatus and is not more than 30 feet long.

3.2.6.15 Surface Raceways and Assemblies

Mount surface raceways plumb and level, with the base and cover secured. Minimum circuit run is three-wire, with one wire designated as ground.

3.2.6.16 Cable Trays

Support cable trays from ceiling hangers, equipment bays, or floor or wall supports. Cable trays may be mounted on equipment racks. Provide support when the free end extends beyond 3 feet. Maximum support spacing is 6 feet. Support trays 10-inches wide or less by one hanger. Support trays greater than 10 inches wide by two hangers. Bond cable trays at splices.

3.2.7 Wiring

Color code feeder and branch circuit conductors as follows:

CONDUCTOR	COLOR AC
Phase A	Black (208VAC); Brown (480VAC)
Phase B	Red (208VAC); Orange (480VAC)
Phase C	Blue (208VAC); Yellow (480VAC)
Neutral	White (208VAC); Natural Gray (480VAC)
Equipment Grounds	Green

Use conductors up to and including AWG No. 2 that are manufactured with colored insulating materials. For conductors larger than AWG No. 2, have ends identified with color plastic tape in outlet, pull, or junction boxes.

Splice in accordance with the NFPA 70. Provide conductor identification within each enclosure where a tap, splice, or termination is made and at the equipment terminal of each conductor. Match terminal and conductor identification as indicated.

Where several feeders pass through a common pullbox, tag the feeders to clearly indicate the electrical characteristics, circuit number, and panel designation.

3.2.8 Wiring Devices

3.2.8.1 Wall Switches and Receptacles

Install wall switches and receptacles so that when device plates are applied, the plates are aligned vertically to within 1/16 inch.

Bond ground terminal of each flush-mounted receptacle to the outlet box with an approved green bonding jumper when used with dry wall type construction.

3.2.8.2 Device Plates

Ensure device plates for switches are suitably engraved with a description of the loads when not within sight of the loads controlled.

Mark device plates and receptacle cover plates for receptacles other than 125-volt, single-phase, duplex, convenience outlets. Show the circuit number, voltage, frequency, phasing, and amperage available at the receptacle. Use self-adhesive labels having 1/4 inch embossed letters.

Similarly mark device plates for convenience outlets indicating the supply panel and circuit number.

3.2.9 Splices and Connectors

Make all splices in AWG No. 8 and smaller with approved insulated electrical type .

Make all splices in AWG No. 6 and larger with insulated electrical lugs type. Wrap joints with an insulating tape that has an insulation and temperature rating equivalent to that of the conductor.

3.2.10 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. Provide telecommunications system conductor identification as specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEMS.

3.2.10.1 Marking Strips

Provide marking strips 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.

3.2.11 Safety Switches

Securely fasten switches to the supporting structure or wall, utilizing a minimum of four 1/4 inch bolts. Do not use sheet metal screws and small machine screws for mounting. Do not mount switches in an inaccessible location or where the passageway to the switch may become obstructed. Mounting height 5 feet above floor level, when possible.

3.2.12 Boxes and Fittings

Provide pullboxes where necessary in the conduit system to facilitate conductor installation. For conduit runs longer than 100 feet or with more than three right-angle bends, install a pullbox at a convenient intermediate location.

Securely mount boxes and enclosures to the building structure using supports that are independent of the conduit entering or leaving the boxes.

Select the mounting height of wall-mounted outlet and switch boxes, as measured between the bottom of the box and the finished floor, in accordance with ICC/ANSI A117.1 and as follows, unless otherwise indicated:

LOCATION	MOUNTING HEIGHT (inches)
Receptacles in offices	18
Receptacles in corridors	18
Receptacles in shops and laboratories	48
Receptacles in rest rooms	48
Switches for light control	48

3.2.13 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.

3.2.14 Electrical Penetrations

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

3.2.15 Panelboards

Securely mount panelboards so that the top operating handle does not exceed 72-inches above the finished floor. Do not mount equipment within 36-inches of the front of the panel. Ensure directory card information is complete and legible.

3.2.16 Dry-Type Distribution Transformers

Connect dry-type transformers with flexible metallic conduit.

3.2.17 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.

3.2.18 Field Fabricated Nameplates

Ensure nameplates conform to 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 identifies the function and, when applicable, the position. Provide nameplates that are melamine plastic, 0.125-inch thick, white with black center core and a matte finish surface. Accurately align lettering and engrave into the core. Minimum size of nameplates is 1 by 2.5 inches. Lettering is a minimum of 0.25-inch high normal block style.

3.2.19 Identification Plates and Warnings

Provide identification plates for lighting and power panelboards, motor control centers, all line voltage heating and ventilating control panels, fire detector and sprinkler alarms, door bells, pilot lights, disconnect switches, manual starting switches, and magnetic starters. Attach identification plates to process control devices and pilot lights.

Install identification plates for all line voltage enclosed circuit breakers, identifying the equipment served, voltage, phase(s) and power source. For circuits 480 volts and above, install conspicuously located warning signs in accordance with OSHA requirements.

3.3 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.4 WARNING SIGN MOUNTING

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

3.5 FIELD APPLIED MOUNTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting: as specified in Section 09 90 00 PAINTS AND COATINGS.

3.6 FIELD QUALITY CONTROL

After completion of the installation and splicing, and prior to energizing the conductors, perform wire and cable continuity and insulation tests as herein specified before the conductors are energized.

Provide all necessary test equipment, labor, and personnel to perform the tests, as herein specified.

Isolate completely all wire and cable from all extraneous electrical connections at cable terminations and joints. Use substation and switchboard feeder breakers, disconnects in combination motor starters, circuit breakers in panel boards, and other disconnecting devices to isolate the circuits under test.

Perform insulation-resistance test on each field-installed conductor with respect to ground and adjacent conductors. Applied potential is 500 volts dc for 300 volt rated cable and 1000 volts dc for 600 volt rated cable. Take readings after 1 minute and until the reading is constant for 15 seconds. Minimum insulation-resistance values is not less than 25 Megohms for 300 volt rated cable and 100 Megohms for 600 volt rated cable. For circuits with conductor sizes AWG No. 8 and smaller insulation resistance testing is not required.

Perform continuity test to insure correct cable connection end-to-end (i.e correct phase conductor, grounded conductor, and grounding conductor wiring). Repair and verify any damages to existing or new electrical equipment resulting from mis-wiring. Receive approval for all repairs prior to commencement of the repair.

Conduct phase-rotation tests on all three-phase circuits using a phase-rotation indicating instrument. Perform phase rotation of electrical connections to connected equipment in a clockwise direction, facing the source.

Perform 600-volt wiring test on 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 approximately 500 volts to provide direct reading of resistance. Minimum resistance: 250,000 ohms.

Perform the standard, not optional, transformer 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.

Perform ground-fault receptacle test for ground-fault receptacles with a "load" (such as a plug in light) to verify that the "line" and "load" leads are not reversed.

Submit test reports in accordance with referenced standards in this section.

Final acceptance requires the successful performance of wire and cable under test. Do not energize any conductor until the final test reports are reviewed and approved.

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LIGHTING CONTROL DEVICES
08/19

PART 1 GENERAL

1.1 REFERENCES

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

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 1	(2000; R 2015) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2	(2000; R 2005; Errata 2008) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2017; ERTA 1-2 2017; TIA 17-1; TIA 17-2; TIA 17-3; TIA 17-4; TIA 17-5; TIA 17-6; TIA 17-7; TIA 17-8; TIA 17-9; TIA 17-10; TIA 17-11; TIA 17-12; TIA 17-13; TIA 17-14; TIA 17-15; TIA 17-16; TIA 17-17) National Electrical Code

U.S. FEDERAL COMMUNICATIONS COMMISSION (FCC)

FCC Part 15	Radio Frequency Devices (47 CFR 15)

UNDERWRITERS LABORATORIES (UL)

UL 98	(2016) UL Standard for Safety Enclosed and Dead-Front Switches
UL 773	(2016; Reprint Nov 2017) UL Standard for Safety Plug-In, Locking Type Photocontrols for Use with Area Lighting
UL 773A	(2016; Reprint May 2018) UL Standard for Safety Nonindustrial Photoelectric

1.2 DEFINITIONS

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

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Lighting System Drawings; G

SD-03 Product Data

Installation Instructions; G

Dimming Controls; G

Light Level Sensor; G

Lighting Contactor; G

Time Switch; G

Photocell Switch; G

Occupancy Sensors; G

SD-06 Test Reports

System Operation Tests

SD-10 Operation and Maintenance Data

Lighting Control System, Data Package 5

1.4 QUALITY CONTROL

1.4.1 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. Ensure equipment, materials, installation, and workmanship are in accordance with the mandatory and advisory provisions of NFPA 70, IEEE C2 unless more stringent requirements are specified or indicated.

1.4.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Provide products which have been in satisfactory commercial or industrial use for 2 years prior to bid opening. Ensure the 2-year period includes applications of equipment and materials under similar circumstances and of similar size. Ensure the product has been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Submit lighting system drawings showing luminaire configuration, control zones, and detection range of specified control devices. Ensure lighting system drawings include photometric calculations showing lighting levels in foot candles for all areas indicated. Ensure lighting calculations and photometric plans are created using industry standard light modeling software. Hand calculations will not be accepted.

a. Provide lighting control system of the non-centralized and non-addressable type that does not include any programmable devices. Control devices are of the line-voltage or low-voltage types and are used to create specific hard-wired control zones to turn lights on and off or to provide light dimming capabilities.

b. Lighting control system must comply with these specifications, all applicable construction document drawings, all applicable codes, and all local authorities having jurisdiction. Lighting control system equipment includes, but is not limited to, time control switches, manual and safety switches, L.E.D. dimmable drivers, light level sensors, incandescent dimmer switches, lighting contactors, photocell switches, and occupancy sensors.

2.1.1 System Requirements

The lighting control system and lighting end devices must revert to the on position in the event of a loss of power or control signal to the system or end devices.

2.2 COMPONENTS

2.2.1 Manual Switches

Provide a switch mechanism consisting of a heavy-duty general-purpose precision snap-acting switch, single-pole, single-throw, suitable for operation on a 277 volt, 60 Hz, single-phase system. Provide with a selector switch having a minimum of three positions: ON, OFF, and AUTOMATIC. Use the automatic position when photoelectric or timer control is desired. Interface the selector switch with the lighting system magnetic contactor to control system activity.

Ensure switches conform to UL 98 as applicable. Provide a quick-make, quick-break type switch such that a screwdriver is required to open the switch door when the switch is on, with blades visible when the door is

open. Coordinate terminal lugs with the wire size.

2.2.2 Dimming Controls

Provide a single slide dimmer switch with on-off control, compatible with the L.E.D. dimmable driver. Control the L.E.D. driver light output over the full dimming range. Provide a L.E.D. dimmable driver control which is approved by the ballast manufacturer.

2.2.3 Light Level Sensor

Provide UL listed light level sensor capable of detecting changes in ambient lighting levels, with a dimming range of 20 percent to 100 percent, minimum. Ensure sensor is designed for use with L.E.D. dimmable driver and voltage system to which they are connected. Provide a sensor capable of controlling 40 L.E.D. drivers, minimum, with a sensor light level adjustable with a set level range from 10 to 100 foot-candles, minimum. Provide a sensor with a bypass function to electrically override the sensor control.

2.2.4 Lighting Contactor

Provide NEMA ICS 2, mechanically held contactorwith photocell input for outdoor locations, rated 277 volts, 30 amperes, and 6 poles, with coils rated 120 volts. Provide in a NEMA 4 enclosure conforming to NEMA ICS 6. Provide contactors with silver alloy double-break contacts and coil clearing contacts for mechanically held contactor requiring no arcing contacts. Provide contactor with hand-off-automatic selector switch.

2.2.5 Time Switch

Provide astronomic dial type or electronic type, arranged to turn "ON" at sunset and turn "OFF" at a predetermined time between 8:30 p.m. and 2:30 a.m. or at sunrise, automatically changing the settings each day in accordance with seasonal changes of sunset and sunrise. Provide a 277 volts rated switch, having automatically wound spring mechanism or capacitor, to maintain accurate time for a minimum of 7 hours following power failure. Provide time switch with a manual on-off bypass switch. Surface mount the housing for the time switch, inside a NEMA 4 enclosure conforming to NEMA ICS 6.

2.2.6 Photocell Switch

Ensure photocell switches conform to UL 773 or UL 773A as applicable. Provide hermetically sealed photocells that use cadmium-sulfide or silicon diode type cells. Provide photocells that are rated at 277 volts ac, 60 Hz with single-throw contacts and designed to fail to the ON position. Provide photocells that turn on at or below 3 foot-candles and off at 4 to 10 foot-candles. Provide time delay to prevent accidental switching from transient light sources. Provide a directional lens in front of the cell to prevent fixed light sources from creating a turnoff condition.

Provide a photocell with the following:

In a U.V. stabilized polycarbonate housing with swivel arm and adjustable window slide, rated 1800 VA, minimum.

2.2.7 Occupancy Sensors

Provide UL listed occupancy sensor complying with FCC Part 15. Design occupancy sensors and power packs to operate on the voltage indicated. Provide sensors and power packs with circuitry that only allows load switching at or near zero current crossing of supply voltage, with mounting as indicated. Provide sensor with an LED occupant detection indicator, adjustable sensitivity, and adjustable delayed-off time range of 5 minutes to 15 minutes. Provide white wall mounted sensors, and white ceiling mounted sensors. Provide ceiling mounted sensors with 360 degree coverage unless otherwise indicated.

Provide sensors with:

a. Ultrasonic/Infrared Combination Sensor

(1) Occupancy detection to turn lights on requires both ultrasonic and infrared sensor detection, such that the lights remain on if either the ultrasonic or infrared sensor detects movement. Provide infrared sensor with a lens selected for indicated usage and daylight filter to prevent short wavelength infrared interference. Provide crystal controlled ultrasonic sensor frequency.

PART 3 EXECUTION

3.1 INSTALLATION

Submit installation instructions for light-sensitive, occupancy sensitive, and/or motion sensitive control devices in accordance with the manufacturer's recommended instructions for installation.

3.1.1 Photoconductive Control Devices

Install photoconductive control devices in accordance with the manufacturer's installation instructions.

3.1.2 Time Control Switches

Install switches with not less than four 1/4 inch bolts. Do not use sheet metal screws.

3.1.3 Manual and Safety Switches

Coordinate terminal lugs with the wire size. Securely fasten switches to the supporting structure or wall using not less than four 1/4 inch bolts. Do not use sheet metal screws.

3.1.4 Magnetic Contactors

Install magnetic contactors, mechanically held, electrically operated, conforming to NEMA ICS 1 and NEMA ICS 2, suitable for 277 volts, single phase, 60 Hz, with coil voltage of 120 volts. Provide contactors with maximum continuous ampere rating and number of poles as indicated on drawings. For contactors mounted indoors, provide enclosures conforming to NEMA ICS 6, Type 1. Provide each contactor with a spare, normally open auxiliary contact.

Coordinate terminal lugs with the wire size. Securely fasten switches to

the supporting structure or wall using not less than four 1/4 inch bolts. Do not use sheet metal screws.

3.2 EQUIPMENT IDENTIFICATION

3.2.1 Manufacturer's Nameplate

Provide each item of equipment with a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in an inconspicuous place; the nameplate of the distributing agent is not acceptable.

3.2.2 Labels

Provide labeled control devices, clearly marked for operation of specific lighting functions according to type. Note the following devices characteristics in the format "Use Only."

Locate markings where readily visible to service personnel, but unseen from normal viewing angles when devices are in place.

3.3 FIELD QUALITY CONTROL

Perform system operation tests in accordance with referenced standards in this section.

Demonstrate that photoconductive control devices operate satisfactorily in the presence of the Contracting Officer.

Measure and record foot-candle levels in areas indicated and compare to submitted photometric calculations. Perform all lighting measurements in the presence of the Contracting Officer. Take measurements in areas representing a minimum of 10% relative sample. Ensure measured lighting levels are within 10% of the calculated values. Where lighting levels are determined to be deficient contractor will modify system to bring lighting levels into compliance at no additional cost to the Government.

3.4 CLOSEOUT ACTIVITIES

Submit operation and maintenance data, lighting control system, data package 5, in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and as specified herein. Show information for all lighting fixtures, control modules, control zones, occupancy sensors, motion sensors, light level sensors, power packs, dimming ballasts, schematic diagrams and all interconnecting control wire, conduit, and associated hardware.

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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.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1	(2008) Electric Meters Code for Electricity Metering

ASTM INTERNATIONAL (ASTM)

ASTM B1	(2013) Standard Specification for Hard-Drawn Copper Wire
ASTM B8	(2011; R 2017) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2017; Errata 2017) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C80.1	(2005) American National Standard for Electrical Rigid Steel Conduit (ERSC)
ANSI C80.3	(2015) American National Standard for Electrical Metallic Tubing (EMT)
ANSI C80.5	(2015) American National Standard for

	Electrical Rigid Aluminum Conduit
NEMA 250	(2014) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 1	(2000; R 2015) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2	(2000; R 2005; Errata 2008) 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	(2016; SUPP 2016) 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	(1992; R 1997) Standard for Dry-Type Transformers for General Applications
NEMA TC 2	(2013) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 3	(2016) Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing
NEMA TP 1	(2002) Guide for Determining Energy Efficiency for Distribution Transformers
NEMA VE 2	(2017) Cable Tray Installation Guideline
NEMA WD 1	(1999; R 2015) Standard for General Color Requirements for Wiring Devices
NEMA WD 6	(2016) Wiring Devices Dimensions Specifications
NEMA Z535.4	(2011; R 2017) American National Standard for Product Safety Signs and Labels

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2017; ERTA 1-2 2017; TIA 17-1; TIA 17-2; TIA 17-3; TIA 17-4; TIA 17-5; TIA 17-6; TIA 17-7; TIA 17-8; TIA 17-9; TIA 17-10; TIA 17-11; TIA 17-12; TIA 17-13; TIA 17-14) National Electrical Code
NFPA 70E	(2018; TIA 18-1; TIA 81-2) Standard for Electrical Safety in the Workplace
NFPA 780	(2017) Standard for the Installation of Lightning Protection Systems

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-568-D.1	(2017) Commercial Building Telecommunications Cabling Standard
TIA-569	(2015d) Commercial Building Standard for Telecommunications Pathways and Spaces
TIA-607-C	(2015c; addendum 1 2017) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises

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

29 CFR 1910.147	The Control of Hazardous Energy (Lock Out/Tag Out)

UNDERWRITERS LABORATORIES (UL)

UL 1	(2005; Reprint Aug 2017) UL Standard for Safety Flexible Metal Conduit
UL 1063	(2017) UL Standard for Safety Machine-Tool Wires and Cables
UL 1242	(2006; Reprint Mar 2014) Standard for Electrical Intermediate Metal Conduit -- Steel
UL 1449	(2014; Reprint Jul 2017) UL Standard for Safety Surge Protective Devices
UL 1561	(2011; Reprint Jun 2015) Dry-Type General Purpose and Power Transformers
UL 1660	(2014) Liquid-Tight Flexible Nonmetallic Conduit
UL 1699	(2017) UL Standard for Safety Arc-Fault Circuit-Interrupters
UL 20	(2010; Reprint Feb 2012) General-Use Snap Switches
UL 360	(2013; Reprint May 2018) UL Standard for

	Safety Liquid-Tight Flexible Metal Conduit
UL 44	(2018) Thermoset-Insulated Wires and Cables
UL 467	(2013; Reprint Jun 2017) UL Standard for Safety Grounding and Bonding Equipment
UL 486A-486B	(2018) UL Standard for Wire Connectors
UL 486C	(2018) Splicing Wire Connectors
UL 489	(2016) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 498	(2017; Reprint Nov 2017) UL Standard for Safety Attachment Plugs and Receptacles
UL 50	(2015) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations
UL 508	(2018) UL Standard for Industrial Control Equipment
UL 510	(2017) 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 Nov 2014) Conduit, Tubing and Cable Fittings
UL 514C	(2014; Reprint Dec 2014) Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL 6	(2007; Reprint Nov 2014) Electrical Rigid Metal Conduit-Steel
UL 651	(2011; Reprint Jun 2016) UL Standard for Safety Schedule 40 and 80 Rigid PVC Conduit and Fittings
UL 67	(2018) UL Standard for Safety Panelboards
UL 6A	(2008; Reprint Nov 2014) Electrical Rigid Metal Conduit - Aluminum, Red Brass, and Stainless Steel
UL 797	(2007; Reprint Mar 2017) UL Standard for Safety Electrical Metallic Tubing -- Steel
UL 817	(2015; Reprint May 2017) UL Standard for Safety Cord Sets and Power-Supply Cords
UL 83	(2017) UL Standard for Safety

	Thermoplastic-Insulated Wires and Cables
UL 869A	(2006) 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

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-580-01	(2016) Telecommunications Interior Infrastructure Planning And Design, With Change 1

U. S. SIGNAL NETWORK ENTYERPRISE CENTER

Ft. Bragg NEC IDC	(2017) Installation Design Criteria for Fort Bragg Specific Communications Infrastructure Requirements

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" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00.

SD-02 Shop Drawings

Panelboards; G

Transformers; G

Cable trays; G

SD-03 Product Data

Receptacles; G

Circuit breakers; G

Switches; G

Transformers; G

Enclosed circuit breakers; G

Motor controllers; G

Telecommunications Grounding Busbar; G

Surge protective devices; G

Include performance and characteristic curves.

SD-06 Test Reports

600-volt wiring test; G

Grounding system test; G

Transformer tests; G

Ground-fault receptacle test; G

SD-09 Manufacturer's Field Reports

Transformer factory tests

SD-10 Operation and Maintenance Data

Electrical Systems, Data Package 5; G

Submit operation and maintenance data in accordance with Section 01 78 23, OPERATION AND MAINTENANCE DATA and as specified herein.

1.4 QUALITY ASSURANCE

1.4.1 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.

1.4.2 Standard Products

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

1.4.2.1 Alternative Qualifications

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

1.4.2.2 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 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.

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.

2.2.6.1 Liquid-Tight Flexible Metal Conduit, Steel

UL 360.

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 UL 514B.

2.2.9 Liquid-Tight Flexible Nonmetallic Conduit

UL 1660.

2.3 CABLE TRAYS

NEMA VE 2. Provide the following:

a. Cable trays: form a wireway system, with a nominal depth as indicated.

b. Cable trays: constructed of aluminum or 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: as indicated.

2.3.1 Basket-Type Cable Trays

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

2.3.2 Cable Runway

Provide size as indicated with maximum rung spacing of 9 inches.

2.4 OUTLET BOXES AND COVERS

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

2.4.1 Floor Outlet Boxes

Provide the following:

a. Boxes: nonadjustable and concrete tight.

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

c. Telecommunications outlets: consisting of flush, aluminum or stainless steel housing with a receptacle as specified and 1 inch bushed side opening.

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

e. Provide gaskets where necessary to ensure watertight installation.

f. Provide plugs with installation instructions to the Contracting Officer for 5 percent of outlet boxes for the capping of outlets upon removal of service fittings.

2.4.2 Outlet Boxes for Telecommunications System

Provide the following:

a. Standard type 4 11/16 inches square by 2 1/8 inches deep.

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

c. Outlet boxes for fiber optic telecommunication outlets: include a minimum 3/8 inch deep single or two gang plaster ring as shown and installed using a minimum 1 inch conduit system.

d. Outlet boxes for handicapped telecommunications station: 4 by 2 1/8 by 2 1/8 inches deep.

2.5 CABINETS, JUNCTION BOXES, AND PULL BOXES

Volume greater than 100 cubic inches, UL 50, hot-dip, zinc-coated, if sheet steel.

2.6 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.

2.6.1 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.2.6.1.1 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.

2.6.2 Color Coding

Provide color coding for service, feeder, branch, control, and signaling circuit conductors.

2.6.2.1 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.

2.6.2.2 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

2.6.3 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 lighting fixtures require 90-degree Centigrade (C) conductors, provide only conductors with 90-degree C insulation or better.

2.6.4 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.

2.6.4.1 Bonding Conductor for Telecommunications

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

2.6.5 Cable Tray Cable or Power Limited Tray Cable

UL listed; type TC or PLTC.

2.6.6 Cord Sets and Power-Supply Cords

UL 817.

2.7 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.

2.8 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 or brushed-finish aluminum, 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 be permitted.

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

2.9 SWITCHES

2.9.1 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: white 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.

2.9.2 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.

2.9.3 Breakers Used as Switches

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

2.9.4 Disconnect Switches

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

2.10 RECEPTACLES

Provide the following:

a. UL 498, hard use (also designated heavy-duty), grounding-type.

b. Ratings and configurations: as indicated.

c. Bodies: white 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.

2.10.1 Weatherproof Receptacles

Provide receptacles, UL listed for use in "wet locations". Include cast metal box with gasketed, hinged, lockable and weatherproof while-in-use, polycarbonate, UV resistant/stabilized cover plate.

2.10.2 Ground-Fault Circuit Interrupter Receptacles

UL 943, duplex type for mounting in standard outlet box. Provide device capable of detecting current leak of 6 milliamperes or greater 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.

2.10.3 Special Purpose Receptacles

Receptacles serving special equipment indicated on plans are special purpose. Provide in ratings indicated.

2.10.4 Tamper-Resistant Receptacles

Provide duplex receptacle with mechanical sliding shutters that prevent

the insertion of small objects into its contact slots.

2.11 PANELBOARDS

Provide panelboards in accordance with the following:

a. UL 67 and UL 50 having a short-circuit current rating as indicated.

b. Panelboards for use as service disconnecting means: 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. "Specific breaker placement" is required in panelboards to match the breaker placement indicated in the panelboard schedule on the drawings.

f. Use of "Subfeed Breakers" is not acceptable unless specifically indicated otherwise.

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

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

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

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

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

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

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

2.11.1 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 conduit hubs welded to the cabinet.

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, except that doors over 24 inches long provided with a three-point latch having a knob with a T-handle, and a cylinder lock.

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.

2.11.2 Panelboard Buses

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

2.11.2.1 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.

2.11.3 Circuit Breakers

UL 489, thermal magnetic-type or solid state-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.

2.11.3.1 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.

2.11.3.2 Circuit Breaker With Ground-Fault Circuit Interrupter

UL 943 and NFPA 70. Provide with "push-to-test" button, visible indication of tripped condition, and ability to detect and trip on current imbalance of 6 milliamperes or greater per requirements of UL 943 for Class A ground-fault circuit interrupter.

2.11.3.3 Circuit Breakers for HVAC Equipment

Provide circuit breakers for HVAC equipment having motors (group or individual) marked for use with HACR type and UL listed as HACR type.

2.11.3.4 Arc-Fault Circuit Interrupters

UL 489, UL 1699 and NFPA 70. Molded case circuit breakers: rated as indicated. Provide with "push-to-test" button.

2.12 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. Provide solid neutral.

2.13 MOTOR SHORT-CIRCUIT PROTECTOR (MSCP)

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

2.14 TRANSFORMERS

Provide transformers in accordance with the following:

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

b. Provide transformers in NEMA enclosure, as indicated.

c. 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 115 degrees C under full-rated load in maximum ambient of 40 degrees C.

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

2.14.1 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. Minimum efficiency, based on factory test results: not be less than NEMA Class 1 efficiency as defined by NEMA TP 1.

2.14.2 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-Factor rating as indicated 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.

2.15 MOTORS

Provide motors in accordance with the following:

a. NEMA MG 1 FIRE PUMPS.

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

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

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

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

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

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

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

2.15.1 High Efficiency Single-Phase Motors

Single-phase fractional-horsepower alternating-current motors: high efficiency types corresponding to the applications listed in NEMA MG 11. 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.

2.15.2 Premium Efficiency Polyphase Motors

Select polyphase motors based on high efficiency characteristics relative to typical characteristics and applications as listed in NEMA MG 10. 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.

2.15.3 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.

2.15.4 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 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.

2.16 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, 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 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.

j. 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.

k. 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.

l. Minimum short circuit withstand rating of combination motor controller: 22,000 rms symmetrical amperes.

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

2.16.1 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.

2.16.2 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 (4) 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.

2.16.2.1 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 eEach connected terminal with the circuit designation or wire number placed on or near the terminal in permanent contrasting color.

2.16.3 Enclosures for Motor Controllers

NEMA ICS 6.

2.16.4 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.

2.16.5 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.

2.16.6 Pilot and Indicating Lights

Provide LED cluster lamps.

2.17 MANUAL MOTOR STARTERS (MOTOR RATED SWITCHES)

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

2.17.1 Pilot Lights

Provide yoke-mounted, seven element LED cluster light module. Color: in accordance with NEMA ICS 2.

2.18 LOCKOUT REQUIREMENTS

Provide disconnecting means 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. Comply with requirements of Division 23, "Mechanical" for mechanical isolation of machines and other equipment.

2.19 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.

2.20 GROUNDING AND BONDING EQUIPMENT

2.20.1 Ground Rods

UL 467. Ground rods: copper-clad steel, with minimum diameter of 3/4 inch and minimum length 10 feet. Sectional ground rods are permitted.

2.20.2 Ground Bus

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

2.20.3 Telecommunications Grounding Busbar

Provide corrosion-resistant grounding busbar suitable for indoor

installation in accordance with TIA-607-C. 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 telecommunications main grounding busbar (TMGB) in the telecommunications entrance facility and a (TGB) in all other telecommunications rooms and equipment rooms. The telecommunications main grounding busbar (TMGB) and the telecommunications grounding busbar (TGB): sized in accordance with the immediate application requirements and with consideration of future growth. Provide telecommunications grounding 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 TMGB and 2 in wide for TGBs with length as indicated;

c. Listed by a nationally recognized testing laboratory.

2.21 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.

2.22 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.

2.23 WARNING SIGNS

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

persons before examination, adjustment, servicing, or maintenance of the equipment.

2.24 FIRESTOPPING MATERIALS

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

2.25 SURGE PROTECTIVE DEVICES

Provide parallel type surge protective devices (SPD) which comply with UL 1449 at the service entranceswitchboard. Provide surge protectors in a NEMA 1 enclosure per NEMA ICS 6. Use Type 1 or Type 2 SPD and connect on the load side of a dedicated circuit breaker.

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

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

Maximum L-L Voltage Protection Rating:

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

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

2.26 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, outdoors: ANSI Light Gray.

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

2.27 SOURCE QUALITY CONTROL

2.27.1 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.

2.28 COORDINATED POWER SYSTEM PROTECTION

Prepare analyses as specified in Section 26 28 01.00 10 COORDINATED POWER SYSTEM PROTECTION.

PART 3 EXECUTION

3.1 INSTALLATION

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

3.1.1 Underground Service

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

3.1.2 Service Entrance Identification

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

3.1.2.1 Labels

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

3.1.3 Wiring Methods

Provide insulated conductors installed in rigid steel conduit, IMC, rigid nonmetallic conduit, or EMT, except where specifically indicated or

specified otherwise or required by NFPA 70 to be installed otherwise. Grounding conductor: separate from electrical system neutral conductor. Provide insulated green equipment grounding conductor for circuit(s) installed in conduit and raceways. Shared neutral, or multi-wire branch circuits, are not permitted with arc-fault circuit interrupters. Minimum conduit size: 1/2 inch in diameter for low voltage lighting and power circuits. Vertical distribution in multiple story buildings: made with metal conduit in fire-rated shafts, with metal conduit extending through shafts for minimum distance of 6 inches. Firestop conduit which penetrates fire-rated walls, fire-rated partitions, or fire-rated floors in accordance with Section 07 84 00, FIRESTOPPING.

3.1.3.1 Pull Wire

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

3.1.4 Conduit Installation

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

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 severe physical damage including but not limited to equipment rooms where moving or replacing equipment could physically damage the EMT.

d. Do not use in hazardous areas.

e. Do not use outdoors.

f. Do not use in fire pump rooms.

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

3.1.4.3 Restrictions Applicable to Flexible Conduit

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

3.1.4.4 Underground Conduit

Plastic-coated rigid steel; plastic-coated steel IMC; PVC, Type EPC-40. Plastic coating: extend minimum 6 inches above floor.

3.1.4.5 Conduit for Circuits Rated Greater Than 600 Volts

Rigid metal conduit or IMC only.

3.1.4.6 Conduit Installed Under Floor Slabs

Conduit run under floor slab: located a minimum of 12 inches below the vapor barrier. Seal around conduits at penetrations thru vapor barrier.

3.1.4.7 Conduit Through Floor Slabs

Where conduits rise through floor slabs, do not allow curved portion of bends to be visible above finished slab. All communications conduits in or below the slab must rise through the slab using rigid steel conduit. The transition from PVC to rigid steel conduit must take place prior to the sweep up to the building at the 90-degree bend.

3.1.4.8 Conduit Installed in Concrete Floor Slabs

Rigid steel; steel IMC; or PVC, Type EPC-40. Locate so as not to adversely affect structural strength of slabs. Install conduit within middle one-third of concrete slab. Do not stack conduits. Space conduits horizontally not closer than three diameters, except at cabinet locations. Curved portions of bends must not be visible above finish slab. Increase slab thickness as necessary to provide minimum one inch cover over conduit. Where embedded conduits cross building and/or expansion joints, provide suitable watertight expansion/deflection fittings and bonding jumpers. Expansion/deflection fittings must allow horizontal and vertical movement of raceway. Conduit larger than one inch trade size: installed parallel with or at right angles to main reinforcement; when at right angles to reinforcement, install conduit close to one of supports of slab.

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. 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 installationwith 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. Support exposed risers in wire shafts of multistory buildings by U-clamp hangers at each floor level and at 10 foot maximum intervals. Where conduit crosses building expansion joints, provide suitable expansion fitting that maintains conduit electrical continuity by bonding jumpers or other means. For conduits greater than 2 1/2 inches inside diameter, provide supports to resist forces of 0.5 times the equipment weight in any direction and 1.5 times the equipment weight in the downward direction.

3.1.4.11 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 liquidtight flexible conduit in wet and damp locations for equipment subject to vibration, noise transmission, movement or motors. Provide separate ground conductor across flexible connections.

3.1.4.14 Telecommunications and Signal System Pathway

Install telecommunications pathway in accordance with TIA-569, TIA-568-D.1, UFC 3-580-01, and Ft. Bragg NEC IDC..

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 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-C. Install cable trays parallel with or at right angles to ceilings, walls, and structural members. Support in accordance with manufacturer recommendations but at not more than 6 foot intervals as indicated. Coat contact surfaces of aluminum 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.

3.1.6 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 fixturesfor 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. Threaded studs driven in by powder charge and provided with lockwashers and nuts may be used in lieu of wood screws, expansion shields, or machine screws. 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.

3.1.6.1 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.

3.1.6.2 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. Telecommunications pull boxes shall be sized per the TIA 569-D when conduit is over 1" in diameter.

3.1.6.3 Extension Rings

Extension rings are not permitted for new construction. Use only on existing boxes in concealed conduit systems where wall is furred out for new finish.

3.1.7 Mounting Heights

Mount panelboards, enclosed circuit breakers, motor controller and disconnecting switches so height of operating handle at its highest position is maximum 78 inches above floor. 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 indicated. . Measure mounting heights of wiring devices and outletsto center of device or outlet.

3.1.8 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 manufacturer's recommendations.

3.1.8.1 Marking Strips

Provide marking strips 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.

3.1.9 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.

3.1.9.1 Splices of Aluminum Conductors

Make with solderless circumferential compression-type, aluminum-bodied connectors UL listed for AL/CU. Remove surface oxides from aluminum conductors by wire brushing and immediately apply oxide-inhibiting joint compound and insert in connector. After joint is made, wipe away excess joint compound, and insulate splice.

3.1.10 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.

3.1.11 Electrical Penetrations

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

3.1.12 Grounding and Bonding

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

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

Make ground connection to driven ground rods on exterior of building. 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-C. Where ground fault protection is employed, ensure that connection of ground and neutral does not interfere with correct operation of fault protection.

3.1.12.1 Ground Rods

Provide cone pointed ground rods. 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, additional rods, spaced on center, not less than twice the distance of the length of the rod. 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.

3.1.12.2 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 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. 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.

3.1.12.3 Ground Bus

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

grounding system. Use bolted connections in lieu of thermoweld, so they can be changed as required by additions and/or alterations.

3.1.12.4 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.

3.1.12.5 Telecommunications System

Provide telecommunications grounding in accordance with the following:

a. Telecommunications Grounding Busbars: Provide a telecommunications main grounding busbar (TMGB) in the telecommunications entrance facility. Install the TMGB as close to the electrical service entrance grounding connection as practicable. Provide a telecommunications grounding busbar (TGB) in all other telecommunications rooms and telecommunications equipment rooms. Install the TGB 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 TGB near the backbone cabling and associated terminations. In addition, locate the TGB 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 TGB, bond that panelboard's alternating current equipment ground (ACEG) bus (when equipped) or the panelboard enclosure to the TGB. Install telecommunications grounding 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 TMGB 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 exceeds3 feet in length, bond the conductors to each end of the conduit using a grounding bushing or a No. 6 AWG conductor, minimum per NEC 250.64 e.3. Provide a telecommunications bonding backbone (TBB) that originates at the TMGB extends throughout the building using the telecommunications backbone pathways, and connects to the TGBs 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 TGB 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 TMGB or the TGB.

c. Telecommunications Grounding Connections: Telecommunications grounding connections to the TMGB or TGB: utilize listed compression two-hole lugs, exothermic welding, suitable and equivalent one hole non-twisting lugs, or other irreversible compression type connections. Bond all metallic pathways, cabinets, and racks for telecommunications cabling and interconnecting hardware located within the same room or space as the TMGB or TGB to the TMGB or TGB respectively. In a metal frame (structural steel) building, where the steel framework is readily accessible within the room; bond each TMGB and TGB 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 TGB or TMGB, sized in accordance with TIA-607-C, 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 TGB 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.

3.1.13 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.

3.1.14 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.

3.1.15 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.

3.1.16 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 Watthour Meters

ANSI C12.1.

3.1.18 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.

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: as specified 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.

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 approximately 500 volts to provide direct reading of resistance. Minimum resistance: 250,000 ohms.

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.

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.

-- End of Section --

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SECTION 26 24 13

SWITCHBOARDS
05/15

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.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1	(2008) Electric Meters Code for Electricity Metering

ASTM INTERNATIONAL (ASTM)

ASTM A780/A780M	(2009; R 2015) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM D1535	(2014; R 2018) Standard Practice for Specifying Color by the Munsell System
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C37.13	(2015) Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures
IEEE C37.90.1	(2013) Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
IEEE C57.13	(2016) Requirements for Instrument Transformers

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2017; Errata 2017) Standard for Acceptance Testing Specifications for

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	(2017; ERTA 1-2 2017; TIA 17-1; TIA 17-2; TIA 17-3; TIA 17-4; TIA 17-5; TIA 17-6; TIA 17-7; TIA 17-8; TIA 17-9; TIA 17-10; TIA 17-11; TIA 17-12; TIA 17-13; TIA 17-14) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 489	(2016) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 891	(2005; Reprint Oct 2012) Switchboards

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" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.00 37, SUSTAINABITY. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Switchboard Drawings; G

SD-03 Product Data

Switchboard; G

SD-06 Test Reports

Switchboard Design Tests; G

Switchboard Production Tests; G

Acceptance Checks and Tests; G

SD-07 Certificates

Cybersecurity Equipment Certification; G

Submit certification indicating conformance with the paragraph CYBERSECURITY EQUIPMENT CERTIFICATION.

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

Service Entrance Available Fault Current Label; G

1.4 QUALITY ASSURANCE

1.4.1 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.

1.4.2 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 (designer of record) to provide breaker settings that ensures protection and coordination are achieved.

1.4.3 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.

1.4.4 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.

1.4.4.1 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.

1.4.4.2 Material and Equipment Manufacturing Date

Products manufactured more than 1 year prior to date of delivery to site are not acceptable.

1.5 MAINTENANCE

1.5.1 Switchboard Operation and Maintenance Data

Submit Operation and Maintenance Manuals in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

1.5.2 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. Design test reports.

f. Production test reports.

1.6 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 aligned as indicated.

b. All circuit breakers: front accessible.

c. Front and rear aligned switchboards.

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 hinged rear covers.

c. Front doors: provided with padlockable vault handles with a three point catch.

d. Base: includes any part of enclosure that is within 3 inches of concrete pad.

e. 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 of the main and branch devices as indicated.

2.2.2.4 Distribution Sections

Provide the distribution sections consisting of circuit breakers as indicated.

2.2.3 Protective Device

Provide main and branch protective devices as indicated.

2.2.3.1 Power Circuit Breaker

Provide the following:

a. IEEE C37.13. electrically operated drawout, unfused, low-voltage power circuit breaker with a short-circuit current rating as indicated at 480 volts.

b. Breaker frame size: 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, electrically operated, low voltage molded-case circuit breaker, with a short-circuit current rating of as indicated at 480 volts.

b. Breaker frame size: as indicated.

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) Indicated 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 as indicated.

(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 watts, vars, VA, kWh, kvarh, and kVAh.

(5) 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 Metering

2.2.6.1 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 in a Modbus protocol via a RS485 serial port.

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.

2.2.6.2 Electronic Watthour Meter

ANSI C12.1. Provide a switchboard style electronic programmable watthour meter, semi-flush mounted, as indicated. Meter can be 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.

a. Design: Provide meter designed for use on a 3-phase, 4-wire, 480Y/277 volt system with 3 current transformers. Include necessary KYZ pulse initiation hardware for Energy Monitoring and Control System (EMCS).

b. Coordination: Provide meter coordinated with ratios of current transformers and transformer secondary voltage.

c. Class: 20. Accuracy: plus or minus 1.0 percent. Finish: Class II.

d. Kilowatt-hour Register: five digit electronic programmable type.

e. Demand Register:

(1) Provide solid state.

(2) Meter reading multiplier: Indicate multiplier on the meter face.

(3) Demand interval length: programmed for 60 minutes with rolling demand up to six subintervals per interval.

f. Meter fusing: Provide a fuse block mounted in the metering compartment containing one fuse per phase to protect the voltage input to the watthour meter. Size fuses as recommended by the meter manufacturer.

g. Provide meter with a communications port, RS485, with Modbus RTU serial or Ethernet, Modbus-TCP communications.

IEEE C57.13. Provide single ratio transformers, 60 hertz, 2000 to 5-ampere ratio, 1.5 rating factor, with a metering accuracy class of 0.3

through B-1.8.

2.2.7 Transformer

Provide transformer section in switchboard in accordance with UL 891 and as indicated. Provide the transformer and section that is suitable for the installation. Provide a transformer conforming to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

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 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 lttering 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.

2.5.3 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.

2.5.4 Cybersecurity Equipment Certification

Furnish a certification that control systems are designed and tested in accordance with DoD Instruction 8500.01, DoD Instruction 8510.01, and as required by individual Service Implementation Policy.

2.6 COORDINATED POWER SYSTEM PROTECTION

Provide a power system study as specified in Section 26 28 01.00 10 COORDINATED POWER SYSTEM PROTECTION.

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.

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 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.

3.2.1 Switchboard

ANSI/NEMA PB 2.1.

3.2.2 Meters and Instrument Transformers

ANSI C12.1.

3.2.3 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.

3.2.4 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.

3.2.5 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.

3.3 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES

3.3.1 Exterior Location

Mount switchboard 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 inch No. 6 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 the top of the concrete slab is approximately 4 inches above the finished grade.

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

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

f. Provide conduit turnups and cable entrance space required by the equipment to be mounted.

g. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant.

h. Cut off and bush conduits 3 inches above slab surface.

i. Provide concrete work as specified in Section 03 30 00.00 10 CAST-IN-PLACE CONCRETE.

3.3.2 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 00.00 10 CAST-IN-PLACE CONCRETE.

3.4 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.

3.4.1 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.

3.4.1.1 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.

3.4.1.2 Circuit Breakers - Low Voltage - Power

a. Visual and Mechanical Inspection

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

(2) Inspect physical and mechanical condition.

(3) Inspect anchorage, alignment, and grounding.

(4) Verify that all maintenance devices are available for servicing and operating the breaker.

(5) Inspect arc chutes.

(6) Inspect moving and stationary contacts for condition, wear, and alignment.

(7) Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of the breaker are correct.

(8) Perform all mechanical operator and contact alignment tests on both the breaker and its operating mechanism.

(9) 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.

(10) Verify cell fit and element alignment.

(11) Verify racking mechanism.

(12) Confirm correct application of manufacturer's recommended lubricants.

b. Electrical Tests

(1) Perform contact-resistance tests on each breaker.

(2) Perform insulation-resistance tests.

(3) Adjust Breaker(s) for final settings in accordance with Government provided settings.

(4) Determine long-time minimum pickup current by primary current injection.

(5) Determine long-time delay by primary current injection.

(6) Determine short-time pickup and delay by primary current injection.

(7) Determine ground-fault pickup and delay by primary current injection.

(8) Determine instantaneous pickup value by primary current injection.

(9) Activate auxiliary protective devices, such as ground-fault or undervoltage relays, to ensure operation of shunt trip devices; Check the operation of electrically-operated breakers in their cubicle.

(10) Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and antipump function.

(11) Verify operation of charging mechanism.

3.4.1.3 Circuit Breakers

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.

3.4.1.4 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.

3.4.1.5 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.

3.4.1.6 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.

3.4.1.7 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.

3.4.2 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 5 working days advance notice of the dates and times for checks, settings, and tests.

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COORDINATED POWER SYSTEM PROTECTION
10/07

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 242	(2001; Errata 2003) Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems - Buff Book
IEEE 399	(1997) Brown Book IEEE Recommended Practice for Power Systems Analysis
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C37.13	(2015) Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures
IEEE C37.16	(2009) Standard for Preferred Ratings, Related Requirements, and Application Recommendations for Low-Voltage AC (635 V and below) and DC 3200 V and below) Power Circuit Breakers
IEEE C37.2	(2008) Standard for Electrical Power System Device Function Numbers, Acronyms and Contact Designations
IEEE C37.90	(2005; R 2011) Standard for Relays and Relay Systems Associated With Electric Power Apparatus
IEEE C57.13	(2016) Requirements for Instrument Transformers

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

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 2005; Errata 2008) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V

NEMA ICS 3	(2005; R 2010) Medium-Voltage Controllers Rated 2001 to 7200 V AC
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA/ANSI C12.11	(2007) Instrument Transformers for Revenue Metering, 10 kV BIL through 350 kV BIL (0.6 kV NSV through 69 kV NSV)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2017; ERTA 1-2 2017; TIA 17-1; TIA 17-2; TIA 17-3; TIA 17-4; TIA 17-5; TIA 17-6; TIA 17-7; TIA 17-8; TIA 17-9; TIA 17-10; TIA 17-11; TIA 17-12; TIA 17-13; TIA 17-14) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 1203	(2013; Reprint Apr 2018) UL Standard for Safety Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations
UL 198M	(2018) UL Standard for Mine-Duty Fuses
UL 486E	(2015; Reprint Nov 2017) UL Standard for Safety Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors
UL 489	(2016) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 508	(2018) UL Standard for Industrial Control Equipment
UL 845	(2005; Reprint Jul 2011) Motor Control Centers

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Fault Current Analysis
Protective Device Coordination Study
Equipment
System Coordinator
Protective Relays

Installation

SD-06 Test Reports

Field Testing

1.3 QUALITY ASSURANCE

1.3.1 System Coordinator

System coordination, recommended ratings and settings of protective devices, and design analysis shall be accomplished by a registered professional electrical power engineer with a minimum of 3 years of current experience in the coordination of electrical power systems. Submit verification of experience and license number, of a registered Professional Engineer as specified above. Experience data shall include at least five references for work of a magnitude comparable to this contract, including points of contact, addresses and telephone numbers.

1.3.2 System Installer

Calibration, testing, adjustment, and placing into service of the protective devices shall be accomplished by a manufacturer's product field service engineer or independent testing company with a minimum of two years of current product experience in protective devices.

1.4 DELIVERY, STORAGE, AND HANDLING

Devices and equipment shall be visually inspected when received and prior to acceptance from conveyance. Protect stored items from the environment in accordance with the manufacturer's published instructions. Damaged items shall be replaced.

1.5 EXTRA MATERIALS

Spare fuses or spare fuse elements shall be delivered to the Contracting officer when the electrical system is accepted, as indicated in 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

PART 2 PRODUCTS

2.1 STANDARD PRODUCT

Provide protective devices and equipment which are the standard product of a manufacturer regularly engaged in the manufacture of the product and that essentially duplicate items that have been in satisfactory utility type use for at least two years prior to bid opening. Submit data consisting of manufacturer's time-current characteristic curves for individual protective devices, recommended settings of adjustable protective devices, and recommended ratings of non-adjustable protective devices.

2.2 NAMEPLATES

Provide nameplates to identify all protective devices and equipment. Nameplate information shall be in accordance with UL 489.

2.3 CORROSION PROTECTION

Metallic materials shall be protected against corrosion. Ferrous metal hardware shall be zinc or chrome-plated.

2.4 MOTOR CONTROLS AND MOTOR CONTROL CENTERS

Motor controls and motor control centers shall be in accordance with NEMA ICS 1, NEMA ICS 2, NEMA ICS 3 and NEMA ICS 6, and UL 508and UL 845.

2.4.1 Motor Starters

Provide combination starters with circuit breakers and fusible switches as indicated.

2.4.2 Reduced-Voltage Starters

Provide reduced-voltage starters for polyphase motors 20 hp or larger, of the single-step autotransformer, reactor, or resistor type having an adjustable time interval between application of reduced and full voltages to the motors. Wye-delta reduced voltage starter or part winding increment starters having an adjustable time delay between application of voltage to first and second winding of motor, may be used in lieu of the reduced voltage starters specified above for starting of motor-generator sets, centrifugally operated equipment or reciprocating compressors provided with automatic unloaders.

2.4.3 Thermal-Overload Protection

Each motor of 1/8 hp or larger shall be provided with thermal-overload protection. Polyphase motors shall have overload protection in each ungrounded conductor. The overload-protection device shall be provided either integral with the motor or controller, or shall be mounted in a separate enclosure. Unless otherwise specified, the protective device shall be of the manually reset type. Single or double pole tumbler switches specifically designed for alternating-current operation only may be used as manual controllers for single-phase motors having a current rating not in excess of 80 percent of the switch rating.

2.4.4 Low-Voltage Motor Overload Relays

2.4.4.1 General

Thermal and magnetic current overload relays shall conform to NEMA ICS 2 and UL 508. Overload protection shall be provided either integral with the motor or controller, and shall be rated in accordance with the requirements of NFPA 70. Standard units shall be used for motor starting times up to 7 second. Slow units shall be used for motor starting times from 8 to 12 seconds. Quick trip units shall be used on hermetically sealed, submersible pumps, and similar motors.

2.4.4.2 Construction

Manual reset type thermal relays shall be bimetallic construction. Automatic reset type relays shall be bimetallic construction. Magnetic current relays shall consist of a contact mechanism and a dash pot mounted on a common frame.

2.4.4.3 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. Trip current ratings shall be established by selection of the replaceable overload device and shall not be adjustable. Where the controller is remotely-located or difficult to reach, an automatic reset, non-compensated overload relay shall be provided. Manual reset overload relays shall be provided otherwise, and at all locations where automatic starting is provided. Where the motor is located in a constant ambient temperature, and the thermal device is located in an ambient temperature that regularly varies by more than 14 degrees F, an ambient temperature-compensated overload relay shall be provided.

2.4.5 Automatic Control Devices

2.4.5.1 Direct Control

Automatic control devices (such as thermostats, float or pressure switches) which control the starting and stopping of motors directly shall be designed for that purpose and have an adequate horsepower rating.

2.4.5.2 Pilot-Relay Control

Where the automatic-control device does not have such a rating, a magnetic starter shall be used, with the automatic-control device actuating the pilot-control circuit.

2.4.5.3 Manual/Automatic Selection

a. Where combination manual and automatic control is specified and the automatic-control device actuates the pilot control circuit of a magnetic starter, the magnetic starter shall be provided with a three-position selector switch marked MANUAL-OFF-AUTOMATIC.

b. Connections to the selector switch shall only allow the normal automatic regulatory control devices to be bypassed when the switch is in the Manual position; all safety control devices, such as low-or high-pressure cutouts, high-temperature cutouts, and motor-overload protective devices, shall be connected in the motor-control circuit in both the Manual and the Automatic positions of the selector switch. Control circuit connections to any MANUAL-OFF-AUTOMATIC switch or to more than one automatic regulatory control device shall be made in accordance with wiring diagram approved by the contracting Officer unless such diagram is included on the drawings. All controls shall be 120 volts or less unless otherwise indicated.

2.5 LOW-VOLTAGE FUSES

2.5.1 General

Low-voltage fuses shall conform to NEMA FU 1. Time delay and nontime delay options shall be as shown. Equipment provided under this contract shall be provided with a complete set of properly rated fuses when the equipment manufacturer utilizes fuses in the manufacture of the equipment, or if current-limiting fuses are required to be installed to limit the ampere-interrupting capacity of circuit breakers or equipment to less than the maximum available fault current at the location of the equipment to be installed. Fuses shall have a voltage rating of not less than the phase-to-phase circuit voltage, and shall have the time-current

characteristics requires for effective power system coordination.

2.5.2 Cartridge Fuses; Noncurrent-Limiting Type

Cartridge fuses of the noncurrent-limiting type shall be Class H, nonrenewable, dual element, time lag type and shall have interrupting capacity of 10,000 amperes. Class H Fuses shall conform to UL 198M. At 500 percent current, cartridge fuses shall not blow in less than 10 seconds. Cartridge fuses shall be used for circuits rated in excess of 30 amperes, 125 volts, except where current-limiting fuses are indicated.

2.5.3 Cartridge Fuses; Current-Limiting Type

Cartridge fuses, current-limiting type, Class L, RK1 or RK5 shall have tested interrupting capacity not less than 100,000 amperes. Fuse holders shall be the type that will reject Class H fuses.

a. Class L fuses shall conform to UL 198M.

b. Class R fuses shall conform to UL 198M.

2.5.3.1 Continuous Current Ratings (600 amperes and smaller)

Service entrance and feeder circuit fuses (600 amperes and smaller) shall be Class RK1, current-limiting, with 200,000 amperes interrupting capacity.

2.5.3.2 Continuous Current Ratings (greater than 600 amperes)

Service entrance and feeder circuit fuses (greater than 600 amperes) shall be Class L, current-limiting, with 200,000 amperes interrupting capacity.

2.5.3.3 Motor and Transformer Circuit Fuses

Motor, motor controller, transformer, and inductive circuit fuses shall be Class RK1 or RK5, current-limiting, time-delay with 200,000 amperes interrupting capacity.

2.6 MOTOR SHORT-CIRCUIT PROTECTOR (MSCP)

2.6.1 General

Motor short-circuit protectors shall conform to UL 508 and shall be provided as shown. Protectors shall be used only as part of a combination motor controller which provides coordinated motor branch-circuit overload and short-circuit protection, and shall be rated in accordance with the requirements of NFPA 70.

2.6.2 Construction

Motor short-circuit protector bodies shall be constructed of high temperature, dimensionally stable, long life, nonhygroscopic materials. Protectors shall fit special MSCP mounting clips and shall not be interchangeable with any commercially available fuses. Protectors shall have 100 percent one-way interchangeability within the A-Y letter designations. All ratings shall be clearly visible.

2.6.3 Ratings

Voltage ratings shall be not less than the applicable circuit voltage.

Letter designations shall be A through Y for motor controller Sizes 0, 1, 2, 3, 4, and 5, with 100,000 amperes interrupting capacity rating. Letter designations shall correspond to controller sizes as follows:

CONTROLLER SIZE	MSCP DESIGNATION
NEMA 0	A-N
NEMA 1	A-P
NEMA 2	A-S
NEMA 3	A-U
NEMA 4	A-W
NEMA 5	A-Y

2.7 MOLDED-CASE CIRCUIT BREAKERS

2.7.1 General

Molded-case circuit breakers shall conform to UL 489 and UL 489. Circuit breakers may be installed in panelboards, switchboards, enclosures, motor control centers, or combination motor controllers. Circuit breakers and circuit breaker enclosures located in hazardous (classified) areas shall conform to UL 1203.

2.7.2 Construction

Molded-case circuit breakers shall be assembled as an integral unit in a supporting and enclosing housing of glass reinforced insulating material providing high dielectric strength. Circuit breakers shall be suitable for mounting and operating in any position. Lugs shall be listed for copper conductors only in accordance with UL 486E. Single-pole circuit breakers shall be full module size with not more than one pole per module. Multi-pole circuit breakers shall be of the common-trip type having a single operating handle such that an overload or short circuit on any one pole will result in all poles opening simultaneously. Sizes of 100 amperes or less may consist of single-pole breakers permanently factory assembled into a multi-pole unit having an internal, mechanical, nontamperable common-trip mechanism and external handle ties. All circuit breakers shall have a quick-make, quick-break overcenter toggle-type mechanism, and the handle mechanism shall be trip-free to prevent holding the contacts closed against a short-circuit or sustained overload. All circuit breaker handles shall assume a position between "ON" and "OFF" when tripped automatically. All ratings shall be clearly visible.

2.7.3 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. The interrupting rating of the circuit breakers shall be at least equal to the available short-circuit current at the line terminals of the circuit breaker and correspond to the UL listed integrated short-circuit current rating specified for the panelboards and switchboards. Molded-case circuit breakers shall have nominal voltage ratings, maximum

continuous-current ratings, and maximum short-circuit interrupting ratings in accordance with UL 489. Ratings shall be coordinated with system X/R ratio.

2.7.4 Cascade System Ratings

Circuit breakers used in series combinations shall be in accordance with UL 489. Equipment, such as switchboards and panelboards, which house series-connected circuit breakers shall be clearly marked accordingly. Series combinations shall be listed in the UL Recognized Component Directory under "Circuit Breakers-Series Connected."

2.7.5 Thermal-Magnetic Trip Elements

Thermal magnetic circuit breakers shall be provided as shown. Automatic operation shall be obtained by means of thermal-magnetic tripping devices located in each pole providing inverse time delay and instantaneous circuit protection. The instantaneous magnetic trip shall be adjustable and accessible from the front of all circuit breakers on frame sizes above 150 amperes.

2.7.6 Solid-State Trip Elements

Solid-state circuit breakers shall be provided as shown. All electronics shall be self-contained and require no external relaying, power supply, or accessories. Printed circuit cards shall be treated to resist moisture absorption, fungus growth, and signal leakage. All electronics shall be housed in an enclosure which provides protection against arcs, magnetic interference, dust, and other contaminants. Solid-state sensing shall measure true RMS current with error less than one percent on systems with distortions through the 13th harmonic. Peak or average actuating devices are not acceptable. Current sensors shall be toroidal construction, encased in a plastic housing filled with epoxy to protect against damage and moisture and shall be integrally mounted on the breaker. Where indicated on the drawings, circuit breaker frames shall be rated for 100 percent continuous duty. Circuit breakers shall have tripping features as shown on the drawings and as described below:

a. Long-time current pick-up, adjustable from 50 percent to 100 percent of continuous current rating.

b. Adjustable long-time delay.

c. Short-time current pick-up, adjustable from 1.5 to 9 times long-time current setting.

d. Adjustable short-time delay.

e. Instantaneous current pick-up, adjustable from 1.5 to 9 times long-time current setting.

f. Ground-fault pick-up, adjustable from 20 percent to 60 percent of sensor rating, but in no case greater than 1200 amperes. Sensing of ground-fault current at the main bonding jumper or ground strap shall not be permitted.

g. Adjustable ground-fault delay.

h. Overload and Short-circuit and Ground-fault trip indicators shall be

provided.

2.7.7 Current-Limiting Circuit Breakers

Current-limiting circuit breakers shall be provided as shown. Current-limiting circuit breakers shall limit the let-through I square times t to a value less than the I square times t of one-half cycle of the symmetrical short-circuit current waveform. On fault currents below the threshold of limitation, breakers shall provide conventional overload and short-circuit protection. Integrally-fused circuit breakers shall not be used.

2.7.8 SWD Circuit Breakers

Circuit breakers rated 15 amperes or 20 amperes and intended to switch 277 volts or less fluorescent lighting loads shall be marked "SWD."

2.7.9 HACR Circuit Breakers

Circuit breakers 60 amperes or below, 240 volts, 1-pole or 2-pole, intended to protect multi-motor and combination-load installations involved in heating, air conditioning, and refrigerating equipment shall be marked "Listed HACR Type."

2.7.10 Motor Circuit Protectors (MCP)

Motor circuit protectors shall conform to UL 489 and UL 489 and shall be provided as shown. MCPs shall consist of an adjustable instantaneous trip circuit breaker in conjunction with a combination motor controller which provides coordinated motor circuit overload and short-circuit protection. Motor Circuit Protectors shall be rated in accordance with NFPA 70.

2.8 LOW-VOLTAGE POWER CIRCUIT BREAKERS

2.8.1 Construction

Low-voltage power circuit breakers shall conform to IEEE C37.13 and IEEE C37.16 and shall be three-pole, single-throw, stored energy, electrically operated, with drawout mounting. Solid-state trip elements which require no external power connections shall be provided. Circuit breakers shall have an open/close contact position indicator, charged/discharged stored energy indicator, primary disconnect devices, and a mechanical interlock to prevent making or breaking contact of the primary disconnects when the circuit breaker is closed. Control voltage shall be as indicated. The circuit breaker enclosure shall be suitable for its intended location.

2.8.2 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. Circuit breakers shall be rated for 100 percent continuous duty and shall have trip current ratings and frame sizes as shown. Nominal voltage ratings, maximum continuous-current ratings, and maximum short-circuit interrupting ratings shall be in accordance with IEEE C37.16. Tripping features shall be as follows:

a. Long-time current pick-up, adjustable from 50 percent to 100 percent of sensor current rating.

b. Adjustable long-time delay.

c. Short-time current pick-up, adjustable from 1.5 to 9 times long-time current setting.

d. Adjustable short-time delay.

e. Instantaneous current pick-up, adjustable from 1.5 to 9 times long-time current setting.

f. Ground-fault pick-up, adjustable from 20 percent to 60 percent of sensor rating, but in no case greater than 1200 amperes. Sensing of ground-fault current at the main bonding jumper or ground strap shall not be permitted.

g. Adjustable ground-fault delay.

h. Overload and Short-circuit and Ground-fault trip indicators shall be provided.

2.9 SUBSTATION AND SWITCHGEAR PROTECTIVE RELAYS

Solid-state and Electromechanical and Microprocessor-based protective relays shall be as shown and shall be of a type specifically designed for use on power switchgear or associated electric power apparatus. Protective relays shall conform to IEEE C37.90. Relays and auxiliaries shall suitable for operation with the instrument transformer ratios and connections provided.

2.9.1 Construction

Relays for installation in metal-clad switchgear shall be of the semi-flush, rectangular, back-connected, dustproof, switchboard type. Cases shall have a black finish and window-type removable covers capable of being sealed against tampering. Relays shall be of a type that can be withdrawn, through approved sliding contacts, from fronts of panels or doors without opening current transformer secondary circuits, disturbing external circuits, or requiring disconnection of any relay leads. Necessary test devices shall be incorporated within each relay and shall provide a means for testing either from an external source of electric power or from associated instrument transformers. Each relay shall be provided with an operation indicator and an external target reset device. Relays shall have necessary auxiliaries for proper operation. Relays and auxiliaries shall be suitable for operation with the instrument transformer ratios and connections provided.

2.9.2 Ratings

Relays shall be the manufacturer's standard items of equipments with appropriate ranges for time dial, tap, and other settings. Relay device numbers shall correspond to the function names and descriptions of IEEE C37.2.

2.9.3 Overcurrent Relays

Overcurrent relays shall be as follows:

a. Phase overcurrent relays for main and tie circuit breakers shall be single-phases, nondirectional, induction solid-state

microprocessor-based type, time delay, device 51, current taps as indicated with characteristic curves that are as indicated.

b. Ground overcurrent relays for main circuit breakers shall be nondirectional, induction solid-state microprocessor-based type, time delay, device as indicted and with characteristic curves that are as indicated.

c. Ground overcurrent relays for tie circuit breakers shall be nondirectional, induction solid-state microprocessor-based type, time delay, device 51N, residually connected, with current taps as indicated and with characteristic curves that are as indicated.

d. Phase overcurrent relays for feeder circuit breakers shall be single-phase, nondirectional, induction solid-state microprocessor-based type, device 50/51, with instantaneous-current pick-up range as indicated, with time-delay-current taps as indicated and with characteristic curves that are as indicated.

e. Ground overcurrent relays for feeder circuit breakers shall be nondirectional, solid-state microprocessor-based type instantaneous, device with current pick-up range as indicated.

2.9.4 Directional Overcurrent Relays

Directional overcurrent relays shall be as follows:

a. Directional phase overcurrent relays shall be single-phase, induction solid-state microprocessor-based type, with instantaneous units. Phase relays, device 67, shall have an instantaneous-current pick-up range as indicated, with time-delay-current taps as indicated and with characteristic curves that are as indicated.

b. Directional ground overcurrent relays, device 67N, shall have an instantaneous-current pick-up range as indicated, with time-delay-current taps as indicated and with characteristic curves that are as indicated.

2.9.5 Automatic Reclosing Relay

Relay, device 79, shall be of the three-phase, four-reclosure type, providing immediate initial reclosure, and three time-delay reclosures. Adjustable time delays shall be 10 to 60 seconds for reset and 0 to 45 seconds for reclosing. Units shall have instantaneous trip lockout after any preset trip when closing in on a fault. Auxiliary devices shall provided for lockout when an associated circuit breaker is tripped after reclosures and automatically reset when an associated circuit breaker is not tripped after any reclosure.

2.9.6 Transformer Differential and Lockout Relays

Differential relays, device 87T, shall be of the three-phase or the single-phase high-speed percentage differential type suitable for the protection of two-winding transformers, and shall be provided with a harmonic-restraint feature. Lockout relay, device 86T, shall be of the type which, when used in conjunction with the 87T relay, trips and locks out the indicated circuit breakers.

2.9.7 Bus Differential and Lockout Relays

Bus differential relay, device 87B, shall be of the three-phase or single-phase, high-speed impedance differential type suitable for protection of buses. Lockout relay, device 86B, shall be of a type which, when used in conjunction with the 87B relay, trips and locks out the indicated circuit breaker.

2.10 INSTRUMENT TRANSFORMERS

2.10.1 General

Instrument transformers shall comply with NEMA/ANSI C12.11 and IEEE C57.13. Instrument transformers shall be configured for mounting in/on the device to which they are applied. Polarity marks on instrument transformers shall be visually evident and shown on the drawings.

2.10.2 Current Transformers

Unless otherwise indicated, bar, wound, or window-type transformers are acceptable; and except for window-type units installed over insulated buses, transformers shall have a BIL rating consistent with the rated BIL of the associated switchgear or electric power apparatus bushings, buses or conductors. Current transformers shall have the indicated ratios. The continuous thermal-current rating factor shall be not less than 2.0 . Other thermal and mechanical ratings of current transformers and their primary leads shall be coordinated with the design of the circuit breaker and shall be not less than the momentary rating of the associated circuit breaker. Circuit protectors shall be provided across secondary leads of the current transformers to prevent the accidental open-circuiting of the transformers while energized. Each terminal of each current transformer shall be connected to a short-circuiting terminal block in the circuit interrupting mechanism cabinet, power transformer terminal cabinet, and in the associated instrument and relay cabinets.

2.10.2.1 For Power Transformers

Single-ratio bushing type current transformers shall be provided internally around power transformer bushings as shown. Single-ratio units shall have a minimum metering accuracy class of 0.3B-0.5.

2.10.2.2 For Metal-Clad Switchgear

Single-ratio units, used for metering and relaying, shall have a metering accuracy class rating of .3 B-0.5.

2.10.2.3 For kW Hour and Demand Metering (Low Voltage)

Current transformers shall conform to IEEE C57.13. Current transformers with a metering accuracy Class of 0.3 through B-1.8, with a minimum RF of 2.0 at 86 degrees F, with 600-volt insulation, and 10 kV BIL shall be provided. Butyl-molded, window-type current transformers mounted.

2.10.2.4 Voltage Transformers

Voltage transformers shall have indicated ratios. Units shall have an accuracy rating of .03. Voltage transformers shall be of the drawout type having current-limiting fuses in both primary and secondary circuits. Mechanical interlocks shall prevent removal of fuses, unless the

associated voltage transformer is in a drawout position. Voltage transformer compartments shall have hinged doors.

2.11 COORDINATED POWER SYSTEM PROTECTION

Analyses shall be prepared to demonstrate that the equipment selected and system constructed meet the contract requirements for ratings, coordination, and protection. They shall include a load flow analysis, a fault current analysis, and a protective device coordination study. Submit the study along with protective device equipment submittals. No time extensions or similar contact modifications will be granted for work arising out of the requirements for this study. Approval of protective devices proposed will be based on recommendations of this study. The Government shall not be held responsible for any changes to equipment, device ratings, settings, or additional labor for installation of equipment or devices ordered and/or procured prior to approval of the study. The studies shall be performed by a registered professional engineer with demonstrated experience in power system coordination in the last 3 years. Provide a list of references complete with points of contact, addresses and telephone numbers. The selection of the engineer is subject to the approval of the Contracting Officer.

2.11.1 Scope of Analyses

The fault current analysis, and protective device coordination study shall begin at: the source bus and extend down to system buses where fault availability is 10,000 amperes (symmetrical) for building/facility 600 volt level distribution buses.

2.11.2 Determination of Facts

The time-current characteristics, features, and nameplate data for each existing protective device shall be determined and documented. Coordinate with the commercial power company for fault current availability at the site.

2.11.3 Single Line Diagram

A single line diagram shall be prepared to show the electrical system buses, devices, transformation points, and all sources of fault current (including generator and motor contributions). A fault-impedance diagram or a computer analysis diagram may be provided. Each bus, device or transformation point shall have a unique identifier. If a fault-impedance diagram is provided, impedance data shall be shown. Location of switches, breakers, and circuit interrupting devices shall be shown on the diagram together with available fault data, and the device interrupting rating.

2.11.4 Fault Current Analysis

2.11.4.1 Method

The fault current analysis shall be performed in accordance with methods described in IEEE 242, and IEEE 399.

2.11.4.2 Data

Actual data shall be utilized in fault calculations. Bus characteristics and transformer impedance shall be those proposed. Data shall be documented in the report.

2.11.4.3 Fault Current Availability

Balanced three-phase fault, bolted line-to-line fault, and line-to-ground fault current values shall be provided at each voltage transformation point and at each power distribution bus. The maximum and minimum values of fault available at each location shall be shown in tabular form on the diagram or in the report.

2.11.5 Coordination Study

The study shall demonstrate that the maximum possible degree of selectivity has been obtained between devices specified, consistent with protection of equipment and conductors from damage from overloads and fault conditions. The study shall include a description of the coordination of the protective devices in this project. A written narrative shall be provided 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 (an analysis of any device curves which overlap); coordination between upstream and downstream devices; and relay settings. 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) shall be provided. Composite coordination plots shall be provided on log-log graph paper.

2.11.6 Study report

a. The report shall include a narrative describing: the analyses performed; the bases and methods used; and the desired method of coordinated protection of the power system.

b. The study shall include descriptive and technical data for existing devices and new protective devices proposed. The data shall include manufacturers published data, nameplate data, and definition of the fixed or adjustable features of the existing or new protective devices.

c. The report shall document utility company data including system voltages, fault MVA, system X/R ratio, time-current characteristic curves, current transformer ratios, and relay device numbers and settings.

d. The report shall contain fully coordinated composite time-current characteristics curves for each bus in the system, as required to ensure coordinated power system protection between protective devices or equipment. The report shall include recommended ratings and settings of all protective devices in tabulated form.

e. The report shall provide the calculation performed for the analyses, including computer analysis programs utilized. The name of the software package, developer, and version number shall be provided.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with details of the work, verify dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

3.2 INSTALLATION

Submit procedures including diagrams, instructions, and precautions required to properly install, adjust, calibrate, and test the devices and equipment. Install protective devices in accordance with the manufacturer's published instructions and in accordance with the requirements of NFPA 70 and IEEE C2.

3.3 FIELD TESTING

Prior to field tests, submit the proposed test plan consisting of complete field test procedure, tests to be performed, test equipment required, and tolerance limits, and complete testing and verification of the ground fault protection equipment, where used. Submit performance test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Each test report shall indicate the final position of controls.

3.3.1 General

Perform field testing in the presence of the Contracting Officer. Notify the Contracting Officer 14 days prior to conducting tests. Furnish all materials, labor, and equipment necessary to conduct field tests. Perform all tests and inspections recommended by the manufacturer unless specifically waived by the Contracting Officer. Maintain a written record of all tests which includes date, test performed, personnel involved, devices tested, serial number and name of test equipment, and test results.

3.3.2 Safety

Provide and use safety devices such as rubber gloves, protective barriers, and danger signs to protect and warn personnel in the test vicinity. Replace any devices or equipment which are damaged due to improper test procedures or handling.

3.3.3 Molded-Case Circuit Breakers

Circuit breakers shall be visually inspected, operated manually, and connections checked for tightness. Current ratings shall be verified and adjustable settings incorporated in accordance with the coordination study.

3.3.4 Power Circuit Breakers

3.3.4.1 General

Visually inspect the circuit breaker and operate the circuit breaker manually; adjust and clean primary contacts in accordance with manufacturer's published instructions; check tolerances and clearances; check for proper lubrication; and ensure that all connections are tight. For electrically operated circuit breakers, verify operating voltages on closing and tripping coils. Verify fuse ratings in control circuits; electrically operate the breaker, where applicable; and implement settings in accordance with the coordination study.

3.3.5 Protective Relays

Protective relays shall be visually and mechanically inspected, adjusted,

tested, and calibrated in accordance with the manufacturer's published instructions. Submit data including calibration and testing procedures and instructions pertaining to the frequency of calibration, inspection, adjustment, cleaning, and lubrication. Tests shall include pick-up, timing, contact action, restraint, and other aspects necessary to ensure proper calibration and operation. Relay settings shall be implemented in accordance with the coordination study. Relay contacts shall be manually or electrically operated to verify that the proper breakers and alarms initiate.

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SECTION 26 29 23

VARIABLE FREQUENCY DRIVE SYSTEMS UNDER 600 VOLTS
04/06

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 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

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2014) 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	(2009; R 2014) 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	(2014) Adjustable-Speed Drives

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2017; ERTA 1-2 2017; TIA 17-1; TIA 17-2; TIA 17-3; TIA 17-4; TIA 17-5; TIA 17-6; TIA 17-7; TIA 17-8; TIA 17-9; TIA 17-10; TIA 17-11; TIA 17-12; TIA 17-13; TIA 17-14) National Electrical Code

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-461	(2015; Rev G) Requirements for the Control of Electromagnetic Interference

Characteristics of Subsystems and Equipment

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

47 CFR 15	Radio Frequency Devices

UNDERWRITERS LABORATORIES (UL)

UL 489	(2016) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 508C	(2002; Reprint Nov 2010) Power Conversion Equipment

1.2 RELATED REQUIREMENTS

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM apply to this section with additions and modifications specified herein. Refer to Commissioning Requirements in Specification 01 91 00.00 37 COMMISSIONING.

1.3 SYSTEM DESCRIPTION

1.3.1 Performance Requirements

1.3.1.1 Electromagnetic Interference Suppression

Computing devices, as defined by 47 CFR 15, MIL-STD-461 rules and regulations, shall be certified to comply with the requirements for class A computing devices and labeled as set forth in part 15.

1.3.1.2 Electromechanical and Electrical Components

Electrical and electromechanical components of the Variable Frequency Drive (VFD) shall not cause electromagnetic interference to adjacent electrical or electromechanical equipment while in operation.

1.3.2 Electrical Requirements

1.3.2.1 Power Line Surge Protection

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

1.3.2.2 Sensor and Control Wiring Surge Protection

I/O functions as specified shall be protected against surges induced on control and sensor wiring installed outdoors and as shown. The inputs and outputs shall be tested 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" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance with Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Schematic Diagrams; G

Interconnecting Diagrams; G

Installation Drawings; G

Submit drawings for government approval prior to equipment construction or integration. Modifications to original drawings made during installation shall be immediately recorded for inclusion into the as-built drawings.

SD-03 Product Data

Variable Frequency Drives; G

Wires and Cables

Equipment Schedule

Include data indicating compatibility with motors being driven.

SD-06 Test Reports

VFD Test

Performance Verification Tests

Endurance Test

SD-08 Manufacturer's Instructions

Installation instructions

SD-09 Manufacturer's Field Reports

VFD Factory Test Plan; G

Factory test results

SD-10 Operation and Maintenance Data

Variable Frequency Drives, Data Package 4

Submit 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. Submit 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.

1.5 QUALITY ASSURANCE

1.5.1 Schematic Diagrams

Show 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 V.F.D.'s and motors indicated. Indicate ventilation requirements, adequate clearances, and cable routes.

1.5.4 Equipment Schedule

Provide schedule of equipment supplied. Schedule shall provide a cross reference between manufacturer data and identifiers indicated in shop drawings. Schedule shall include the total quantity of each item of equipment supplied. For complete assemblies, such as VFD'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 Factory Test Results

Document test results and submit to government within 7 working days after completion of test.

1.6 DELIVERY AND STORAGE

Equipment delivered and placed in storage shall be stored with protection from the weather, humidity and temperature variations, dirt and dust, or other contaminants.

1.7 WARRANTY

The complete system shall be warranted by the manufacturer for a period of one year, or the contracted period of any extended warrantee agreed upon by the contractor and the Government, after successful completion of the acceptance test. Any component failing to perform its function as specified and documented shall be repaired or replaced by the contractor at no additional cost to the Government. Items repaired or replaced shall be warranted for an additional period of at least one year from the date that it becomes functional again, as specified in FAR 52.246-21 Warranty of Construction.

1.8 MAINTENANCE

1.8.1 Spare Parts

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

1.8.2 Maintenance Support

During the warranty period, the Contractor shall provide on-site, on-call maintenance services by Contractor's personnel on the following basis: The service shall be on a per-call basis with 36 hour response. Contractor shall support the maintenance of all hardware and software of the system. Various personnel of different expertise shall be sent on-site depending on the nature of the maintenance service required. Costs shall 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, shall be borne by the Contractor.

PART 2 PRODUCTS

2.1 VARIABLE FREQUENCY DRIVES (VFD)

Provide frequency drive to control the speed of induction motor(s). The VFD shall 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 508C shall change fixed voltage, fixed frequency, ac line power to a fixed dc voltage. The converter shall utilize a full wave bridge design incorporating diode rectifiers. Silicon Controlled Rectifiers (SCR) are not acceptable. The converter shall be insensitive to three phase rotation of the ac line and shall not cause displacement power factor of less than .95 lagging under any speed and load condition.

c. An inverter stage shall change fixed dc voltage to variable frequency, variable voltage, ac for application to a standard NEMA design B squirrel cage motor. The inverter shall be switched in a manner to produce a sine coded pulse width modulated (PWM) output waveform.

d. The VFD shall be capable of supplying 150 percent of rated full load current for one minute at maximum ambient temperature.

e. The VFD shall be designed to operate from a voltage indicated on plans, plus or minus 10 percent, three phase, 60 Hz supply, and control motors with a corresponding voltage rating.

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

g. Adjustable full-time current limiting shall limit the current to a preset value which shall not exceed 120 percent of the controller rated current. The current limiting action shall maintain the V/Hz ratio constant so that variable torque can be maintained. Short time starting override shall allow starting current to reach 175 percent of controller rated current to maximum starting torque.

h. The controllers shall 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 shall be included such that a failure in the controller electronic circuitry shall not cause frequency to exceed 110 percent of the maximum controller output frequency selected.

i. Minimum and maximum output frequency shall 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 shall not be less than 96 percent.

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

l. Protection of power semiconductor components shall be accomplished without the use of fast acting semiconductor output fuses. Subjecting the controllers to any of the following conditions shall 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 shall be included such that current exceeding an adjustable threshold shall activate a 60 second timing circuit. Should current remain above the threshold continuously for the timing period, the controller will automatically shut down.

n. A slip compensation circuit shall be included which will sense changing motor load conditions and adjust output frequency to provide speed regulation of NEMA B motors to within plus or minus 0.5 percent of maximum speed without the necessity of a tachometer generator.

o. The VFD shall 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 VFD shall 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.

p. The VFD shall include external fault reset capability. All the necessary logic to accept an external fault reset contact shall be included.

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

r. Provide the following operator control and monitoring devices mounted on the front panel of the VFD:

(1) Manual speed potentiometer.

(2) Hand-Off-Auto (HOA) switch.

(3) Power on light.

(4) Drive run power light.

(5) Local display.

s. Provide properly sized NEMA rated by-pass and isolation contactors to enable operation of motor in the event of VFD failure. Mechanical and electrical interlocks shall be installed between the by-pass and isolation contactors. Provide a selector switch and transfer delay timer.

2.2 ENCLOSURES

Provide equipment enclosures conforming to NEMA 250, NEMA ICS 7, NEMA ICS 6.

2.3 WIRES AND CABLES

All wires and cables shall conform to NEMA 250, NEMA ICS 7, NFPA 70.

2.4 NAMEPLATES

Nameplates external to NEMA enclosures shall conform with the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Nameplates internal to enclosures shall be manufacturer's standard, with the exception that they must be permanent.

2.5 SOURCE QUALITY CONTROL

2.5.1 VFD Factory Test Plan

To ensure quality, each VFD shall be subject to a series of in-plant quality control inspections before approval for shipment from the manufacturer's facilities. Provide test plans and 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 shall supervise the installation of all equipment, and wiring.

3.2 FIELD QUALITY CONTROL

Specified products shall be tested as a system for conformance to specification requirements prior to scheduling the acceptance tests. Contractor shall conduct performance verification tests in the presence of Government representative, observing and documenting complete compliance of the system to the specifications. Contractor shall submit a signed copy of the test results, certifying proper system operation before scheduling tests.

3.2.1 VFD Test

A proposed test plan shall be submitted to the contracting officer at least 28 calendar days prior to proposed testing for approval. The tests shall 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. The contractor shall inform the Government at least 14 working days prior to the dates of testing. Contractor shall provide video tapes, if available, of all training provided to the Government for subsequent use in training new personnel. 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.

3.2.2 Performance Verification Tests

"Performance Verification Test" plan shall provide the step by step procedure required to establish formal verification of the performance of the VFD. Compliance with the specification requirements shall 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. The contractor shall inform the Government 14 calendar days

prior to the date the test is to be conducted.

3.2.3 Endurance Test

Immediately upon completion of the performance verification test, the endurance test shall commence. The system shall be operated at varying rates for not less than 192 consecutive hours, at an average effectiveness level of .9998, to demonstrate proper functioning of the complete PCS. Continue the test on a day-to-day basis until performance standard is met. During the endurance test, the contractor shall not be allowed in the building. The system shall respond as designed.

3.3 DEMONSTRATION

3.3.1 Training

Coordinate training requirements with the Contracting Officer.

3.3.1.1 Instructions to Government Personnel

Provide the services of competent instructors 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 shall be thoroughly familiar with the subject matter they are to teach. The Government personnel designated to attend the training will have a high school education or equivalent. The number of training days of instruction furnished shall 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 shall be turned over to the Government at the end of last training session.

3.3.1.2 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

3.3.1.3 Engineering/Maintenance Personnel Training

Accomplish the training program as specified. Training shall be conducted on site at a location designated by the Government. Provide a one-day training session to train 4 engineering personnel in the functional operations of the system. This training shall include:

a. System overview

b. General theory of operation

c. System operation

d. System configuration

e. Alarm formats

f. Failure recovery procedures

g. Troubleshooting and repair

h. Maintenance and calibration

i. System programming and configuration

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UNINTERRUPTIBLE POWER SUPPLY (UPS) SYSTEM ABOVE 15 KVA CAPACITY
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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 450	(2010) Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications
IEEE 485	(2010) Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications
IEEE C57.110	(2008) Recommended Practice for Establishing Liquid-Filled and Dry-Type Power and Distribution Transformer Capability When Supplying Nonsinusoidal Load Currents
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 ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA PE 1	(2012; R 2017) Uninterruptible Power Systems (UPS) Specification and Performance Verification

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2017; ERTA 1-2 2017; TIA 17-1; TIA 17-2; TIA 17-3; TIA 17-4; TIA 17-5; TIA 17-6; TIA 17-7; TIA 17-8; TIA 17-9; TIA 17-10; TIA 17-11; TIA 17-12; TIA 17-13; TIA 17-14) National Electrical Code

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When

used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

UPS System
Installation

SD-03 Product Data

Spare Parts
Field Training; G

SD-06 Test Reports

Factory Testing
Field Supervision, Startup and Testing

SD-10 Operation and Maintenance Data

Operating and Maintenance Manuals; G

1.3 QUALITY ASSURANCE

1.3.1 Reliability

UPS shall have a minimum acceptable system Mean Time Between Failures (MTBF) of 105,000 hours. A failure is defined as any interruption to or degradation of the UPS output. Automatic switching to bypass due to a problem with the UPS system does not constitute a failure, provided that the critical load is not disturbed.

1.3.2 Maintainability

UPS shall have a maximum acceptable system Mean Time To Repair (MTTR) of 30 minutes. Repair time is defined as the clock time from the arrival of the service technician to the time when the UPS is restored to service either by repair or substitution of the failed component.

1.4 DELIVERY, STORAGE, AND HANDLING

Equipment placed in storage shall be protected from humidity and temperature variations, dirt, dust, or other contaminants.

1.5 PROJECT/SITE CONDITIONS

1.5.1 Environmental Requirements

The UPS and battery system shall be capable of withstanding any combination of the following external environmental conditions without mechanical or electrical damage or degradation of operating characteristics.

1.5.1.1 Operating Altitude

Sea level to 4,000 feet. (Systems applied at higher altitudes shall be

derated in accordance with the manufacturer's instructions).

1.5.1.2 Non-Operating Altitude

Sea level to 40,000 ft.

1.5.1.3 Operating Ambient Temperature Range

32 to 104 degrees F.

1.5.1.4 Non-Operating and Storage Ambient Temperature Range

Minus 4 to plus 140 degrees F.

1.5.1.5 Operating Relative Humidity

0 to 95 percent, without condensation.

1.5.2 Sound Pressure Levels

Sound pressure levels produced by the UPS, when operating under full rated load, at a distance of 5 feet in any direction from the perimeter of the unit, shall not exceed 75 dB as measured on the A scale of a standard sound level meter at slow response.

1.6 EXTRA MATERIALS

Provide one set of special tools, calibration devices, and instruments required for operation, calibration, and maintenance of the equipment. Submit spare parts data for each different item of material and equipment specified, not later than the date of beneficial occupancy, including a complete list of parts and supplies with current unit prices and source of supply and an itemized price breakdown of spare parts recommended for stocking. The recommended spare parts selected shall be those which, in the manufacturer's judgment, will be involved in the majority of maintenance difficulties encountered.

PART 2 PRODUCTS

2.1 SYSTEM REQUIREMENTS

Provide a UPS system consisting of UPS module, battery system, battery protective device, system cabinet, static bypass transfer switch, controls and monitoring. Connect input ac power to the normal source ac input of the UPS module. The battery shall be connected to the dc input of the UPS module through the battery protective device. The ac output of the UPS system shall be connected to the critical loads. Active electronic devices shall be solid state. Semiconductor devices shall be sealed. Relays shall be dust-tight.

2.1.1 UPS Module and Battery System

UPS module shall contain required input isolation transformer, rectifier/charger unit, inverter unit and controls, battery protective device, and any other specified equipment/devices. Battery system shall contain the battery cells, racks, battery disconnect, battery monitor and cabinet, if required.

2.1.2 UPS System Devices

The UPS system shall include the system cabinet, static bypass transfer switch, system protective devices, monitoring and controls, means of isolating the system from the critical load, and remote monitoring interfaces.

2.1.3 Design Requirements

2.1.3.1 Semiconductor Fusing

Power semiconductors shall be fused to prevent cascaded or sequential semiconductor failures. Indicator lamp denoting blown fuse conditions shall be readily observable by the operator without removing panels or opening cabinet doors.

2.1.3.2 Interchangeability

The subassemblies in one UPS module shall be interchangeable with the corresponding modules within the same UPS, and from one UPS system to another of identical systems.

2.1.3.3 Control Power

Control power shall be derived from two sources, input and output, with automatic selective control. The control power circuit shall have suitable protection, appropriately marked and located in the immediate vicinity of the input protective device.

2.1.3.4 EMI/RFI Protection

The components and the system shall be designed to minimize the emission of electromagnetic waves that may cause interference with other equipment.

2.1.3.5 Wiring

Wiring practices, materials, and coding shall be in accordance with the requirements of NFPA 70 and other applicable standards. Wire runs shall be protected in a manner which separates power and control wiring. Control wiring shall be minimum No. 16 AWG extra-flexible stranded copper. Logic-circuit wiring may be smaller. Ribbon cables shall be minimum No. 22 AWG. Control wiring shall have permanently attached wire numbers.

2.1.3.6 Terminations

Terminals shall be supplied for making power and control connections. Terminal blocks shall be provided for field wiring terminals. Terminal blocks shall be heavy-duty, strap-screw type. Terminal blocks for field wiring shall be located in one place in each module and in the system cabinet. Control wiring shall be extended to the terminal block location. No more than two wires shall land on any terminal point. Where control wiring is attached to the same point as power wiring, a separate terminal shall be provided. If bus duct is used, bus stubs shall be provided where bus duct enters cabinets.

2.1.3.7 Internal Assembly

The subassemblies shall be mounted in pull-out and/or swing-out trays

where feasible. Cable connections to the trays shall be sufficiently long to allow easy access to all components. Where not feasible to mount subassemblies in pull-out or swing-out trays, they shall be firmly mounted inside the enclosure. Test points or logic indicators shall be labeled and located on the front edge of the control logic cards, if used.

2.1.3.8 Cabinet Structure

UPS system shall be installed in cabinets of heavy-duty structure meeting the NEMA PE 1 standards for floor mounting. UPS module cabinet shall be structurally adequate for forklift handling or lifting. Removable lifting eyes shall be provided on top of each cabinet. UPS module cabinet shall have hinged and lockable doors on the front only, with assemblies and components accessible from the front. Doors shall be key lockable. Operating controls shall be located outside the locked doors. Input, output, and battery cables shall be installed through the top or bottom of the cabinet.

2.1.3.9 Cabinet Finish

Equipment cabinet shall be cleaned, primed and painted in the manufacturer's standard colors, in accordance with accepted industry standards.

2.1.3.10 Mimic Bus

If painted, mimic bus and other front-panel markings (such as those showing circuit breakers or switches and fuses) shall be painted with durable acrylic-based paint.

2.1.3.11 Live Parts (300 Volts and Above)

Live parts (300 volts and above) that are exposed when front access doors are open shall be adequately protected or covered to minimize the chance of accidental contact.

2.1.3.12 Drawout Assemblies

Drawout assemblies weighing 50 lbs or more shall be provided with a means of lifting, either an overhead device or a hoisting device.

2.1.3.13 Safety

UPS shall be equipped with instruction plates including warnings and cautions, suitably located, describing any special or important procedures to be followed in operating and servicing the equipment.

2.2 STANDARD PRODUCTS

a. Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of such products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Equipment shall be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

b. Parts and materials comprising the UPS system shall be new, of current manufacture, of a high grade and free of defects and imperfections, and shall not have been in prior service except as required during

aging and factory testing.

2.3 NAMEPLATES

Each major item of equipment shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment.

2.4 LOAD PROFILE

The UPS system shall be compatible with the load characteristics of connected equipment and load configuration shown on plans. Provide compensation for UPS/load interaction problems resulting from nonlinear loads or transformer and motor inrush.

2.5 UPS SYSTEM RATINGS

Unless stated otherwise, the parameters listed are under full output load at 0.8 power factor, with batteries fully charged and floating on the dc bus and with nominal input voltage.

2.5.1 System Capacity

Overall 30 kVA, 24 kW, non redundant, at 40 degrees C.

2.5.2 Module Capacity

As indicated

concrete sealer2.5.3 Battery Capacity

Discharge time to end voltage: 15 minutes, at 77 degrees F. Battery shall be capable of delivering 125 percent of full rated UPS load at initial start-up.

2.5.4 Static Switch

100 amperes, 30,000 amperes symmetrical Symmetrical interrupting capacity.

2.5.5 System Bus Bracing

Braced for 30,000 amperes symmetrical interrupting capacity.

2.5.6 ac Input

2.5.6.1 Voltage

480 volts line-to-line.

2.5.6.2 Number of Phases

3-phase, 3-wire, plus ground.

2.5.6.3 Voltage Range

Plus 10 percent, minus 15 percent, without affecting battery float voltage or output voltage.

2.5.6.4 Frequency

60 Hz, plus or minus 5 percent.

2.5.6.5 Power Walk-In

20 percent to 100 percent over 15 to 24 seconds.

2.5.6.6 Total Harmonic Current Distortion (Thd) Reflected into the Primary Line

5 percent maximum.

2.5.6.7 Transformer Sub-Cycle Inrush

4 to 8 times full load rating.

2.5.7 ac Output

2.5.7.1 Voltage

208 volts line-to-line, 120 volts line-to-neutral.

2.5.7.2 Number of Phases

3-phase, 4-wire, plus ground.

2.5.7.3 Voltage Regulation

2.5.7.3.1 Balanced Load

Plus or minus 1.0 percent.

2.5.7.3.2 Load Imbalance

50 percent load imbalance, phase-to-phase; plus or minus 2 percent.

2.5.7.3.3 Voltage Modulation

No-load voltage modulation; Plus or minus 1 percent.

2.5.7.3.4 Voltage Drift

Plus or minus 1 percent over any 30 day interval (or length of test) at stated ambient conditions.

2.5.7.4 Voltage Adjustment

Plus or minus 5 percent manually.

2.5.7.5 Frequency

60 Hz

2.5.7.6 Frequency Regulation

Plus or minus 0.1 percent.

2.5.7.7 Frequency Drift

Plus or minus 0.1 percent over any 24 hour interval (or length of test) at stated ambient conditions when on internal oscillator.

2.5.7.8 Harmonic Content (RMS Voltage)

3 percent single harmonic, maximum; 5 percent total maximum with linear load. Voltage THD shall be less than 7 percent with up to 50 percent nonlinear load and a crest factor of less than 3 to 1.

2.5.7.9 Load Power Factor Operating Range

1.0 to 0.8 lagging.

2.5.7.10 Phase Displacement

2.5.7.10.1 Balanced Load

Plus or minus 1 degree of bypass input.

2.5.7.10.2 50 Percent Load Imbalance Phase-to-Phase

Plus or minus 3 degrees of bypass input.

Wave-Form Deviation Factor

5 percent at no load.

2.5.7.11 Overload Capability (at Full Voltage) (Excluding Battery)

a. 125 percent load for 10 minutes.

b. 150 percent load for 30 seconds.

c. 300 percent load for one cycle after which it shall be current limited to 150 percent until fault is cleared or UPS goes to bypass.

2.5.7.12 Load Sharing of Parallel Modules

Plus or minus 5 percent of average load per module.

2.5.8 Transient Response

2.5.8.1 Voltage Transients

2.5.8.1.1 50 Percent Load Step/0 Percent to 50 Percent Load

Plus or minus 8 percent.

2.5.8.1.2 50 Percent Load Step/50 Percent to 100 Percent Load

Plus or minus 8 percent.

2.5.8.1.3 Loss or Return of ac Input

Plus or minus 1 percent.

2.5.8.1.4 Loss or Return of Redundant Module:

2.5.8.1.4.1 Manually

Plus or minus 8 percent.

2.5.8.1.4.2 Automatically

Plus or minus 8 percent.

2.5.8.1.5 Automatic Transfer of Load from UPS to Bypass

Plus or minus 4 percent.

2.5.8.1.6 Manual Retransfer of Load from Bypass to UPS

Plus or minus 4 percent.

2.5.8.1.7 Response Time

Recovery to 99 percent steady-state condition within 50 milliseconds after any of the above transients.

2.5.8.2 Frequency

2.5.8.2.1 Transients

Plus or minus 0.5 Hz maximum.

2.5.8.2.2 Slew Rate

1.0 Hz maximum per second.

2.5.9 Efficiency

2.5.9.1 Minimum Single-Module Efficiency

90 percent at full load kW.

2.5.9.2 Minimum System Efficiency

89 percent at full system load kW.

2.6 UPS MODULE

2.6.1 General Description

UPS module shall consist of a rectifier/charger unit and a 3-phase inverter unit with their associated transformers, synchronizing equipment, protective devices and accessories as required for operation.

2.6.2 Rectifier/Charger Unit

Rectifier/charger unit shall be solid state and shall provide direct current to the dc bus.

2.6.2.1 Input Protective Device

Rectifier/charger unit shall be provided with an input protective device. The protective device shall be sized to accept simultaneously the

full-rated load and the battery recharge current. The protective device shall be capable of shunt tripping and shall have 35,000 amperes symmetrical interrupting capacity. The protective device shall have provision for locking in the "off" position. A surge suppression device shall be installed at the UPS input to protect against lightning and switching surges.

2.6.2.2 Power Transformer

A dry-type, isolated-winding power transformer shall be used for the rectifier unit. The transformer's hottest spot winding temperature shall not exceed the temperature limit of the transformer insulation material when operating at full load. The transformer insulation shall be Class H, 150 degrees C rise. Transformer connections shall be accessible from the front.

2.6.2.3 Power Walk-In

Rectifier/charger unit shall be protected by a power walk-in feature such that when ac power is returned to the ac input bus, the total initial power requirement will not exceed 20 percent of the rated full load current. This demand shall increase gradually to 100 percent of the rated full load current plus the battery charging current over the specified time interval.

2.6.2.4 Sizing

Rectifier/charger unit shall be sized for the following two simultaneous operating conditions:

a. Supplying the full rated load current to the inverter.

b. Recharging a fully-discharged battery to 95 percent of rated ampere-hour capacity within ten times the discharge time after normal ac power is restored, with the input protective device closed.

2.6.2.5 Battery Charging Current

2.6.2.5.1 Primary Current Limiting

Battery-charging current shall be voltage regulated and current limited. The battery-charging current limit shall be separately adjustable from 2 percent to 25 percent of the maximum discharge current. After the battery is recharged, the rectifier/charger unit shall maintain the battery at full float charge until the next operation under input power failure. Battery charger shall be capable of providing equalizing charge to the battery.

2.6.2.5.2 Second Step Current Limiting

The rectifier/charger unit shall also have a second-step battery current limit. This second-step current limit shall sense actual battery current and reduce the input power demand for battery recharging to 50 percent (adjustable from 30 percent to 70 percent) of the normal rate without affecting the system's ability to supply full-rated power to the connected load. The second-step current-limit circuit shall be activated by a dry contact signal from the generator set controls and shall prevent normal rate battery recharging until utility power is restored.

2.6.2.6 Output Filter

Rectifier/charger unit shall have an output filter to minimize ripple current supplied to the battery; the ripple current into the battery shall not exceed 3 percent RMS.

2.6.2.7 dc Voltage Adjustment

Rectifier/charger unit shall have manual means for adjusting dc voltage for battery equalization, to provide voltage within plus 10 percent of nominal float voltage.

2.6.2.8 Battery Isolation Protective Device

Module shall have a dc protective device to isolate the module from the battery system. The protective device size and interrupting rating shall be as required by system capacity and shall incorporate a shunt trip as required by circuit design. The protective device shall have provision for locking in the "off" position.

2.6.3 Inverter Unit

Inverter unit shall be a solid-state device capable of accepting power from the dc bus and providing ac power within specified limits.

2.6.3.1 Output Overload

The inverter shall be able to sustain an overload as specified across its output terminals. The inverter shall not shut off, but shall continue to operate within rated parameters, with inverse-time overload shutdown protection.

2.6.3.2 Synchronism

The inverter shall normally operate in phase-lock and synchronism with the bypass source. Should the bypass source frequency deviate beyond 60 Hz by more than 0.5 Hz, the internal frequency oscillators contained in the power module shall be used to derive the new frequency reference. Upon restoration of the bypass source within the required tolerance, the inverter shall resynchronize with that source at a slew rate not exceeding the specified rate. The oscillator shall be temperature compensated and shall be manually adjustable. The design of the oscillator and synchronizing circuits shall be such that failure of any associated component, connector pin, terminal lead wire or dc power source in either the open or shorted mode shall affect only one inverter leg. Such failure shall not cause transient disturbance of the critical load in excess of the stated limits.

2.6.3.3 Phase Balance

Electronic controls shall be incorporated to provide individual phase voltage compensation to obtain phase balance.

2.6.3.4 Modular Construction

Each control logic printed circuit board shall be electrically and physically packaged on an individual plug-in module with separate indication and adjustments.

2.6.3.5 Output Protective Device

The output protective device shall be capable of shunt tripping and shall have interrupting capacity as specified. Protective device shall have provision for locking in the "off" position.

2.6.3.6 Output Transformer

The inverter output transformer shall be similar to the input transformer and shall be capable of handling up to K-13 nonlinear loads as described in IEEE C57.110.

2.6.3.7 Modular Inverter Isolation

Each inverter in the UPS system shall have fault sensing and static isolation as well as an output protective device, to remove a faulted module from the system without affecting the critical load bus beyond the stated limits.

2.6.4 External Protection

UPS module shall have built-in self-protection against undervoltage, overvoltage, overcurrent and surges introduced on the ac input source and/or the bypass source. The UPS system shall sustain input surges without damage in accordance with IEEE C62.41.1 and IEEE C62.41.2. The UPS shall also have built-in self-protection against overvoltage and voltage surges introduced at the output terminals by paralleled sources, load switching, or circuit breaker operation in the critical load distribution system.

2.6.5 Internal Protection

UPS module shall be self-protected against overcurrent, sudden changes in output load and short circuits at the output terminals. UPS module shall be provided with output reverse power detection which shall cause that module to be disconnected from the critical load bus when output reverse power is present. UPS module shall have built-in protection against permanent damage to itself and the connected load for predictable types of failure within itself and the connected load. At the end of battery discharge limit, the module shall shut down without damage to internal components.

2.7 STATIC BYPASS TRANSFER SWITCH

Provide a static bypass transfer switch as an integral part of the UPS consisting of a static switch and a bypass protective device or bypass switch. The control logic shall contain an automatic transfer circuit that senses the status of the inverter logic signals and alarm conditions and provides an uninterrupted transfer of the load to the bypass ac power source, without exceeding the transient limits specified herein, when a malfunction occurs in the UPS or when an external overload condition occurs. The power section of the static bypass transfer switch shall be provided as a plug-in type assembly to facilitate maintenance. The static bypass transfer switch shall be used to connect the bypass ac power source or the UPS inverter output to the critical load when required, and shall have the following features:

2.7.1 Uninterrupted Transfer

The static bypass transfer switch shall automatically cause the bypass ac power source to assume the critical load without interruption when the bypass control logic senses one of the following conditions and the UPS inverter output is synchronized to the bypass ac power source:

a. Inverter overload exceeds unit's rating.

b. Battery protection period is expired and bypass is available.

c. Inverter failure.

2.7.2 Interrupted Transfer

If an overload occurs and the UPS inverter output is not synchronized to the bypass ac power source, the UPS inverter output shall current-limit for 200 milliseconds minimum. The inverter shall then turn off and an interrupted transfer to the bypass ac power source shall be made. If the bypass ac power source is beyond the conditions stated below, an interrupted transfer shall be made upon detection of a fault condition:

a. Bypass voltage greater than plus or minus 10 percent from the UPS rated output voltage.

b. Bypass frequency greater than plus or minus 0.5 Hz from the UPS rated output frequency.

c. Phase differential of ac bypass voltage to UPS output voltage greater than plus or minus 3 degrees.

2.7.3 Manual Transfer

It shall be possible to make a manually-initiated static transfer from the system status and control panel by turning the UPS inverter off.

2.7.4 Automatic Uninterrupted Forward Transfer

The static bypass transfer switch shall automatically forward transfer, without interruption after the UPS inverter is turned "on", or after an instantaneous overload-induced reverse transfer has occurred and the load current has returned to less than the unit's 100 percent rating.

2.7.5 Forced Transfer

The control logic circuitry shall provide the means of making a forced or reverse transfer of the static bypass transfer switch on an interrupted basis. Minimum interruption shall be 200 milliseconds when the UPS inverter is not synchronized to the bypass ac power source.

2.7.6 Overload Ratings

The static bypass transfer switch shall withstand the following overload conditions:

a. 2000 percent of UPS output rating for two cycles.

b. 200 percent of UPS output rating for 5 minutes.

c. 125 percent of UPS output rating for 10 minutes.

2.7.7 Static Switch Disconnect

A static switch disconnect shall be incorporated to isolate the static bypass transfer switch assembly so it can be removed for servicing. The switch shall be equipped with auxiliary contacts and provision for padlocking in either the "on" or "off" position.

2.8 MAINTENANCE BYPASS SWITCH

2.8.1 General

Provide a maintenance bypass switch as an integral part of the UPS located within the UPS module. The maintenance bypass switch shall provide the capability to continuously support the critical load from the bypass ac power source while the UPS is isolated for maintenance. The maintenance bypass switch shall be housed in an isolated compartment inside the UPS cabinet in such a way that service personnel will not be exposed to electrically live parts while maintaining the unit. Switch shall contain a maintenance bypass protective device and a module isolation protective device.

2.8.2 Load Transfer

The maintenance bypass switch shall provide the capability of transferring the critical load from the UPS static bypass transfer switch to maintenance bypass and then back to the UPS static bypass transfer switch with no interruption to the critical load.

2.9 MODULE CONTROL PANEL

The UPS module shall be provided with a control/indicator panel. The panel shall be on the front of the UPS module. Controls, meters, alarms and indicators for operation of the UPS module shall be on this panel.

2.9.1 Module Meters

2.9.1.1 Monitored Functions

The following functions shall be monitored and displayed:

a. Input voltage, phase-to-phase (all three phases).

b. Input current, all three phases.

c. Input frequency.

d. Battery voltage.

e. Battery current (charge/discharge).

f. Output voltage, phase-to-phase and phase-to-neutral (all three phases).

g. Output current, all three phases.

h. Output frequency.

i. Output kilowatts.

j. Elapsed time meter to indicate hours of operation, 6 digits.

k. Bypass voltage, phase-to-phase and phase-to-neutral (all three phases).

l. Output kilovars.

m. Output kilowatt hours, with 15-minute demand attachment.

2.9.1.2 Meter Construction

Meters shall have 1 percent accuracy and shall be digital type (minimum 4 significant digits).

2.9.2 Module Controls

Module shall have the following controls:

a. Lamp test/reset pushbutton.

b. Alarm test/reset pushbutton.

c. Module input protective device trip pushbutton, with guard.

d. Module output protective device trip pushbutton, with guard.

e. Battery protective device trip pushbutton, with guard.

f. Emergency off pushbutton, with guard.

g. dc voltage adjustment potentiometer, with locking guard.

h. Control power off switch.

i. UPS/bypass transfer selector switch.

j. Static bypass transfer switch enable/disable selector switch.

2.9.3 Module Alarm Indicators

Module shall have indicators for the following alarm items. Any one of these conditions shall turn on an audible alarm and the appropriate summary indicator. Each new alarm shall register without affecting any previous alarm.

a. Input ac power source failure.

b. Input protective device open.

c. Output protective device open.

d. Overload.

e. Overload shutdown.

f. dc overvoltage.

g. dc ground fault.

h. Low battery.

i. Battery discharged.

j. Battery protective device open.

k. Blower failure.

l. Input transformer overtemperature.

m. Inverter transformer overtemperature.

n. Equipment overtemperature.

o. Operating on internal oscillator.

p. Fuse blown.

q. Control power failure.

r. Charger off.

s. Inverter off.

t. Emergency off.

u. UPS on battery.

v. Critical load on static bypass.

w. Static bypass transfer switch disabled.

x. Inverter output overvoltage.

y. Inverter output undervoltage.

z. Inverter output overfrequency.

aa. Inverter output underfrequency.

bb. Bypass source overvoltage.

cc. Bypass source undervoltage.

dd. Bypass source overfrequency.

ee. Bypass source underfrequency.

ff. Bypass source to inverter out of synchronization.

2.9.4 Module Mimic Panel

UPS module shall have a mimic panel in the format of a module single-line diagram, with status indicators for input, output, battery protective devices, and battery disconnect switch. Each protective device shall have indicators for open (green) and closed (red), to give positive indication. The mimic panel shall provide indication of the following additional functions:

a. Charger on (functional).

b. UPS on-line (inverter furnishing load power).

c. UPS on-bypass (static switch operating).

d. System alarm (flashes for abnormalities, minor or major faults).

2.9.5 Module Emergency Off Button

Pressing the emergency off button shall cause the affected module to be disconnected from the system, via its input protective device, output protective device, and battery protective device. Activation of this button shall not affect the operation of the remainder of the system.

2.10 SELF-DIAGNOSTIC CIRCUITS

The control logic shall include status indicators for trouble-shooting the control circuits. These indicators shall be mounted on the circuit card edge or face such that they will be visible without repositioning the card, and shall be labeled with the function name.

2.11 INDICATORS

Minimum display shall include the following indicators:

a. Load on UPS.

b. Load on battery.

c. Load on bypass.

d. Low battery.

e. Summary alarm.

f. New alarm (to alert the operator that a second summary alarm condition has occurred).

2.12 AUDIBLE ALARM

Any single indicator shall also turn on the audible alarm. An audible alarm test/reset button and lamp test/reset button shall be included. This reset button shall not affect nor reset the alarm on the module.

2.13 TEMPERATURE CONTROL

2.13.1 General

Cabinet and enclosure ventilation shall be adequate to ensure that components are operated within their ratings. Forced-air cooled rectifier, inverter, and control unit will be acceptable. The cooling fans shall continue operation if UPS input power is lost. Redundancy shall be provided so that failure of one fan or associated circuit breaker will not cause an overheat condition. Cooling air shall enter the lower front of the cabinets and exhaust at the top. Blower power failure shall be indicated as a visual and audible alarm on the control panel. Air inlets shall have filters that can be replaced without opening the cabinet doors.

2.13.2 Blower Power Source

Blower power source shall be internally derived from the input and output sides of UPS module, with automatic transfer arrangement.

2.13.3 Temperature Sensors

Temperature sensors shall be provided to monitor the air temperature. Separate sensors shall monitor the temperature of rectifier and inverter heat sinks. Separate sensors shall also monitor the transformer temperature. Critical equipment overtemperature indication shall start a timer that shall shut down the UPS system if the temperature does not return below the setpoint level in 15 minutes.

2.14 BATTERY SYSTEM

2.14.1 General

A storage battery with sufficient ampere-hour rating to maintain UPS output at full capacity for the specified duration shall be provided for each UPS module. The battery shall be of heavy-duty, industrial design suitable for UPS service. The cells shall be provided with flame arrestor vents, intercell connectors and cables, cell-lifting straps, cell-numbering sets, and terminal grease. Intercell connectors shall be sized to maintain terminal voltage within voltage window limits when supplying full load under power failure conditions. Cell and connector hardware shall be stainless steel of a type capable of resisting corrosion from the electrolyte used.

2.14.2 Battery Ratings

Type	nickel cadmium
Specific gravity when fully charged	1.215
End voltage	1.67 volts per cell
Float voltage	2.17 to 2.26 volts per cell
Equalizing voltage	2.33 to 2.38 volts per cell

2.14.3 Battery Construction

The battery shall be of the valve-regulated, sealed, non-gassing, recombinant type.

2.14.4 Battery Cabinet

The battery pack assembly shall be furnished in a battery cabinet matching the UPS cabinet. The battery cabinet shall be designed to allow for checking the torque on the connections in the battery system and to provide adequate access for annual housekeeping chores. External wiring interface shall be through the bottom or top of the assembly. A smoke and high temperature alarm shall annunciate detection of either smoke or high temperature within the battery cabinet.

2.14.5 Cell-Terminal Covers

Acid-resistant transparent cell-terminal covers not exceeding 6 feet in length and with vent holes drilled on top where needed shall be provided.

2.14.6 Battery Disconnect

Each battery pack assembly shall have a fused disconnect switch provided in a NEMA 1 enclosure, finished with acid-resistant paint and located in line with the assembly. Switch shall be complete with line side and load side bus bars for connection to battery cells. Switch shall be rated as required by system capacity, and shall have an external operator that is lockable in the "off" position.

2.14.7 Battery Monitor

A battery monitor shall be provided for each battery pack assembly. At a minimum, this device shall monitor the following parameters:

a. Total system voltage.

b. Ambient room temperature.

c. Total battery discharge cycles with a duration of greater than 5 minutes.

The monitor shall also record the total accumulated discharge minutes and accumulated battery system discharge kW hours.

2.15 FACTORY TESTING

The UPS system shall be factory tested to meet the requirements specified using a test battery (not the battery to be supplied with the system). UPS module shall be factory load tested as an independent assembly with 3-phase ac input power and with battery power for a minimum of 8 hours, with meter readings taken every 30 minutes. Load shall be balanced at rated kVA and rated power factor.

a. Submit a detailed description of proposed factory test and field test procedures, including proposed dates and steps outlining each test, how it is to be performed, what it accomplishes, and its duration, not later than 2 months prior to the date of each test.

b. Factory tests for the UPS module shall be run under full load, and will be witnessed by the Government. Should a malfunction occur, the problem shall be corrected and the test shall be repeated. As a minimum, the factory tests shall include the parameters described in paragraphs ac Input, ac Output, Transient Response and Efficiency. The tests shall encompass all aspects of operation, such as module failure, static bypass operation, battery failure, input power failure and overload ratings.

c. Notify the Government in writing at least 2 weeks before testing. Factory-test time shall not be used for system debugging and/or checkout. Such work shall be done prior to notifying the Government that the system is ready for testing. Factory tests shall be performed during normal business hours. The system shall be interconnected and tested for an additional 8 hours to ensure proper wiring and performance.

d. Submit factory and field test reports in booklet form tabulating factory and field tests and measurements performed, upon completion and testing of the installed system. Factory and field test reports shall be signed by an official authorized to certify on behalf of the manufacturer of the UPS system that the system meets specified requirements. The reports shall be dated after the award of this contract, shall state the Contractor's name and address, shall name the project and location, and shall list the specific requirements which are being certified.

2.15.1 Transient Tests

Transient tests shall be conducted using high-speed oscillograph type recorders to demonstrate the operation of the components to the satisfaction of the Government. These tests shall include 50 percent to 100 percent load changes, manual transfer, manual retransfer, low dc bus initiated transfer and low ac output bus transfer. A recording instrument equipped with an event marker shall be used.

2.15.2 Efficiency Tests

Testing for efficiency shall be performed at zero output up to 100 percent of stated kVA output in 25 percent steps, 0.9 power factor, with battery fully charged and floating on the dc bus, with nominal input voltage, and with modules connected to the system to represent actual operating conditions.

2.16 INSPECTION

Inspection before shipment is required. The manufacturer shall notify the Government at least 2 weeks before shipping date so that an inspection can be made.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with details of the work, verify dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 INSTALLATION

The UPS system shall be set in place, wired and connected in accordance with the approved shop drawings and manufacturer's instructions. Submit detail drawings consisting of a complete list of equipment and materials, manufacturer's descriptive and technical literature, battery sizing calculations according to IEEE 485, installation instructions, single-line diagrams, ladder-type schematic diagrams, elevations, layout drawings, and details required to demonstrate that the system has been coordinated and will function properly as a unit. The UPS battery shall be shipped to the site dry.

3.3 FIELD SUPERVISION, STARTUP AND TESTING

The services of a manufacturer's representative who is experienced in the installation, adjustment, and operation of the equipment specified shall be provided. The representative shall supervise the installation,

adjustment and testing of the equipment. The representative shall check the wiring between equipment, start up the system, and field test the functions, interlocks and protective devices to ensure that the total system is functioning according to the intent of the design. The field tests shall be performed under the supervision of a factory-trained representative of the equipment manufacturer and witnessed by the Government. The Government shall be given 2 weeks written advance notice of the date and time when testing will be conducted.

3.3.1 Field Tests

As a minimum, the startup and field test procedures shall include the following:

a. Ensure that shipping members have been removed.

b. Check for damage (dents, scratches, frame misalignment, damage to panel devices, etc).

c. Ensure that interiors are free of foreign materials, tools and dirt.

d. Attach a phase rotation meter to the UPS input, output and bypass buses, and observe proper phase sequences.

e. Torque test bus connections at shipping splits. Also torque test battery connections.

f. Check each electrical bus for proper phasing and identification.

g. Check and test selector switches and meters for proper operation.

h. Check doors for proper alignment and operation.

i. Check and test each protective device for proper mechanical and electrical operation.

j. Check protective device overcurrent trip settings.

k. Check and test indicating lights for proper operation and color.

l. Perform onsite field test procedures.

m. Demonstrate to the Government that the specified functions and interlocks have been implemented.

n. Provide IEEE 450 battery installation certification.

o. Check key interlock key numbers, if used, to ensure agreement with interlocking scheme.

3.3.2 Load Test

The installed system shall be load tested for a continuous 24 hour period by means of resistive load banks. The system shall be continuously tested at 1/2 load for 8 hours, 3/4 load for 8 hours and full load for 8 hours. The equipment manufacturer shall provide resistive load banks of total kW load of equipment to facilitate startup under load conditions, and to conduct load tests described above. Instrument readings shall be recorded every half hour for the following:

a. Input voltage (all three phases, for each module).

b. Input current (all three phases, for each module).

c. Input frequency.

d. Battery voltage for each module.

e. Output voltage (all three phases, for each module).

f. Output current (all three phases, for each module).

g. Output kilowatts for each module.

h. Output frequency.

i. Output voltage (all three phases - system output).

j. Output current (all three phases - system output).

k. Output kilowatts (system output).

3.3.3 Full Load Burn In Test

The installed system shall undergo an additional full load burn-in period of 24 continuous hours. If a failure occurs during the burn-in period, the tests shall be repeated. Instrument readings shall be recorded every half hour as above. During the burn-in period, the following tests shall be performed:

a. With the UPS carrying maximum continuous design load and supplied from the normal source, switch 100 percent load on and off a minimum of five times within the burn-in period.

b. With the UPS carrying maximum continuous design load and supplied from the emergency source, repeat the switching operations described in step a. Also, verify that the UPS module rectifier charger unit(s) go into the second-step current limit mode.

c. With the UPS carrying maximum continuous design load and operating on battery power, repeat the switching operations described in step a above.

d. Continue operation on battery power for 1 minute, then restore normal power.

Furnish a high-speed dual trace oscillograph to monitor ten or more cycles of the above tests at the ON and OFF transitions and two typical steady-state periods, one shortly after the load is energized (at 30 to 60 seconds) and one after operation has stabilized (at 8 to 10 minutes). Four copies of the traces shall be delivered to the Contracting Officer.

3.3.4 Battery Discharge Test

With the battery fully charged, the system shall undergo a complete battery discharge test to full depletion and a recharge to nominal conditions. Instrument readings shall be recorded every minute during discharge for the following:

a. Battery voltage for each module.

b. Battery current for each module.

c. Output voltage (all three phases) for each module.

d. Output current (all three phases) for each module.

e. Output kilowatts for each module.

f. Output voltage (all three phases - system output).

g. Output current (all three phases - system output).

h. Output kilowatts (system output).

i. Output frequency.

3.4 POSTING FRAMED DATA AND INSTRUCTIONS

Framed data and instructions containing wiring and control diagrams under glass or in laminated plastic shall be posted where directed. Condensed operating instructions, prepared in typed form, shall be framed as specified above and posted beside the diagrams. The framed instructions shall be posted before acceptance testing of the system.

3.5 FIELD TRAINING

Provide a field training course, for designated operating and maintenance staff members, for a total period of 12 hours of normal working time starting after the system is functionally complete but prior to final acceptance test. Submit lesson plans and training manuals for the training phases, including type of training to be provided and proposed dates, with a list of reference materials.

a. Divide the 12 hours into two sessions of 6 hours each. Each session shall be conducted on a different day.

b. Field training shall cover the items contained in the operating and maintenance manuals. Submit 6 complete copies of operation manuals for the UPS System outlining the step-by-step procedures required for system startup, operation and shutdown. The instructions shall include the manufacturer's name, equipment model number, service manual, parts list, and brief description of equipment and its basic operational features.

c. Submit 6 complete copies of maintenance manuals listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. Corrective maintenance procedures shall identify the most probable failures and the appropriate repairs. Test measurement levels shall be referenced to specific test points on the installed equipment. Operation and maintenance manuals may be either combined or separate.

-- End of Section --

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SECTION 26 36 00.00 10

AUTOMATIC TRANSFER SWITCH AND BY-PASS/ISOLATION SWITCH
10/07

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	(2016) Standard Practice for Operating Salt Spray (Fog) Apparatus

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 602	(2007) Recommended Practice for Electric Systems in Health Care Facilities - White Book
IEEE C37.13	(2015) Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures
IEEE C37.90.1	(2013) Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
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 ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 1	(2000; R 2015) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 10 Part 2	(2005) AC Transfer Equipment, Part 2: Static AC Transfer Equipment
NEMA ICS 2	(2000; R 2005; Errata 2008) 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 110	(2016) Standard for Emergency and Standby Power Systems
NFPA 70	(2017; ERTA 1-2 2017; TIA 17-1; TIA 17-2; TIA 17-3; TIA 17-4; TIA 17-5; TIA 17-6; TIA 17-7; TIA 17-8; TIA 17-9; TIA 17-10; TIA 17-11; TIA 17-12; TIA 17-13; TIA 17-14) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

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 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings
Equipment
Installation

SD-03 Product Data

Equipment

SD-06 Test Reports

Testing; G

SD-07 Certificates

Equipment
Switching Equipment

SD-10 Operation and Maintenance Data

Switching Equipment; G
Instructions; G

1.3 QUALITY ASSURANCE

1.3.1 Detail Drawings

Submit interface equipment connection diagram showing conduit and wiring between ATS and related equipment. Submit schematic, external connection, one-line schematic and wiring diagram of each ATS assembly. Device, nameplate, and item numbers shown in list of equipment and material shall appear on drawings wherever that item appears. Diagrams shall show interlocking provisions and cautionary notes, if any. Operating instructions shall be shown either on one-line diagram or separately. Unless otherwise approved, one-line and elementary or schematic diagrams shall appear on same drawing.

1.3.2 Switching Equipment

Upon request, manufacturer shall provide notarized letter certifying compliance with requirements of this specification, including withstand current rating (WCR). Submit evidence that ATS withstand current rating (WCR) has been coordinated with upstream protective devices as required by UL 1008. Submit an operating manual outlining step-by-step procedures for system startup, operation, and shutdown. Manual shall include manufacturer's name, model number, service manual, parts list, and brief description of equipment and basic operating features. Manufacturer's spare parts data shall be included with supply source and current cost of recommended spare parts. Manual shall include simplified wiring and control diagrams for system as installed.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Provide material and equipment which are standard products of a manufacturer regularly engaged in manufacturing the products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Submit list of proposed equipment and material, containing a description of each separate item, and certificates of compliance showing evidence of UL listing and conformance with applicable NEMA standards. Such certificates are not required if manufacturer's published data, submitted and approved, reflect UL listing or conformance with applicable NEMA standards. The experience use shall include applications in similar circumstances and of same design and rating as specified ATS. Equipment shall be capable of being serviced by a manufacturer-authorized and trained organization that is, in the Contracting Officer's opinion, reasonably convenient to the site.

2.2 NAMEPLATE

Nameplate showing manufacturer's name and equipment ratings shall be made of corrosion-resistant material with not less than 1/8 inch tall characters. Nameplate shall be mounted to front of enclosure and shall comply with nameplate requirements of NEMA ICS 2.

2.3 AUTOMATIC TRANSFER SWITCH (ATS)

ATS shall be electrically operated and mechanically held in both operating positions. ATS shall be suitable for use in emergency systems described in NFPA 70. ATS shall be UL listed. ATS shall be manufactured and tested in accordance with applicable requirements of IEEE C37.90.1, IEEE C37.13,

IEEE C62.41.1, IEEE C62.41.2, IEEE 602, NEMA ICS 1, NEMA ICS 2, NEMA ICS 10 Part 2, UL 1008 and UL 1066. ATS shall conform to NFPA 110. To facilitate maintenance, manufacturer's instruction manual shall provide typical maximum contact voltage drop readings under specified conditions for use during periodic maintenance. Manufacturer shall provide instructions for determination of contact integrity. ATS shall be rated for continuous duty at specified continuous current rating. ATS shall be fully compatible and approved for use with BP/IS specified. BP/IS shall be considered part of ATS system. ATS shall have following characteristics:

Voltage	As indicated on plans
Number of Phases	Three
Number of Wires	Four
Frequency	60 Hz
Poles	Three switched and switched neutral
ATS WCR	Rated to withstand short-circuit current as indicated on plans
Nonwelding Contacts	Rated for nonwelding of contacts when used with upstream feeder overcurrent devices shown and with available fault current specified.
Main and Neutral Contacts	Contacts shall have silver alloy composition. Neutral contacts shall have same continuous current rating as main or phase contacts .

2.3.1 Override Time Delay

Provide adjustable time delay to override monitored source deviation from 0.5 to 6 seconds and factory set at 1 second. ATS shall monitor phase conductors to detect and respond to sustained voltage drop of 15 percent of nominal between any two normal source conductors and initiate transfer action to emergency source and start engine driven generator after set time period. Pickup voltage shall be adjustable from 85 to 100 percent of nominal and factory set at 90 percent. Dropout voltage shall be adjustable from 75 to 98 percent of pickup value and factory set at 85 percent of nominal.

2.3.2 Transfer Time Delay

Time delay before transfer to emergency power source shall be adjustable from 0 to 5 minutes and factory set at 0 minutes. ATS shall monitor frequency and voltage of emergency power source and transfer when frequency and voltage are stabilized. Pickup voltage shall be adjustable

from 85 to 100 percent of nominal and factory set at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal and factory set at 90 percent.

2.3.3 Return Time Delay

Time delay before return transfer to normal power source shall be adjustable from 0 to 30 minutes and factory set at 30 minutes. Time delay shall be automatically defeated upon loss or sustained undervoltage of emergency power source, provided that normal supply has been restored.

2.3.4 Engine Shutdown Time Delay

Time delay shall be adjustable from 0 to 30 minutes and shall be factory set at 10 minutes.

2.3.5 Exerciser

Provide a generator exerciser timer. Run times shall be user programmable. The generator exerciser shall be selectable between load transfer and engine run only, and shall have a fail-safe feature that will retransfer the ATS to normal during the exercise period.

2.3.6 Auxiliary Contacts

Two normally open and two normally closed auxiliary contacts rated at 15 amperes at 120 volts shall operate when ATS is connected to normal power source, and two normally open and two normally closed contacts shall operate when ATS is connected to emergency source.

2.3.7 Supplemental Features

ATS shall be furnished with the following:

a. Engine start contact.

b. Emergency source monitor.

c. Test switch to simulate normal power outage.

d. Voltage sensing. Pickup voltage adjustable from 85 to 100 percent of nominal; dropout adjustable from 75 to 98 percent of pickup.

e. Time delay bypass switch to override return time delay to normal.

f. Manual return-to-normal switch.

g. Means shall be provided in the ATS to insure that motor/transformer load inrush currents do not exceed normal starting currents. This shall be accomplished with either in-phase monitoring, time-delay transition, or load voltage decay sensing methods. If manufacturer supplies an in-phase monitoring system, the manufacturer shall indicate under what conditions a transfer cannot be accomplished. If the manufacturer supplies a time-delay transition system, the manufacturer shall supply recommendations for establishing time delay. If load voltage decay sensing is supplied, the load voltage setting shall be user programmable.

2.3.8 Operator

Manual operator conforming to UL 1008 shall be provided, and shall incorporate features to prevent operation by unauthorized personnel. ATS shall be designed for safe manual operation under full load conditions. If manual operation is accomplished by opening the door, then a dead-front shall be supplied for operator safety.

2.3.9 Override Switch

Override switch shall bypass automatic transfer controls so ATS will transfer and remain connected to emergency power source, regardless of condition of normal source. If emergency source fails and normal source is available, ATS shall automatically retransfer to normal source.

2.3.10 Green Indicating Light

A green indicating light shall supervise/provide normal power source switch position indication and shall have a nameplate engraved NORMAL.

2.3.11 Red Indicating Light

A red indicating light shall supervise/provide emergency power source switch position indication and shall have a nameplate engraved EMERGENCY.

2.4 BY-PASS/ISOLATION SWITCH (BP/IS)

2.4.1 Design

Bypass/isolation switch (BP/IS) shall permit load by-pass to either normal or emergency power source and complete isolation of associated ATS, independent of ATS operating position. BP/IS and associated ATS shall be products of same manufacturer and shall be completely interconnected and tested at factory and at project site as specified. BP/IS shall be manufactured, listed, and tested in accordance with paragraph AUTOMATIC TRANSFER SWITCH (ATS) and shall have electrical ratings that exceed or equal comparable ratings specified for ATS. Operating handles shall be externally operated and arranged so that one person can perform the bypass and isolation functions through the operation of a maximum of two handles within 5 seconds. The ATS shall have provisions for locking in the isolation position. Handle for manual operation shall be permanently attached to operating mechanism. BP/IS operation shall be accomplished without disconnecting switch load terminal conductors. Isolation handle positions shall be marked with engraved plates or other approved means to indicate position or operating condition of associated ATS, as follows:

a. Indication shall be provided to show that ATS section is providing power to the load.

b. Indication shall be provided of ATS isolation. The ATS controls shall 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 shall be capable of functioning as a manual transfer switch to transfer the load to either power source. The ATS shall be capable of undergoing functional operation testing without service interruption. The ATS may also be completely removed from the enclosure, if required for maintenance or repair, while the bypass section continues to power the load.

2.4.2 Switch Construction

Bypass/isolation switch shall be constructed for convenient removal of parts from front of switch enclosure without removal of other parts or disconnection of external power conductors. Contacts shall be as specified for associated ATS, including provisions for inspection of contacts without disassembly of BP/IS or removal of entire contact enclosure. To facilitate maintenance, manufacturer shall provide instructions for determination of contact integrity. BP/IS and associated ATS shall be interconnected with suitably sized copper bus bars silver-plated at each connection point, and braced to withstand magnetic and thermal forces created at WCR specified for associated ATS.

2.5 ENCLOSURE

ATS and accessories shall be installed in free-standing, floor-mounted, ventilated NEMA ICS 6, Type 1, smooth sheet metal enclosure constructed in accordance with applicable requirements of UL 1066 and/or UL 1008. Metal gauge shall be not less than No. 14. Enclosure shall be equipped with at least two approved grounding lugs for grounding enclosure to facility ground system using No. 4 AWG copper conductors. Factory wiring within enclosure and field wiring terminating within enclosure shall comply with NFPA 70. If wiring is not color coded, wire shall be permanently tagged or marked near terminal at each end with wire number shown on approved detail drawing. Terminal block shall conform to NEMA ICS 4. Terminals shall be arranged for entrance of external conductors from top and bottom of enclosure as shown. Main switch terminals, including neutral terminal if used, shall be pressure type suitable for termination of external copper conductors shown.

2.5.1 Construction

Enclosure shall be constructed 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. Enclosure of ATS with BP/IS shall be constructed to protect personnel from energized BP/IS components during ATS maintenance.

2.5.2 Cleaning and Painting

Both the inside and outside surfaces of an enclosure, including means for fastening, shall be protected 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. Finish shall be manufacturer's standard material, process, and color and shall be free from runs, sags, peeling, or other defects. An enclosure marked Type 1, 3R, 4 or 12 shall be 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.

2.6 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 2 weeks prior to test date. Submit certified factory and

field test reports, within 14 days following completion of tests. Reports shall be certified and dated and shall demonstrate that tests were successfully completed prior to shipment of equipment.

2.6.1 Factory Testing

A prototype of specified ATS shall be factory tested in accordance with UL 1008. In addition, factory tests shall be performed 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.

2.6.2 Factory Test Reports

Manufacturer shall provide three certified copies of factory test reports.

PART 3 EXECUTION

3.1 INSTALLATION

ATS shall be installed as shown and in accordance with approved manufacturer's instructions. Submit dimensioned plans, sections and elevations showing minimum clearances, weights, and conduit entry provisions for each ATS.

3.2 INSTRUCTIONS

Manufacturer's approved operating instructions shall be permanently secured to cabinet where operator can see them. One-line and elementary or schematic diagram shall be permanently secured to inside of front enclosure door. Submit 6 copies of operating and 6 copies of maintenance manuals listing routine maintenance, possible breakdowns, repairs, and troubleshooting guide.

3.3 SITE TESTING

Following completion of ATS installation and after making proper adjustments and settings, site tests shall be performed in accordance with manufacturer's written instructions to demonstrate that each ATS functions satisfactorily and as specified. Advise Contracting Officer not less than 5 working days prior to scheduled date for site testing, and provide certified field test reports within 2 calendar weeks following successful completion of site tests. Test reports shall describe adjustments and settings made and site tests performed. Minimum operational tests shall include the following:

3.3.1 Insulation Resistance

Insulation resistance shall be tested, both phase-to-phase and phase-to-ground.

3.3.2 Power Failure of Normal Source

Power failure of normal source shall be simulated by opening upstream protective device. This test shall be performed a minimum of five times.

3.3.3 Power Failure of Emergency Source

Power failure of emergency source with normal source available shall be simulated by opening upstream protective device for emergency source. This test shall be performed a minimum of five times.

3.3.4 Low Phase-to-Ground Voltage

Simulate low phase-to-ground voltage for each phase of normal source.

3.3.5 Operation and Settings

Verify operation and settings for specified ATS features, such as override time delay, transfer time delay, return time delay, engine shutdown time delay, exerciser, auxiliary contacts, and supplemental features.

3.3.6 ATS and BP/IS Functions

Verify mannual and automatic ATS and BP/IS functions.

-- End of Section --

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-- End of Section Table of Contents --

SECTION 26 41 00

LIGHTNING PROTECTION SYSTEM
11/13

PART 1 GENERAL

1.1 REFERENCES

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

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2017; ERTA 1-2 2017; TIA 17-1; TIA 17-2; TIA 17-3; TIA 17-4; TIA 17-5; TIA 17-6; TIA 17-7; TIA 17-8; TIA 17-9; TIA 17-10; TIA 17-11; TIA 17-12; TIA 17-13; TIA 17-14) National Electrical Code
NFPA 780	(2017) Standard for the Installation of Lightning Protection Systems

UNDERWRITERS LABORATORIES (UL)

UL 467	(2013; Reprint Jun 2017) UL Standard for Safety Grounding and Bonding Equipment
UL 96	(2016a) UL Standard for Safety Lightning Protection Components
UL Electrical Constructn	(2012) Electrical Construction Equipment Directory

1.2 RELATED REQUIREMENTS

1.2.1 Verification of Dimensions

Confirm all details of work, verify all dimensions in field, and advise Contracting Officer of any discrepancy before performing work. Obtain prior approval of Contracting Officer before making any departures from the design.

1.2.2 System Requirements

Provide a system furnished under this specification consisting of the latest UL Listed products of a manufacturer regularly engaged in production of lightning protection system components. Comply with NFPA 70, NFPA 780, and UL 96.

1.2.3 Lightning Protection System Installers Documentation

Provide documentation showing that the installer is certified with a commercial third-party inspection company whose sole work is lightning protection, or is a UL Listed Lightning Protection Installer. In either case, the documentation must show that they have completed and passed the requirements for certification or listing, and have a minimum of 2 years documented experience installing lightning protection systems for DoD projects of similar scope and complexity.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Overall lightning protection system; G

Each major component; G

SD-06 Test Reports

Lightning Protection and Grounding System Test Plan; G

Lightning Protection and Grounding System Test; G

SD-07 Certificates

Lightning Protection System Installers Documentation; G

Component UL Listed and Labeled; G

Lightning protection system inspection certificate; G

Roof manufacturer's warranty; G

1.4 QUALITY ASSURANCE

In each standard referred to herein, consider the advisory provisions to be mandatory, as though the word "shall" or "must" has been substituted for "should" wherever it appears. Interpret references in these standards to "authority having jurisdiction," or words of similar meaning, to mean Contracting Officer.

1.4.1 Installation Drawings

1.4.1.1 Overall System Drawing

Submit installation shop drawing for the overall lightning protection system. Include on the drawings the physical layout of the equipment (plan view and elevations), mounting details, relationship to other parts of the work, and wiring diagrams.

1.4.1.2 Major Components

Submit detail drawings for each major component including manufacturer's descriptive and technical literature, catalog cuts, and installation instructions.

1.4.2 Component UL Listed and Labeled

Submit proof of compliance that components are UL Listed and Labeled. Listing alone in UL Electrical Constructn, which is the UL Electrical Construction Directory, is not acceptable evidence. In lieu of Listed and Labeled, submit written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that items have been tested and conform to requirements and testing methods of Underwriters Laboratories.

1.4.3 Lightning Protection and Grounding System Test Plan

Provide a lightning protection and grounding system test plan. Detail both the visual inspection and electrical testing of the system and components in the test plan. Identify (number) the system test points/locations along with a listing or description of the item to be tested and the type of test to be conducted. As a minimum, include a sketch of the facility and surrounding lightning protection system as part of the specific test plan for each structure. Include the requirements specified in paragraph, "Testing of Integral Lightning Protection System" in the test plan.

1.4.4 Lightning Protection System Inspection Certificate

Provide certification from a commercial third-party inspection company whose sole work is lightning protection, stating that the lightning protection system complies with NFPA 780. Third party inspection company cannot be the system installer or the system designer. Alternatively, provide a UL Lightning Protection Inspection Master Label Certificate for each facility indicating compliance to NFPA 780.

Inspection must cover every connection, air terminal, conductor, fastener, accessible grounding point and other components of the lightning protection system to ensure 100% system compliance. This includes witnessing the tests for the resistance measurements for ground rods with test wells, and for continuity measurements for bonds. It also includes verification of proper surge protective devices for power, data and telecommunication systems. Random sampling or partial inspection of a facility is not acceptable.

1.5 SITE CONDITIONS

Confirm all details of work, verify all dimensions in field, and advise Contracting Officer of any discrepancy before performing work. Obtain prior approval of Contracting Officer before changing the design.

PART 2 PRODUCTS

2.1 MATERIALS

Do not use a combination of materials that forms an electrolytic couple of such nature that corrosion is accelerated in the presence of moisture unless moisture is permanently excluded from the junction of such metals.

Where unusual conditions exist which would cause corrosion of conductors, provide conductors with protective coatings, such as tin or lead, or oversize conductors. Where a mechanical hazard is involved, increase conductor size to compensate for the hazard or protect conductors. When metallic conduit or tubing is provided, electrically bond conductor to conduit or tubing at the upper and lower ends by clamp type connectors or welds (including exothermic). All lightning protection components, such as bonding plates, air terminals, air terminal supports and braces, chimney bands, clips, connector fittings, and fasteners are to comply with the requirements of UL 96 classes as applicable.

2.1.1 Main and Bonding Conductors

NFPA 780 and UL 96 Class I, Class II, or Class II modified materials as applicable.

2.1.2 Copper Only

Provide copper conductors, except where aluminum conductors are required for connection to aluminum equipment.

2.2 COMPONENTS

2.2.1 Air Terminals

Provide solid air terminals with a blunt tip. Tubular air terminals are not permitted. Support air terminals more than 24 inches in length by suitable brace, supported at not less than one-half the height of the terminal.

2.2.2 Ground Rods

Provide ground rods made of copper-clad steel conforming to conform to UL 467. Provide ground rods that are not less than 3/4 inch in diameter and 10 feet in length. Do not mix ground rods of copper-clad steel or solid copper on the job.

2.2.3 Connections and Terminations

Provide connectors for splicing conductors that conform to UL 96, class as applicable. Conductor connections can be made by clamps or welds (including exothermic). Provide style and size connectors required for the installation.

2.2.4 Connector Fittings

Provide connector fittings for "end-to-end", "Tee", or "Y" splices that conform to NFPA 780 and UL 96.

PART 3 EXECUTION

3.1 INTEGRAL SYSTEM

Provide a lightning protection system that meets the requirements of NFPA 780. Lightning protection system consists of air terminals, roof conductors, down conductors, ground connections, and grounding electrodes and ground ring electrode conductor. Bond secondary conductors with grounded metallic parts within the building. Make interconnections within side-flash distances at or below the level of the grounded metallic parts.

3.1.1 Roof-Mounted Components

Coordinate with the roofing manufacturer and provide certification that the roof manufacturer's warranty is not violated by the installation methods for air terminals and roof conductors.

3.1.1.1 Air Terminals

Use a standing seam base for installation of air terminals on a standing seam metal roof that does not produce any roof penetrations.

3.1.1.2 Roof Conductors

Use a standing seam base for installation of roof conductors on a standing seam metal roof that does not produce any roof penetrations.

3.1.2 Down Conductors

Protect exposed down conductors from physical damage as required by NFPA 780. Use Schedule 80 PVC to protect down conductors. Paint the Schedule 80 PVC to match the surrounding surface with paint that is approved for use on PVC.

3.1.3 Ground Connections

Attach each down conductor and ground ring electrode to ground rods by welding (including exothermic), brazing, or compression. All connections to ground rods below ground level must be by exothermic weld connection or with a high compression connection using a hydraulic or electric compression tool to provide the correct circumferential pressure. Accessible connections above ground level and in test wells can be accomplished by mechanical clamping.

3.1.4 Grounding Electrodes

Extend driven ground rods vertically into the existing undisturbed earth for a distance of not less 10 feet. Set ground rods not less than 3 feet nor more than 8 feet, from the structure foundation, and at least beyond the drip line for the facility. After the completed installation, measure the total resistance to ground using the fall-of-potential method described in IEEE 81. Maximum allowed resistance of a driven ground rod is 25 ohms, under normally dry conditions. Contact the Contracting Officer for direction on how to proceed when two of any three ground rods, driven not less than 10 feet into the ground, a minimum of 10 feet apart, and equally spaced around the perimeter, give a combined value exceeding 50 ohms immediately after having driven. For ground ring electrode, provide continuous No. 1/0 bare stranded copper cable. Lay ground ring electrode around the perimeter of the structure in a trench not less than 3 feet nor more than 8 feet from the nearest point of the structure foundation, and at least beyond the drip line for the facility. Install ground ring electrode to a minimum depth of 30 inches. Install a ground ring electrode in earth undisturbed by excavation, not earth fill, and do not locate beneath roof overhang, or wholly under paved areas or roadways where rainfall cannot penetrate to keep soil moist in the vicinity of the cable.

3.2 APPLICATIONS

3.2.1 Nonmetallic Exterior Walls with Metallic Roof

Bond metal roof sections together which are insulated from each other so that they are electrically continuous, having a surface contact of at least 3 square inches.

3.3 RESTORATION

Where sod has been removed, place sod as soon as possible after completing the backfilling. Restore, to original condition, the areas disturbed by trenching, storing of dirt, cable laying, and other work. Overfill to accommodate for settling. Include necessary topsoil, fertilizing, liming, seeding, sodding, sprigging or mulching in any restoration. Maintain disturbed surfaces and replacements until final acceptance.

3.4 FIELD QUALITY CONTROL

3.4.1 Lightning Protection and Grounding System Test

Test the lightning protection and grounding system to ensure continuity is not in excess of 1 ohm and that resistance to ground is not in excess of 25 ohms. Provide documentation for the measured values at each test point. Test the ground rod for resistance to ground before making connections to the rod. Tie the grounding system together and test for resistance to ground. Make resistance measurements in dry weather, not earlier than 48 hours after rainfall. Include in the written report: locations of test points, measured values for continuity and ground resistances, and soil conditions at the time that measurements were made. Submit results of each test to the Contracting Officer.

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SECTION 26 51 00

INTERIOR LIGHTING

05/16

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SECTION 26 51 00

INTERIOR LIGHTING
05/16

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.

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

ASHRAE 189.1	(2014) Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings
ASHRAE 90.1 - IP	(2013) Energy Standard for Buildings Except Low-Rise Residential Buildings

ASTM INTERNATIONAL (ASTM)

ASTM A1008/A1008M	(2016) 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 A580/A580M	(2018) Standard Specification for Stainless Steel Wire
ASTM A641/A641M	(2009a; R 2014) Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire
ASTM A653/A653M	(2017) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B164	(2003; R 2014) Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire
ASTM B633	(2015) 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

CALIFORNIA ENERGY COMMISSION (CEC)

CEC Title 24	(2016) Building Energy Efficiency Standards For Residential and Nonresidential Buildings

ILLUMINATING ENGINEERING SOCIETY (IES)

IES HB-10	(2011; Errata 2015) IES Lighting Handbook
IES LM-79	(2008) Electrical and Photometric Measurements of Solid-State Lighting Products
IES LM-80	(2015) Measuring Lumen Maintenance of LED Light Sources
IES RP-16	(2010; Addendum A 2008; Addenda B 2009; Addendum C 2016) Nomenclature and Definitions for Illuminating Engineering
IES TM-21	(2011; Addendum B 2015) Projecting Long Term Lumen Maintenance of LED Light Sources

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C62.41	(1991; R 1995) Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2014) 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	(2002) Harmonic Emission Limits - Related Power Quality Requirements for Lighting Equipment
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA SSL 1	(2010) 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 2015) Standard for General Color Requirements for Wiring Devices

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 101	(2018; TIA 18-1; TIA 18-2; TIA 18-3) Life Safety Code
NFPA 70	(2017; ERTA 1-2 2017; TIA 17-1; TIA 17-2; TIA 17-3; TIA 17-4; TIA 17-5; TIA 17-6; TIA 17-7; TIA 17-8; TIA 17-9; TIA 17-10; TIA 17-11; TIA 17-12; TIA 17-13; TIA 17-14) National Electrical Code

U.S. DEPARTMENT OF DEFENSE (DOD)

DOD 8500.01	(2014) Cybersecurity
DOD 8510.01	(2014; Change 1-2016; Change 2-2017) Risk Management Framework (RMF) for DoD Information Technology (IT)

UNDERWRITERS LABORATORIES (UL)

UL 1472	(2015) UL Standard for Safety Solid-State Dimming Controls
UL 1598	(2008; Reprint Oct 2012) Luminaires
UL 20	(2010; Reprint Feb 2012) General-Use Snap Switches
UL 2043	(2013) Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces
UL 508	(2018) UL Standard for Industrial Control Equipment
UL 8750	(2015; Reprint Feb 2018) UL Standard for Safety Light Emitting Diode (LED) Equipment for Use in Lighting Products
UL 916	(2007; Reprint Aug 2014) Standard for Energy Management Equipment
UL 924	(2016; Reprint May 2018) UL Standard for Safety Emergency Lighting and Power Equipment
UL 94	(2013; Reprint Sep 2017) UL Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

1.2 RELATED REQUIREMENTS

Materials not considered to be luminaires or luminaire accessories are specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Luminaires and accessories mounted on exterior surfaces of buildings are specified. Refer to Commissioning Requirements in Specification 01 91 00.00 37 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 IES RP-16.

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 know as 70 percent "Rated Lumen Maintenance Life" as defined in 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" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance with Section 01 33 29.00 37 SUSTAINABILITY. Data, drawings, and reports must employ the terminology, classifications and methods prescribed by the IES HB-10 as applicable, for the lighting system specified. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Luminaire Drawings; G

Occupancy/Vacancy Sensor Coverage Layout; G

SD-03 Product Data

Luminaires; G

Light Sources; G

Drivers, Ballasts and Generators; G

LED Luminaire Warranty; G

Luminaire Design Data; G

Vacancy Sensors; G

Dimming Controllers (Dimmers); G

Timeswitch; G

Exit Signs; G

Emergency Lighting Unit (EBU); G

LED Emergency Drivers; G

Occupancy Sensors; G

Ambient Light Level Sensor; G

SD-06 Test Reports

LED Luminaire - IES LM-79 Test Report; G

LED Light Source - IES LM-80 Test Report; G

LED Light Source - IES TM-21 Test Report; G

Occupancy/Vacancy Sensor Verification Tests; G

SD-07 Certificates

Luminaire Useful Life Certificate; G

LED Driver and Dimming Switch Compatibility Certificate; G

1.5 QUALITY CONTROL

1.5.1 Luminaire Drawings

Include dimensions, accessories, and installation andconstruction details. Photometric data, including zonal lumen data, average and minimum ratio, aiming diagram, and computerized candlepower distribution data must accompany shop drawings.

1.5.2 Occupancy/Vacancy Sensor Coverage Layout

Provide floor plans showing coverage layouts of all devices using manufacturer's product information.

1.5.3 LED Driver and Dimming Switch Compatibility Certificate

Submit certification from the luminaire, driver, or dimmer switch manufacturer that ensures compatibility and operability between devices.

1.5.4 Luminaire Design Data

a. Provide safety certification and file number for the luminaire family that must be listed, labeled, or identified per the NFPA 70 (NEC). Applicable testing bodies are determined by the US Occupational Safety Health Administration (OSHA) as Nationally Recognized Testing Laboratories (NRTL) and include: CSA (Canadian Standards Association),

ETL (Edison Testing Laboratory), and UL (Underwriters Laboratories).

b. Provide long term lumen maintenance projections for each LED luminaire in accordance with IES TM-21. Data used for projections must be obtained from testing in accordance with IES LM-80.

1.5.5 LED Luminaire - IES LM-79 Test Report

Submit test report on manufacturer's standard production model luminaire. Include all applicable and required data as outlined under "14.0 Test Report" in IES LM-79.

1.5.6 LED Light Source - IES LM-80 Test Report

Submit report on manufacturer's standard production LED light source (package, array, or module). Include all applicable and required data as outlined under "8.0 Test Report" in IES LM-80.

1.5.7 LED Light Source - IES TM-21 Test Report

Submit test report on manufacturer's standard production LED light source (package, array or module). Include all applicable and required data, as well as required interpolation information as outlined under "7.0 Report" in IES TM-21.

1.5.8 Occupancy/Vacancy Sensor Verification Tests

Submit test report outlining post-installation coverage and operation of sensors.

1.5.9 Test Laboratories

Test laboratories for the IES LM-79 and 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 at for LM-79 testing.

c. One of the EPA-Recognized Laboratories listed at for LM-80 testing.

1.5.10 Regulatory Requirements

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

1.5.11 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products must have been in satisfactory commercial or industrial use for two years prior to bid opening. The two-year period must include applications of equipment and materials under similar circumstances and of similar size. The product must have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the two-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.

1.5.11.1 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.

1.5.11.2 Material and Equipment Manufacturing Date

Products manufactured more than six months prior to date of delivery to site must not be used, 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 LED Luminaire Warranty

a. Provide a written 5 year on-site replacement warranty for material, fixture finish, and workmanship. On-site replacement includes transportation, removal, and installation of new products.

    (1) Include finish warranty to include failure and substantial deterioration such as blistering, cracking, peeling, chalking, or fading.

    (2) Material warranty must include:

        (a) All drivers.

        (b) Replacement when more than 10 percent of LED sources in any lightbar or subassembly(s) are defective or non-starting.

b. Warranty period must begin on date of beneficial occupancy. Provide the Contracting Officer with signed warranty certificates prior to final payment.

1.6.1.1 Provide Luminaire Useful Life Certificate

Submit certification from the manufacturer indicating the expected useful life of the luminaires provided. The useful life must be directly

correlated from the IES LM-80 test data using procedures outlined in IES TM-21. Thermal properties of the specific luminaire and local ambient operating temperature and conditions must be taken into consideration.

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

Products and materials not considered to be luminaires, luminaire controls, or associated equipment are specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Luminaires, luminaire controls, and associated equipment for exterior applications are specified.

2.2 LUMINAIRES

UL 1598, NEMA C82.77, and UL 8750. Provide luminaires as indicated in luminaire schedule and NL plates or details on project plans. Provide luminaires complete with light sources of quantity, type, and wattage indicated. Provide all luminaires of the same type by the same manufacturer. Luminaires must be specifically designed for use with the driver, ballast or generator and light source provided.

2.2.1 LED Luminaires

Provide luminaires complete with power supplies (drivers) and light sources. Provide design information including lumen output and design life in luminaire schedule on project plans for LED luminaires. LED luminaires must meet the minimum requirements in the following table:

LUMINAIRE TYPE	MINIMUM LUMINAIRE EFFICACY (LE)	MINIMUM COLOR RENDERING INDEX (CRI)
LED TROFFER - 1 x 4 2 x 2 2 x 4	90 LPW	80
LED Downlight	50 LPW	90
LED Track or Accent	40 LPW	80
LED Low Bay/High Bay	80 LPW	70
LED Linear Ambient	80 LPW	80

LED luminaires must also meet the following minimum requirements:

a. Luminaires must have a minimum 5 year manufacturer's warranty.

b. Luminaires must have a minimum L70 lumen maintenance value of 50,000 hours as calculated by IES TM-21, with data obtained per IES LM-80 requirements.

c. Luminaire drive current value must be identical to that provided by test data for luminaire in question.

d. Luminaires must be tested to IES LM-79 and IES LM-80 standards, with the results provided as required in the Submittals paragraph of this specification.

e. Luminaires must be listed with the DesignLights Consortium 'Qualified

Products List' when falling into category of "General Application" luminaires, i.e. Interior Directional, Display Case, Troffer, Linear Ambient, or Low/High Bay. Requirements are shown in the Designlights Consortium "Technical Requirements Table" at https://data.energystar.gov/dataset/EPA-Recognized-Laboratories-For-Lighting-Products/jgwf-7qrr.

f. Provide Department of Energy 'Lighting Facts' label for each luminaire.

2.3 DRIVERS, BALLASTS and GENERATORS

2.3.1 LED Drivers

NEMA SSL 1, UL 8750. LED drivers must be electronic, UL Class 1, constant-current type and comply with the following requirements:

a. Output power (watts)and luminous flux (lumens) as shown in luminaire schedule for each luminaire type to meet minimum luminaire efficacy (LE) value provided.

b. Power Factor (PF) greater than or equal to 0.9 over the full dimming range when provided.

c. Current draw Total Harmonic Distortion (THD) of less than 20 percent.

d. Class A sound rating.

e. Operable at input voltage of 120-277 volts at 60 hertz.

f. Minimum 5 year manufacturer's warranty.

g. RoHS compliant.

h. Integral thermal protection that reduces or eliminates the output power if case temperature exceeds a value detrimental to the driver.

i. UL listed for dry or damp locations typical of interior installations.

j. Fully-dimmable using 0-10V control as indicated in luminaire schedule.

2.4 LIGHT SOURCES

NEMA ANSLG C78.377, NEMA SSL 3. Provide type and wattage as indicated in luminaire schedule on project plans.

2.4.1 LED Light Sources

a. Correlated Color Temperature (CCT) of 3500 degrees K.

b. Minimum Color Rendering Index (CRI) R9 value of 80.

c. High power, white light output utilizing phosphor conversion (PC) process.

d. RoHS compliant.

e. Provide light source color consistency by utilizing a binning tolerance within a 4 step McAdam ellipse.

2.5 LIGHTING CONTROLS

ASHRAE 90.1 - IP ASHRAE 189.1. Provide network certification for all networked lighting control systems and devices per requirements of DOD 8500.01 and DOD 8510.01.

2.5.1 Toggle Switches

Provide line-voltage toggle switches as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.5.2 Dimming Controllers (Dimmers)

UL 1472, UL 20, IEEE C62.41, NEMA SSL 7A. 120/277 V0-10 V dimmers must provide flicker-free, continuously variable light output throughout the dimming range. Provide radio frequency interference suppression integral to device. Provide dimmers utilizing pulse width modulation (PWM)constant current reduction (CCR) technology. Provide device with a vertical slider, paddle, rotary button, or toggle (with adjacent vertical slider) type control, with finish to match switches and outlets in same area. Provide back box in wall with sufficient depth to accommodate body of switch and wiring. 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. Dimmers must be capable of controlling 0-10 volt fluorescent ballasts or LED drivers. Ensure compatibility of dimmer with separate power packs when utilized for lighting control. Dimmers and the ballasts or drivers they control, must be provided from the same manufacturer, or tested and certified as compatible for use together. Provide NEMA SSL 7A-compliant devices.

2.5.3 Sensors for Lighting Control

IEEE C62.41, NEMA WD 1, UL 94, UL 916, UL 508, ASTM D4674 REV A.

2.5.3.1 Occupancy Sensors

Provide occupancy sensors with coverage patterns as indicated on project plans. Provide no less quantity of sensors as shown on plans, but add additional sensors when required to fulfill coverage requirement for the specific model sensor provided. Sensor must be provided with an adaptive learning function that automatically sets sensor in optimum calibration in a set period of time after installation and a non-volatile memory that saves settings after a power outage. Provide sensors designed for ceiling, wall or wall-box installation as indicated. Operating voltage must be 120 277 volts. Provide housing of high-impact, injection-molded thermoplastic with a multi-segmented lens for PIR and dual technology sensors. Sensor operation requires movement to activate luminaires controlled, and turns luminaires off after a set time of inactivity.

2.5.3.1.1 Passive Infrared (PIR) Sensors

Provide ceiling or wall-mounted PIR sensors meeting the following requirements:

a. Temperature compensated, dual element sensor and a multi-element fresnel lens (Poly IR4 material).

b. Technology to optimize automatic time delay to fit occupant usage patterns.

c. No minimum load requirement for line voltage sensors 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. Control voltage sensors must not exceed a maximum load requirement of 20 mA at 24VDC.

d. Time delay of five to 30 minutes in increments of five minutes with a walk through and test mode set by DIP switch.

e. LED indicator that remains active during occupancy.

f. Built-in light level sensor that is operational from 8 to 180 foot-candles.

g. Coverage pattern tested to NEMA WD 7 standards.

h. Standard five year warranty and be UL listed

i. No leakage current to load when in the off mode.

2.5.3.1.2 Ultrasonic Sensors

Provide ceiling-mounted ultrasonic sensors meeting the following requirements:

a. Operate at an ultrasonic frequency of 25 kHz.

b. LED on exterior of device to indicate occupant detection.

c. Adjustable time delay period of 15 seconds to 15 minutes.

d. UL listed with minimum five year warranty.

2.5.3.1.3 Dual Technology Sensors

Provide dual technology sensors that meet the requirements for PIR sensors and ultrasonic sensors indicated above. If either the passive infrared or ultrasonic sensing registers occupancy, the luminaires must remain on.

2.5.3.1.4 High/Low-Bay Sensors

Provide occupancy sensors specifically designed for high/low-bay mounting application using passive infrared (PIR) technology, with the following characteristics:

a. Input voltage of 120/277 volts, at 50/60 hertz.

b. High-impact, injection-molded thermoplastic housing with interchangeable lenses for 360 degree open area coverage or narrow rectangular, warehouse aisle coverage.

c. Utilize zero-crossing circuitry to prevent damage from high inrush current and to promote long life operation.

d. Be designed to mount directly to or adjacent to high or low-bay luminaires.

e. UL listed, CEC Title 24 and ASHRAE 90.1 - IP compliant.

2.5.3.1.5 Power Packs for Sensors

UL 2043, CEC Title 24, ASHRAE 90.1 - IP. Power packs used to provide power to one or more lighting control sensors must meet the following requirements:

a. Input voltage - 120-277 VAC; output voltage - 24 VDC at 225 mA.

b. 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. RoHS compliant.

2.5.3.2 Vacancy Sensors

Provide vacancy sensors as indicated above under paragraph OCCUPANCY SENSORS, but with requirement of a manual operation to activate luminaires controlled. Provide automatic operation to turn luminaires off after a set period of inactivity.

2.5.4 Timeswitch

Provide electronic type timeswitch with a 24 hour7 dayastronomic programming function that changes on/off settings according to seasonal variations of sunset and sunrise, providing a total of 56 on/off set points. Provide 24 hour type digital clock display format. Provide power outage back-up for switch for a minimum of seven days. Provide switch capable of controlling a minimum of channels or loads as indicated. Rate contacts at 30 amps at 120/277 volts for general purpose loads. Provide contacts in a SPSTDPST, normally-closed (NC) configuration. Provide switch with manual bypass or remote override controldaylight savings time adjustment.

House timeswitch in a surface-mounted, lockable, NEMA 1 enclosure constructed of painted steel or plastic polymer conforming to NEMA ICS 6.

2.6 EXIT AND EMERGENCY LIGHTING EQUIPMENT

UL 924, NFPA 101, and NFPA 70 compliant.

2.6.1 Exit Signs

Provide exit signs consuming a maximum of five watts total.

2.6.1.1 LED Self-Powered Exit Signs

Provide edge-lit type with clear acrylic, edge-lit face and aluminum trim having clear aluminum white finish. Provide 6 inch high, 3/4 inch stroke green lettering on face of sign. Provide chevrons on either side of lettering to indicate direction. Provide single or double face as indicated. Equip with automatic power failure device, test switch, and pilot light, and fully automatic high/low trickle charger in a self-contained power pack. Battery must be sealed, maintenance free nickel-cadmium type, and must operate unattended for a period of not less than five years. Emergency run time must be a minimum of 1 1/2 hours. LEDs must have a minimum rated life of 10 years. Provide self-diagnostic

circuitry integral to emergency LED driver.

2.6.1.2 LED Remote-Powered Exit Signs

Provide as indicated above for self-powered type, but without battery and charger. Exit sign must contain provision for 120/277 VAC or 6-48 VDC input from remote source.

2.6.2 Emergency Lighting Unit (EBU)

Provide in UV-stable, thermo-plastic housing with UL damp label or UL wet label as indicated. Emergency lighting units must be rated for 12 volts, except units having no remote-mounted lamps and having no more than two unit-mounted light sources may be rated six volts. Equip units with brown-out sensitive circuit to activate battery when input voltage falls to 75 percent of normal. Equip with two LED, MR-16 type light sources, automatic power failure device, test switch, and pilot light, and fully automatic high/low trickle charger in a self-contained power pack. Battery must be sealed, maintenance free nickel-cadmium type, and must operate unattended for a period of not less than five years. Emergency run time must be a minimum of 1 1/2 hours. LEDs must have a minimum rated life of 10 years. Provide self-diagnostic circuitry integral to emergency LED driver.

2.6.3 LED Emergency Drivers

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 compatible with LED forward voltage requirements, 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.

2.6.4 Self-Diagnostic Circuitry for LED Emergency Drivers

Provide emergency lighting unit with fully-automatic, integral self-testing/diagnostic electronic circuitry. Circuitry must provide for a one minute diagnostic test every 28 days, and a 30 minute diagnostic test every six months, minimum. Any malfunction of the unit must be indicated by LED(s) visible from the exterior of the luminaire. A manual test switch must also be provided to perform a diagnostic test at any given time.

2.7 LUMINAIRE SUPPORT HARDWARE

2.7.1 Wire

ASTM A641/A641M; Galvanized, soft tempered steel, minimum 0.11 inches in diameter, or galvanized, braided steel, minimum 0.08 inches in diameter.

2.7.2 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 Threaded Rods

Threaded steel rods, 3/16 inch diameter, zinc or cadmium coated.

2.7.4 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 POWER HOOK LUMINAIRE HANGERS

UL 1598Provide an assembly consisting of through-wired power hook housing, interlocking plug and receptacle, power cord, and luminaire support loop. Power hook housing must be cast aluminum having two 3/4 inch threaded hubs. Support hook must have safety screw. Fixture support loop must be cast aluminum with provisions for accepting 3/4 inch threaded stems. Power cord must include 16 inches of 3 conductor No. 16 Type SO cord. Assembly must be rated 120 volts or 277 volts, 15 amperes.

2.9 EQUIPMENT IDENTIFICATION

2.9.1 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.

2.9.2 Labels

Provide labeled luminaires in accordance with UL 1598 requirements. All luminaires must be clearly marked for operation of specific light sources and ballasts, generators or drivers. Note the following light source characteristics in the format "Use Only _____":

a. Light source diameter code (T-4, T-5, T-8), tube configuration (twin, quad, triple), base type, and nominal wattage for fluorescent and compact fluorescent luminaires.

b. Light source type, wattage, envelope type (ED17, BD56, etc.) and coating (clear or coated) for HID luminaires.

c. Start type (programmed start, instant start) for fluorescent and compact fluorescent luminaires.

d. ANSI ballast type (M98, M57, etc.) for HID luminaires.

e. Correlated color temperature (CCT) and color rendering index (CRI) for all luminaires.

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. Ballasts, generators or drivers must have clear markings indicating multi-level outputs and indicate proper terminals for the various outputs.

2.10 FACTORY APPLIED FINISH

Provide all luminaires and lighting equipment with factory-applied painting system that as a minimum, meets requirements of NEMA 250 corrosion-resistance test.

2.11 RECESS- AND FLUSH-MOUNTED LUMINAIRES

Provide access to lamp and ballast from bottom of luminaire. Provide trim and lenses for the exposed surface of flush-mounted luminaires as indicated on project drawings and specifications.

2.12 SUSPENDED LUMINAIRES

Provide hangers capable of supporting twice the combined weight of luminaires supported by hangers. Provide with swivel hangers to ensure a plumb installation. Provide cadmium-plated steel with a swivel-ball tapped for the conduit size indicated. Hangers must allow fixtures to swing within an angle of 45 degrees. Brace pendants 4 feet or longer to limit swinging. Single-unit suspended luminaires must have twin-stem hangers. Multiple-unit or continuous row luminaires 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. Provide rods in minimum 0.18 inch diameter.

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations must conform to IEEE C2, NFPA 70, and to the requirements specified herein. Install luminaires and lighting controls to meet the requirements of ASHRAE 90.1 - IP and ASHRAE 189.1. To encourage consistency and uniformity, install luminaires of the same manufacture and model number when residing in the same facility or building.

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, color rendering index, 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. Installation must meet requirements of NFPA 70. Mounting heights specified or indicated must be to the bottom of the luminaire for ceiling-mounted luminaires and to center of luminaire for wall-mounted luminaires. Obtain 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. Recessed and semi-recessed luminaires must be independently supported from the building structure by a minimum of four wires, straps or rods per luminaire and located near each corner of the luminaire. Ceiling grid clips are not allowed as an alternative to

independently supported luminaires. Round luminaires or luminaires smaller in size than the ceiling grid must be independently supported from the building structure by a minimum of four wires, straps or rods per luminaire, spaced approximately equidistant around. Do not support luminaires by acoustical tile ceiling panels. 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. Provide wires, straps, or rods for luminaire support in this section. Luminaires installed in suspended ceilings must also comply with the requirements of Section 09 51 00 ACOUSTICAL CEILINGS.

3.1.3 Suspended Luminaires

Provide suspended luminaires with 45 degree swivel hangers so that they hang plumb and level. Locate so that there are no obstructions within the 45 degree range in all directions. The stem, canopy and luminaire must be capable of 45 degree swing. Pendants, rods, or chains 4 feet or longer excluding luminaire must be braced to prevent swaying using three cables at 120 degree separation. 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. Utilize aligning splines on extruded aluminum luminaires to assure minimal hairline joints. Support steel luminaires to prevent "oil-canning" effects. Luminaire finishes must be free of scratches, nicks, dents, and warps, and must match the color and gloss specified. Match supporting pendants with supported luminaire. Aircraft cable must be stainless steel. Canopies must be finished to match the ceiling and must be low profile unless otherwise shown. Maximum distance between suspension points must be 10 feet or as recommended by the manufacturer, whichever is less.

3.1.4 Ballasts, Generators and Power Supplies

Typically, provide ballasts, generators, and power supplies (drivers) integral to luminaire as constructed by the manufacturer.

3.1.5 Exit Signs and Emergency Lighting Units

Wire exit signs and emergency lighting units ahead of the local switch, to the normal lighting circuit located in the same room or area.

3.1.6 Photocell Switch Aiming

Aim switch according to manufacturer's recommendations.

3.1.7 Occupancy/Vacancy Sensors

Provide testing of sensor coverage in all spaces where sensors are placed. This should be done only after all furnishings (carpet, furniture, workstations, etc.) have been installed. 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. Locate the sensor(s) as indicated and in accordance with the manufacturer's recommendations to maximize energy savings and to avoid nuisance activation and deactivation due to sudden temperature or airflow changes and usage.

3.1.8 Daylight or Ambient Light Level Sensor

Locate sensor as indicated and in accordance with the manufacturer's recommendations. Adjust sensor for 30 foot-candlesor for the indicated light level measured at the work plane for that particular area.

3.2 FIELD APPLIED PAINTING

Paint lighting equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Provide painting as specified in Section 09 90 00 PAINTS AND COATINGS.

3.3 COMMISSIONING REQUIREMENTS

Lighting controls manufacturer shall be present for the commissioning of the lighting system.

-- End of Section --

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CABLE TELEVISION PREMISES DISTRIBUTION SYSTEM

04/06

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SECTION 27 05 14.00 10

CABLE TELEVISION PREMISES DISTRIBUTION SYSTEM
04/06

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.

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2017; ERTA 1-2 2017; TIA 17-1; TIA 17-2; TIA 17-3; TIA 17-4; TIA 17-5; TIA 17-6; TIA 17-7; TIA 17-8; TIA 17-9; TIA 17-10; TIA 17-11; TIA 17-12; TIA 17-13; TIA 17-14; TIA 568.4-d; TIA 569-D) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-569-D	(2015) Commercial Building Standard for Telecommunications Pathways and Spaces
TIA-568-C.4	(2011) Broadband Coaxial Cabling and Components Standards

1.2 SUMMARY

Provide a cable TV premises distribution system consisting of coaxial cables and connecting hardware to transport television signals throughout the building to user locations as indicated. Submit detail drawings including a complete list of equipment and material and containing complete wiring and schematic diagrams and other details required to demonstrate that the system has been coordinated and will function properly as a system. Drawings shall include vertical riser diagrams, equipment rack and panel details, elevation drawings of telecommunications closet walls, outlet face plate details for each outlet configuration, and descriptions and types of cables, conduits, and cable trays, if used. Drawings shall show proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearance for maintenance and operation.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Cable TV Premises Distribution System; G

SD-03 Product Data

Spare Parts.
Test Plan; G
Qualifications

SD-06 Test Reports

Testing

SD-07 Certificates

Materials and Equipment

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Operation and Maintenance Manuals; G

1.4 QUALIFICATIONS

Submit proof of the qualifications of the Contractor, Installers, and Manufacturers that will perform the work, and provide the specified products.

1.4.1 Minimum Contractor Qualifications

Work under this section shall be performed, and equipment shall be furnished and installed, by a qualified Contractor as defined herein. The Contractor shall have a minimum of two years of experience in the installation and testing of coaxial cable-based TV distribution systems and equipment. Installers assigned to the installation of this system or its components shall have a minimum of two years of experience in the installation of the specified coaxial cable and components.

1.4.2 Minimum Manufacturer Qualifications

The equipment and hardware provided under this contract shall be products of manufacturers that have a minimum of two years of experience in producing the types of systems and equipment specified.

1.5 DELIVERY, STORAGE, AND HANDLING

Protect equipment delivered and placed in storage from the weather, humidity and temperature variation, dirt and dust or other contaminants.

1.6 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, non-condensing.

1.7 EXTRA MATERIALS

Submit spare parts data for each different item of material and equipment specified, after approval of detail drawings, not later than 2 months prior to the date of beneficial occupancy. The data shall include a complete list of parts, tools, test equipment and supplies, with current unit prices and source of supply, and a list of spare parts recommended for stocking. Provide the following additional materials required for facility startup:

a. 10 of each type of connector used.
b. 10 of each type of cover plate, with connector.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of the products and that are the manufacturer's latest standard design that has been in satisfactory use for at least one year prior to installation. Where materials or equipment are specified to conform, be constructed or tested to meet specific requirements, submit certification that the items provided conform to such requirements. Certification by a nationally recognized testing laboratory that a representative sample has been tested to meet the requirements, or a published catalog specification statement to the effect that the item meets the referenced standard, is acceptable as evidence that the item conforms. Compliance with these requirements does not relieve the Contractor from compliance with other requirements of the specifications. Materials and equipment shall conform to the respective publications and other requirements specified below and to the applicable requirements of NFPA 70. Cables shall be labeled on both ends with circuit number, room number, or other appropriate marking allowing for correct identification of the cable and its destination. Each faceplate shall be labeled with its function and a unique number to identify the cable run.

2.1.1 Coaxial Cable

Coaxial cable shall be RG-6/U, quad shield. Cable shall be label-verified. Cable jacket shall be factory marked at regular intervals identifying cable type. Cable shall be rated CMP or CMR in accordance with NFPA 70. Interconnecting cables shall be cable assemblies consisting of RG-6/U coaxial cable with male connectors at each end, provided in lengths determined by equipment locations as shown.

2.1.2 Outlets

Cable television outlets, including wall outlet plates, shall be equipped with a female connector to accept the connecting coaxial cable from the user's television set. Faceplates provided shall be white impact resistant plastic.

2.1.3 Outlet Boxes

Electrical boxes for cable television outlets shall be 4-11/16 inch square by 2-1/8 inches deep with minimum 3/8 inch deep single or two gang plaster ring as shown. Conduits shall be minimum 1 inch with Bushings or insulated throat connectors.

PART 3 EXECUTION

3.1 INSTALLATION

Install system components and appurtenances in accordance with NFPA 70, manufacturer's instructions and as shown. Submit record drawings for the installed cable system showing the locations of cable terminations, including outlets, and location and routing of cables. The identifier for each termination and cable shall appear on the drawings. Provide necessary interconnections, services, and adjustments required for a complete cable television distribution system, ready to connect to external television signal sources. Penetrations in fire-rated construction shall be firestopped in accordance with Section 07 84 00 FIRESTOPPING. Install conduits, outlets, raceways, and wiring in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Cables and outlets shall be individually labeled and marked. Cables shall not be installed in the same cable tray, utility pole compartment, or floor trench compartment with ac power cables. Cables not installed in conduit or wireways shall be properly secured and neat in appearance and, if installed in plenums or other spaces used for environmental air, shall comply with NFPA 70 requirements for this type of installation.

3.1.1 Horizontal Cable Installation

The rated cable pulling tension shall not be exceeded. Cable shall not be stressed such that twisting, stretching or kinking occurs. Cable shall not be spliced. All CATV runs shall be in 1" minimum sized conduit with bushings and draglines from the TV location to the CATV demarcation equipment. 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. Cables shall be terminated unless shown otherwise. Minimum bending radius shall not be exceeded during installation or once installed. Cable ties shall not be excessively tightened such that the transmission characteristics of the cable are altered. In raised floor areas, cable shall be installed after the flooring system has been installed. Cable 6 feet long shall be neatly coiled not less than 12 inches in diameter below each feed point in raised floor areas.

3.1.2 Riser Cable Installation

The rated cable pulling tension shall not be exceeded. Riser cable support intervals shall be in accordance with manufacturer's recommendations. Where installation procedures, or any part thereof, are required to be in accordance with the recommendations of the manufacturer of the material being installed, printed copies of these recommendations shall be provided prior to installation. Installation of the item will not be allowed to proceed until the recommendations are received and approved. Cable bend radius shall not be less than ten times the outside diameter of the cable during installation and once installed. Maximum tensile strength rating of the cable shall not be exceeded. Cable shall not be spliced.

3.1.3 Cables

Cables shall have a minimum of 6 inches of slack cable loosely coiled into the cable television outlet boxes. Minimum manufacturer's bend radius

shall not be exceeded.

3.1.4 Pull Cords

Pull cords shall be installed in conduits serving the cable television premises distribution system which do not initially have cable installed.

3.2 TERMINATIONS

Cables and conductors shall sweep into termination areas; cables and conductors shall not bend at right angles. Manufacturer's minimum bending radius shall not be exceeded. Coaxial cables shall be terminated with appropriate connectors as required. Cable shield conductor shall be grounded to communications ground at only one point and shall not make electrical contact with ground anywhere else.

3.3 GROUNDING

The cable television distribution system ground shall be installed in the cable television entrance facility and in any auxiliary closet identified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM or otherwise indicated. Equipment racks shall be connected to the electrical safety ground. In addition, a 2" TGB bar to be added and connected back to the TMGB with the TBB sized per the TIA 607-C.

3.4 TESTING

Submit test reports in booklet form with witness signatures verifying execution of tests. The cable system testing documentation shall include the physical routing and a test report for each cable (end-to-end) from the installed outlet to the main termination point. Testing shall be done in accordance with TIA-569-D and TIA-568-C.4. Test reports shall be submitted within 14 days after completion of testing.Materials and documentation to be furnished under this specification are subject to inspections and tests.

a. Submit a Test Plan defining the tests required to ensure that the system meets technical, operational and performance specifications, 60 days prior to the proposed test date. The plan shall be approved before testing begins. The test plan shall identify the capabilities and functions to be tested, and include detailed instructions for the setup and execution of each test and procedures for evaluation and documentation of the results.

b. Components shall be terminated prior to testing.

c. Equipment and systems will not be accepted until the required inspections and tests have been made, demonstrating that the cable television premises distribution system conforms to the specified requirements, and that the required equipment, systems, and documentation have been provided.

d. After installation of the cable and before connecting system components, each cable section shall be end-to-end tested using a time domain reflectometer (TDR) to determine shorts, opens, kinks, and other impedance discontinuities and their locations. Cable sections showing adverse impedance discontinuities (greater than 6 dB loss) shall be replaced at the Contractor's expense.

e. There shall be no cable splices between system components unless approved by the Government.

3.5 OPERATION AND MAINTENANCE MANUALS

Submit commercial, off-the-shelf manuals for operation, installation, configuration, and maintenance of products provided as a part of the cable television premises distribution system.

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PROTECTIVE DISTRIBUTION SYSTEM (PDS) FOR SIPRNET COMMUNICATION SYSTEMS
08/11

PART 1 GENERAL

1.1 RELATED REQUIREMENTS

1.2 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 SECURITY TELECOMMUNICATIONS AND INFORMATION SYSTEMS SECURITY (NSTISS)

NSTISSAM TEMPEST/2-95	(1995; Am A 2000) RED/BLACK Installation Guidance
CNSSI-7003	(2015) Protective Distribution Systems (PDS)

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-569	(2015d) Commercial Building Standard for Telecommunications Pathways and Spaces

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-580-01	(2016) Telecommunications Interior Infrastructure Planning And Design, With Change 1

U. S. SIGNAL NETWORK ENTYERPRISE CENTER

Ft. Bragg NEC IDC	(2017) Installation Design Criteria for Fort Bragg Specific Communications Infrastructure Requirements
SIPRNET TIC	(2013) SIPRNET Technical Implementation Criteria

1.3 ADMINISTRATIVE REQUIREMENTS

1.3.1 Conditions

Notify the Contracting Officer if it is impossible to install SIPRNET PDS that complies with this section, SIPRNET TIC, and other references.

1.3.2 Construction Methods

Methods of construction that are not specifically described or indicated in the Contract will be subject to the control and approval of the Contracting Officer.

1.3.3 PDS Design

Include separate plans, elevations, sections, details, and attachments to other work. Indicate PDS carrier route, PDS carrier mounting height above finished floor, user drop box mounting height, and user drop box locations. Submit the PDS design to the cognizant Central TEMPEST Technical Authority (CTTA), for a technical review prior to the acquisition of material, through the installation Network Enterprise Center (NEC) or Directorate of Information Management (DOIM).

1.3.4 PDS Design Technical Review

Coordinate with the installation NEC/DOIM and submit PDS design for technical review to CTTA. Provide PDS carrier shop drawings, List of Material (LOM), and any other documentation required 90-days prior to PDS carrier installation (see CNSSI-7003, Appendix C).

1.3.5 PDS Design Approval Request

PDS design approving authority is the installation NEC/DOIM Designated Approving Authority (DAA). Submit PDS design and CTTA technical review to the installation NEC/DOIM to obtained PDS design approval from the DAA prior to installation.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

PDS Design; G
PDS Design Technical Review; G
PDS Design Approval; G

SD-03 Product Data

PDS Hardened Carrier

SD-04 Samples

PDS Carrier Surface Mounted

SD-11 Closeout Submittals

User Drop Box
Other Enclosures

1.5 QUALITY ASSURANCE

1.5.1 Manufacturer's Qualifications

Use firms regularly engaged in manufacture of secure raceway systems,

boxes, and fittings of the types and sizes required, whose products have been in satisfactory use in similar service for not less than 3 years.

1.5.2 Installer's Qualifications

Installer is required to obtain certification from the manufacturer of secure raceway system and install secure raceway system in accordance with manufacturer's instructions.

1.5.3 Equipment

PDS Hardened Carrier shall meet or exceed guidelines as defined by CNSSI-7003 and shall be approved for use by DHS, U.S. Army, U.S. Marine Corps, U.S. Navy, and U.S. Air Force. Submit manufacturer's descriptive data.

1.6 DELIVERY, STORAGE, AND HANDLING

Deliver secure raceways, conduit, fittings and components in factory labeled packages. Store and handle in strict compliance with manufacturer's written instructions and recommendations. Protect from damage due to weather, excessive temperature, and construction operations.

PART 2 PRODUCTS

2.1 PDS CARRIER CONFIGURATION

Use secure, expandable raceway carrier system such as Holocom or equal to include4 an interlocking "clam-shell" design in office environments, Use conduit carrier in Non-office environments, such as hangars, maintenance facilities, warehouse, training areas, industrial areas.

2.1.1 Secure Raceway Carrier

Provide secure raceway, fittings and components manufactured from ferrous material. Submit three 6-inch lengths of exposed type PDS carrier surface mounted conduit material, including component and fitting samples from the manufacturer, along with a LOM to the NEC/DOIM. Show finishes available (if applicable). PDS carrier that is comprised of Secure Raceway systems shall be:

a. Square or rectangular design with removable top covers or solid construction

b. 2 by 4 inch raceway for horizontal backbone and vertical riser runs

c. 1 by 1 inch raceway for vertical user drops from horizontal backbone

d. Utilize elbows, couplings, fittings and connectors constructed from the same type of ferrous material as the secure raceway

e. Do not exceed 70 percent cable fill capacity of secure raceway with removable top cover in horizontal runs. TIA-569 cable fill standards do not apply.

f. Do not exceed 60 percent fill capacity of secure raceway of solid construction. TIA-569 cable fill standards do not apply.

2.1.1.1 Fittings and Components

Fittings and components include flat internal and external elbows, tees, couplings for joining raceway sections, nipples, wire clips, blank end fittings, and device mounting brackets and plates as applicable. Provide full capacity corner elbows and fittings to maintain a controlled 2-inch cable bend radius that meet the TIA-569 specification for Fiber Optic and UTP cabling and exceeding the requirements for communications pathways.

2.1.1.2 Mounting Accessories

Mount secure raceways to the wall partition using 1-inch stand-off mounting brackets or spacers. Do not mount the secure raceways flush with the wall partition.

2.1.1.3 Through Wall Penetrating

a. Use trim plates threaded rigid pipe and locking rings on both the inside and outside of the raceway to secure the thru-wall penetration.

b. Provide dielectric breaks when penetrating secure room wall partitions.

c. Seal space between wall partition and through wall penetration using fire-stop material.

d. Fire-stop vertical risers and through wall penetrations of fire rated wall partitions after pulling cabling. Annotate firewall penetrations on PDS design.

2.1.1.4 Pull Points

a. Provide a pull point for secure raceway with removable top cover every 270 degree change in direction. Provide additional pull points in accordance with the manufacturer's instructions.

b. Provide a pull point for secure raceway of solid construction every 180 degree change in direction. Provide additional pull points in accordance with the manufacturer's instructions.

2.2 USER DROP BOX

Provide User Drop Box (UDB) (aka Secure User Workstation Enclosure, Drop Box, or Lockbox) that is at least 7-inch high by 6-inch wide by 4-inch deep, tamper-resistant design constructed from 16 gauge steel with welded internal hinges, without pre-punched knockouts; and has a single door that has a built-in steel hasp that accepts a GSA approved changeable combination padlock. UDB shall accommodate a complete line of open connectivity outlets; modular inserts for Category 6 UTP or STP cable; fiber optic cabling with matching faceplates. STP cabling shall use shielded connectors, jacks, and patch panels. UDB with exterior hinges, pre-punched knockouts, and built-in locks are not acceptable.

Outlet boxes for wall phones are allowed to be 4" x 2-1/4" electrical box mounted at 48" about finished floor. All other telecommunications boxes shall be a minimum size of 4-11/16' square by 2-1/4" deep.

2.3 ENCLOSURES

Provide equipment and pull-box enclosures constructed from 16 gauge steel;

have a single door with a built-in steel hasp or multi-point security hasp that accepts a GSA approved changeable combination padlock; without pre-punched knockouts; and a tamper-resistant design with welded internal hinges.

PART 3 EXECUTION

3.1 EXAMINATION

Examine the route and mounting locations of the raceways, boxes, distribution systems, supporting structure and accessories, to determine if conditions exist that will inhibit or prevent proper PDS installation. Notify the Contracting Officer in writing of conditions detrimental to proper completion of the work (i.e. that would render the distribution system non-compliant with governing security regulations). Do not proceed with work until unsatisfactory conditions are corrected.

3.2 PDS CARRIER ROUTING

3.2.1 General

Route the PDS carrier in a tree type fashion.

a. Start the PDS horizontal backbone at the TR (SIPRNET TR or at IPS container location) with a single raceway or conduit sized accordingly (70 percent cable fill for secure raceway with removable top cover, 60 percent cable fill for EMT conduit and solid construction secure raceway) to contain CAT6 UTP, CAT6 STP, or fiber optic cable runs.

b. Extend the PDS carrier from the PDS horizontal backbone throughout the facility to areas where SIPRNET access is required. Branch off the PDS horizontal backbone with a horizontal run to an area where the UDB is located.

c. Use vertical carrier runs from the horizontal run to the UDB. TIA-569 change in direction standard does not apply.

d. Use standard under-floor cable distribution methods to distribute SIPRNET cabling within Secure Room with raised flooring.

e. Maintain RED/BLACK cable separation in accordance with NSTISSAM TEMPEST/2-95.

f. Remove all burrs from carrier segments prior to installation.

3.2.2 Distribution Topology

Use a distributed topology when designing the PDS carrier. Locating a small secondary network switch in an equipment enclosure mounted in an Uncontrolled Access Area (UAA) space or in a relay or equipment rack within a Controlled Access Area (CAA) space (i.e. NOC/BOC) that has a high concentration of users is acceptable. Interconnect network switches using single-mode fiber optic cable. Increase the capacity of the network switch to provide service to adjacent spaces as required.

3.2.3 Mounting Location Considerations

a. Route the PDS carrier so that it does not cross windows or doorway openings; does not cross ceiling or wall mounted lighting fixtures;

does not obscure EXIT signs or fire alarms; and maintains a minimum 3-foot separation from fire sprinkler heads.

b. Bend (saddle or offset) conduit to follow wall contours and avoid wall obstacles (columns, pipes, etc.).

c. Use offset raceway to route secure raceway systems around columns and other wall partition obstacles.

d. Route PDS carrier so that it is surface mounted on interior walls wherever possible. Obtain exceptions from NEC/DOIM prior to installation to mount PDS carrier on exterior wall partitions.

e. Route PDS carrier to maximized cable fills in horizontal runs and reduce the number of horizontal runs within the same space.

f. Use all-thread rod to mount the PDS carrier to true ceiling structure when routing across open areas (e.g. large hallways, open office areas, large rooms) that exceed 8 feet. Mounting the PDS carrier directly from suspended ceiling framework is not acceptable.

3.2.4 Adjacent Infrastructure Considerations

Keep conduit a minimum of 6 inches from parallel runs of flues and steam or hot water pipes. A minimum separation of 6-inches is required between the PDS carrier and water pipes, electrical wires, electrical pipes, plumbing, air conditioning, etc.

3.3 INSTALLATION

Strictly comply with manufacturer's installation instructions and recommendations and approved shop drawings. Coordinate installation with adjacent work to ensure proper clearances and compliance with project site manager and NEC/DOIM. Install in accordance with Ft. Bragg NEC IDC and UFC 3-580-01, Telecommunications Interior Infrastructure Planning And Design.

3.3.1 Mounting PDS Carrier

Surface mount PDS Conduit on the wall using conduit clamps, brackets, or mounts with 0.5 to 1-inch offset spacer from the wall surface. Mount PDS carrier to a wall partition every 5 feet and/or within 18 inches of a section or component connection. Do not mount the PDS Carrier directly to the wall surface.

a. Where wall mounting is unavailable, use appropriately sized all thread rods to mount PDS carrier to ceiling structure.

b. Do not mount PDS carrier to acoustical tile ceiling (ATC) framework.

c. Fasten PDS carrier and component items to building wall partitions using appropriate anchor and fastener for wall partition type.

d. Mount PDS carrier so that is is level and plumb along its route. The top edge of the carrier is horizontally level. Whenever possible maintain a minimum of 2-inches below the suspended ceiling line or the true ceiling line, whichever is lower.

e. Use appropriate hanger type to mount PDS Conduit carrier from ceiling

structure.

f. Struts are not allowed to be used to mount secure raceway or conduit to wall partitions.

g. No more than 1/8 inch play is allowed on TOP CAP (top cover) and span cut per segment span.

h. Install the PDS carrier to permit visual inspections of its entire run.

i. Do not block doorways or access to emergency exits and do not inhibit the operation of windows.

j. Do not paint or cover the PDS carrier with wallpaper or other covering unless the paint is applied by the carrier manufacturer.

k. Bond PDS carrier to TGB or TMGB at point of origin.

3.3.2 Enclosures

Use of enclosures with pre-punched knockouts or external hinges is not acceptable. Fasten UDB, pull boxes, and enclosures to the wall partition using fasteners appropriate for the wall partition type.

3.3.2.1 User Drop Box (UDB)

a. Indicate UDB locations in the PDS Plan and on as-built drawings.

b. Size the UDB to terminate up to 6 cables.

c. Coordinate drop box location with furniture, fixtures and equipment that will be used in the vicinity. Surface mount drop boxes on the wall partition approximately 4 to 5 feet above final floor line depending on room furniture height and layout.

3.3.2.2 Other Enclosures

Indicate enclosure type (user drop box, equipment, or pull-box) on shop and as-built drawings.

3.3.3 Mechanical Security

Comply with site specific epoxy standards obtained from the installation NEC/DOIM. Apply a continuous bead of epoxy at all component, coupling, and fitting connection joints of an EMT conduit PDS carrier system. Seal pull box covers to the pull boxes around the mating surfaces after installation if they cannot be secured with GSA approved changeable combination padlock.

3.3.4 Carrier Support

Support carrier with mounting brackets at intervals in accordance with manufacturer's installation sheets.

3.4 FIELD QUALITY ASSURANCE

3.4.1 Physical Inspection

Physically inspect all interfaces to ensure that they are tight and cannot

turn. Also, physically inspect lock covers to ensure that the lock cap is properly sealed inside the locking mechanism.

3.4.2 Magnetic Test

Perform magnet test on all components (e.g. carrier conduit, carrier raceway, pull boxes, enclosures, conduit bodies, cover plates, etc) and fittings used to construct the carrier. Place a magnet on the carrier component or fitting to verify that construction is from ferrous material. Some alloys will fail the magnet test (e.g. 309 stainless steel) but meet the ferrous material requirements. Provide alloy material property list for components that fail magnet test to the Contracting Officer for approval. Use of components and fittings that fail the magnet test and are not made from ferrous material is not acceptable.

3.5 CLEANING AND PROTECTION

Clean exposed surfaces using non-abrasive materials and methods recommended by manufacturer. Protect raceways and boxes until acceptance.

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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	(2016) Indoor Optical Fiber Cables
ICEA S-90-661	(2012) Category 3, 5, & 5e Individually Unshielded Twisted Pair Indoor Cables for Use in General Purpose and LAN Communications Wiring Systems Technical Requirements

NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION (NECA)

NECA/BICSI 568	(2006) Standard for Installing Building Telecommunications Cabling

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI/NEMA WC 66	(2013) Performance Standard for Category 6 and Category 7 100 Ohm Shielded and Unshielded Twisted Pairs

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2017; ERTA 1-2 2017; TIA 17-1; TIA 17-2; TIA 17-3; TIA 17-4; TIA 17-5; TIA 17-6; TIA 17-7; TIA 17-8; TIA 17-9; TIA 17-10; TIA 17-11; TIA 17-12; TIA 17-13; TIA 17-14) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-1152-A	(2016) Requirements for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling
TIA-455-21	(1988a; R 2012) FOTP-21 - Mating Durability of Fiber Optic Interconnecting Devices
TIA-526-7	(2015a) OFSTP-7 Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant
TIA-568-C.1	(2009; Add 2 2011; Add 1 2012) Commercial Building Telecommunications Cabling Standard
TIA-568-C.2	(2009; Errata 2010; Add 2 2014; Add 1 2016) Balanced Twisted-Pair Telecommunications Cabling and Components Standards
TIA-568-C.3	(2008; Add 1 2011) Optical Fiber Cabling Components Standard
TIA-568-D.0	(2015, Add 1 2017) Generic Telecommunications Cabling for Customer Premises
TIA-568-D.1	(2015, Add 1 2017) Commercial Building Telecommunications Cabling Standard
TIA-568-D.2	(2018) Balanced Twisted-Pair Telecommunications Cabling and Components Standards
TIA-568-D.3	(2016) Optical Fiber Cabling Components Standard
TIA-569	(2015d) Commercial Building Standard for Telecommunications Pathways and Spaces
TIA-606	(2017c) Administration Standard for the Telecommunications Infrastructure
TIA-607-C	(2016) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises
TIA/EIA-598	(2014D; Add 2 2018) Optical Fiber Cable Color Coding
TIA/EIA-604-10	(2002a, 2008b, Add 1 2015) FOCIS 10 Fiber Optic Connector Intermateability Standard - Type LC

U.S. FEDERAL COMMUNICATIONS COMMISSION (FCC)

FCC Part 68	Connection of Terminal Equipment to the Telephone Network (47 CFR 68)

U.S. Army Signal Network Enterprise Center

Ft. Bragg NEC IDC	(2017) Installation Design Criteria for Fort Bragg Specific Communications Infrastructure Require0ments

Unified Facilities Criteria

UFC 3-580-01	(2016) Telecommunications Interior Infrastructure Planning and Design, with Change 1

UNDERWRITERS LABORATORIES (UL)

UL 1286	(2008; Reprint Jan 2018) Office Furnishings
UL 1666	(2007; Reprint Jun 2012) Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts
UL 1863	(2004; Reprint Sep 2016) UL Standard for Safety Communication Circuit Accessories
UL 444	(2008; Reprint Apr 2015) Communications Cables
UL 467	(2013; Reprint Jun 2017) UL Standard for Safety Grounding and Bonding Equipment
UL 50	(2015) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations
UL 514C	(2014; Reprint Dec 2014) Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL 969	(2017) UL Standard for Safety Marking and Labeling Systems

1.2 RELATED REQUIREMENTS

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM and Section 33 82 00 TELECOMMUNICATIONS, OUTSIDE PLANT (OSP), apply to this section with additions and modifications specified herein.

1.3 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in this specification shall be as defined in TIA-568-D.1, TIA-568-D.2, TIA-568-D.3, TIA-569, TIA-606 and IEEE 100 and herein.

1.3.1 Campus Distributor (CD)

A distributor from which the campus backbone cabling emanates. (International expression for main cross-connect (MC).)

1.3.2 Building Distributor (BD)

A distributor in which the building backbone cables terminate and at which connections to the campus backbone cables may be made. (International expression for intermediate cross-connect (IC).)

1.3.3 Floor Distributor (FD)

A distributor used to connect horizontal cable and cabling subsystems or equipment. (International expression for horizontal cross-connect (HC).)

1.3.4 Telecommunications Room (TR)

An enclosed space for housing telecommunications equipment, cable, terminations, and cross-connects. The room is the recognized cross-connect between the backbone cable and the horizontal cabling.

1.3.5 Entrance Facility (EF) (Telecommunications)

An entrance to the building for both private and public network service cables (including wireless) including the entrance point at the building wall and continuing to the equipment room.

1.3.6 Equipment Room (ER) (Telecommunications)

An environmentally controlled centralized space for telecommunications equipment that serves the occupants of a building. Equipment housed therein is considered distinct from a telecommunications room because of the nature of its complexity.

1.3.7 Open Cable

Cabling that is not run in a raceway as defined by NFPA 70. This refers to cabling that is "open" to the space in which the cable has been installed and is therefore exposed to the environmental conditions associated with that space.

1.3.8 Open Office

A floor space division provided by furniture, moveable partitions, or other means instead of by building walls.

1.3.9 Pathway

A physical infrastructure utilized for the placement and routing of telecommunications cable.

1.4 SYSTEM DESCRIPTION

The building telecommunications cabling and pathway system shall include permanently installed backbone and horizontal cabling, horizontal and backbone pathways, service entrance facilities, work area pathways, telecommunications outlet assemblies, conduit, raceway, and hardware for splicing, terminating, and interconnecting cabling necessary to transport

telephone and data (including LAN) between equipment items in a building. The horizontal system shall be wired in a star topology from the telecommunications work area to the floor distributor or campus distributor at the center or hub of the star. The backbone cabling and pathway system includes intrabuilding and interbuilding interconnecting cabling, pathway, and terminal hardware. The intrabuilding backbone provides connectivity from the floor distributors to the building distributors or to the campus distributor and from the building distributors to the campus distributor as required. The backbone system shall be wired in a star topology with the campus distributor at the center or hub of the star. Provide telecommunications pathway systems referenced herein as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, Ft. Bragg NEC IDC and UFC 3-580-01.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Telecommunications drawings

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)

Patch panels

Telecommunications outlet/connector assemblies

Equipment support frame

Connector blocks

Spare Parts

Submittals shall include the manufacturer's name, trade name, place of manufacture, and catalog model or number. Include performance and characteristic curves. Submittals shall also include applicable federal, military, industry, and technical society publication references. Should manufacturer's data require supplemental information for clarification, the supplemental information shall be submitted as specified in paragraph REGULATORY REQUIREMENTS and as required in Section 01 33 00 SUBMITTAL PROCEDURES.

SD-06 Test Reports

Telecommunications cabling testing

SD-07 Certificates

Telecommunications Contractor Qualifications

Key Personnel Qualifications

Manufacturer Qualifications

Test plan

SD-09 Manufacturer's Field Reports

Factory reel tests

SD-10 Operation and Maintenance Data

Telecommunications cabling and pathway system Data Package 5

SD-11 Closeout Submittals

Record Documentation

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. Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. Submittals shall include the nameplate data, size, and capacity. Submittals shall also include applicable federal, military, industry, and technical society publication references.

1.6.1.1 Telecommunications Drawings

Provide registered communications distribution designer (RCDD) approved, drawings in accordance with TIA-606. The identifier for each termination and cable shall appear on the drawings. Drawings shall depict final telecommunications installed wiring system infrastructure in accordance with TIA-606. The drawings should provide details required to prove that the distribution system shall properly support connectivity from the EF telecommunications and ER telecommunications, CD's, 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 cabinet/racks. Drawings shall include a complete list of equipment and material, equipment rack details, proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearance for maintenance and operation. Drawings may also be an enlargement of a congested area of T1 or T2 drawings.

1.6.2 Telecommunications Qualifications

Work under this section shall be performed by and the equipment shall be provided by the approved telecommunications contractor and key personnel. Qualifications shall be provided for: the telecommunications system contractor, the telecommunications system installer, and the supervisor (if different from the installer). A minimum of 30 days prior to installation, submit documentation of the experience of the telecommunications contractor and of the key personnel.

1.6.2.1 Telecommunications Contractor

The telecommunications contractor shall be a firm which is regularly and professionally engaged in the business of the applications, installation, and testing of the specified telecommunications systems and equipment. The telecommunications contractor shall demonstrate experience in providing successful telecommunications systems within the past 3 years of similar scope and size. Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for the telecommunications contractor.

1.6.2.2 Key Personnel

Provide key personnel who are regularly and professionally engaged in the business of the application, installation and testing of the specified

telecommunications systems and equipment. There may be one key person or more key persons proposed for this solicitation depending upon how many of the key roles each has successfully provided. Each of the key personnel shall demonstrate experience in providing successful telecommunications systems within the past 3 years.

All supervisors assigned to the installation of this system or any of its components shall have a minimum Technician certification from BICSI and installers assigned to the installation of this system or any of its components shall have a minimum Level 1 installer certification from BICSI. All supervisors and installers shall also have factory certification from each equipment manufacturer that they are qualified to install and test.

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.

The Contractor shall submit certifications to the Contracting officer, who will in turn provide the NEC's Business and Operations Branch (BOB) with documentation that all installers are BICSI and factory certified to install and test the intended products.

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-C.1, TIA-568-C.2, and TIA-568-C.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, 7 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. The response time for warranty service shall be 2 business says for IDS, ACS, and video surveillance system equipment.

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 in hard copy format and in an electronic format (pdf or other acceptable format.)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.

1.10.3 Spare Parts

In addition to the requirements of Section 01 78 23 OPERATION AND MAINTENANCE DATA, provide a complete list of parts and supplies, with current unit prices and source of supply, and a list of spare parts recommended for stocking.

PART 2 PRODUCTS

2.1 COMPONENTS

Components shall be UL or third party certified. Where equipment or materials are specified to conform to industry and technical society reference standards of the organizations, submit proof of such compliance. The label or listing by the specified organization will be acceptable evidence of compliance. In lieu of the label or listing, submit a certificate from an independent testing organization, competent to perform testing, and approved by the Contracting Officer. The certificate shall state that the item has been tested in accordance with the specified organization's test methods and that the item complies with the specified organization's reference standard. Provide a complete system of telecommunications cabling and pathway components using star topology. Provide support structures and pathways, complete with outlets, cables, connecting hardware and telecommunications cabinets/racks. Cabling and interconnecting hardware and components for telecommunications systems shall be UL listed or third party independent testing laboratory certified, and shall comply with NFPA 70 and conform to the requirements specified herein.

2.2 TELECOMMUNICATIONS PATHWAY

Provide telecommunications pathways in accordance with TIA-569 and as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide system furniture pathways in accordance with UL 1286 and Ft. Bragg NEC IDC..

2.3 TELECOMMUNICATIONS CABLING

Cabling shall be UL listed for the application and shall comply with TIA-568-D.0, TIA-568-D.1, TIA-568-D.2, TIA-568-D.3 and NFPA 70. Provide a labeling system for cabling as required by TIA-606 and UL 969. Ship cable on reels or in boxes bearing manufacture date for for 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-D.1, TIA-568-D.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-D.3, UL 1666 and NFPA 70.

Cable shall be imprinted with fiber count, fiber type and aggregate length at regular intervals not to exceed 40 inches.

Provide the number of strands indicated, (but not less than 12 strands between the main telecommunication room and each of the other telecommunication rooms), of single-mode(OS1), tight buffered fiber optic cable.

Provide plenum (OFNP), riser (OFNR), or general purpose (OFN or OFNG) rated non-conductive, fiber optic cable in accordance with NFPA 70. Substitution of a higher rated cable shall be permitted in accordance with NFPA 70. The cable cordage jacket, fiber, unit, and group color shall be in accordance with TIA/EIA-598.

Provide plenum (OFNP) riser (OFNR) , or general purpose (OFN or OFNG) rated non-conductive, fiber optic cable in accordance with NFPA 70. Substitution of a higher rated cable shall be permitted in accordance with NFPA 70. The cable cordage jacket, fiber, unit, and group color shall be in accordance with TIA/EIA-598.

2.3.2 Horizontal Cabling

Provide horizontal cable in compliance with NFPA 70 and performance characteristics in accordance with TIA-568-D.1.

2.3.2.1 Horizontal Copper

Provide horizontal copper cable, UTP, 100 ohm in accordance with TIA-568-D.2, UL 444, ANSI/NEMA WC 66, ICEA S-90-661 . Provide four each individually twisted pair, minimum size 24 AWG conductors, Category 6, with a green thermoplastic jacket. Cable shall be imprinted with manufacturers name or identifier, flammability rating, gauge of conductor, transmission performance rating (category designation) and length marking at regular intervals in accordance with ICEA S-90-661. Provide plenum (CMP), 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 thick4 by 8 feet and installed 6" above finished floor with the 'A' side exposed. . Backboards shall be fire rated by manufacturing process. Fire stamp shall be clearly visible. Backboards shall be provided on a minimum of two adjacent walls in the telecommunication spaces. Each sheet of plywood shall be inspected and verified by the RNECFB QA/QC's before installation. The plywood backboard shall not be painted.

2.4.2 Equipment Support Frame

Provide in accordance with ECIA EIA/ECA 310-E and UL 50.

Racks, floor mounted modular type, 16 gauge steel or 11 gauge aluminum construction, minimum, treated to resist corrosion. Provide rack with vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug and a double duplex receptacle. Rack shall be compatible with 19 inches panel mounting.

Horizontal cable management shall be provided above, below, front, and rear of each patch panel on the standard 19" equipment racks(s). Horizontal cable management shall be of a type that utilizes duct fingers with snap on covers and a minimum of two (2) RU in size.

2.4.3 RNECFB

The RNECFB requires all RNECFB active and passive equipment shall need to be installed in a floor mounted cabinet. The cabinet shall need to have a cipher lock installed per UFC 3-580-01.

2.4.3.1 Equipment Rack Specification

2.4.3.1.1 Main Unit

a. Frame: Rack Main Unit shall be 42U in height (2000mm (78.74”)H x 600mm (23.62”)W x 1100mm (43.31”)D. The product shall be designed in accordance with EIA-310E standard for IT rail-hole spacing and have UL2416 certification. The frame shall be constructed as a welded/bolted steel frame, folded 5-times for maximum strength and rigidity, and promote flexible mounting options and fully adjustable rail positioning. The frame shall include depth markings for ease of EIA rail alignment. The frame shall support 4000 lbs. (1361kg) static weight load, 2500 lbs. (1334kg) dynamic (non- transit) weight load, and shall be equipped with leveling feet.

b. Mounting Rails: Rack shall have two (2) pair of 19” Mounting Rails. The mounting rails shall support the EIA-310E standard hole-mounting pattern, shall be factory-installed in the frame and be individually and infinitely depth-adjustable within the useable space to allow for flexibility of mounting depth. Rails shall be constructed of 12-gauge sheet steel, folded 3 times for maximum rigidity, powder-coat black, with color-contrasting full-height RU position labels on both sides of each rail. Mounting rails shall be capable of accepting tool-less cable management accessories.

c. Doors: Rack doors shall be tool-less removable, and field reversible with 3 hinges per door for added rigidity. Doors shall have front and rear combination lock handles with one (1) 77% perforated locking front door and two (2) 77% perforated split locking rear doors.

d. Side Panels: Rack shall be equipped with four (4) (2 per side) lockable split side panels. Split locking side panels shall be made of 16 gauge (1.5mm) sheet metal and finished in powdercoat black. Panels shall be externally removable and come standard with locks Side panels shall be cable pass-through side panels with brush strips shall be available fitted with brush kits.

e. Top Panel: There shall be a tool-less removable type top panel that

includes provisions for front and rear cable entrance. Panel shall be made of 16 gauge (1.5mm) sheet metal and finished in powder-coat black. The top cover shall include an integrated hole pattern for easy installation of top panel mount accessories (cable management, ladder/cable tray support brackets, etc.), and (1) cutout for top panel fan module. and a minimum of eight (8) cable pass-through brush kits for the top panel.

2.4.3.1.2 Required Equipment Rack Accessories

Rack shall be accessorized with manufacturer approved products.

a. Fan: Fan module shall be 110V with NEMA 5-15P plug connection on an attached 6 foot (1.8m) cord. Fan shall be installed in rack top panel capable of 300CFM air circulation.

b. Horizontal Cable Management: Horizontal cable management shall be single-sided with cover 2U x 4" deep for frontside of rack and single-sided with cover 2U x 6" deep for rear horizontal cable management.

c. Vertical Cable Management: Rack shall contain two (2) full height PDU/cable management brackets. All PDU/Cable Management Brackets shall be depth-adjustable within the frame, and include integrated cable management features to accept tool-less cable management accessories. A minimum of ten (10) tool-less Lobster Claw type cable managers shall be provided for rear vertical cable management,

d. Warranty: Rack shall be warranted against defects in materials and workmanship for two (2) years from date of shipment.

2.4.4 Connector Blocks

Provide insulation displacement connector (IDC) Type 110 for Category 6 systems. Provide blocks for the number of horizontal and backbone cables terminated on the block plus 25 percent spare.

2.4.5 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, cabinet, panels, or backboard for horizontal cable management and individually mounted for vertical cable management. Mount cable guides with screws, or nuts and lockwashers.

2.4.6 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. Provide fiber optic patch cables with crossover orientation in accordance with TIA-568-D.3. Patch cords shall meet minimum performance requirements specified in TIA-568-D.1, TIA-568-D.2 and TIA-568-D.3 for cables, cable length and hardware specified.

2.4.6.1 Modular to 110 Block Patch Panel

Provide in accordance with TIA-568-D.1 and TIA-568-D.2. Panels shall be third party verified and shall comply with EIA/TIACategory 6 requirements. Panel shall be constructed of 0.09 inches minimum aluminum and shall be wall mounted and compatible with anECIA EIA/ECA 310-E 19 inches equipment rack. Panel shall provide 48 non-keyed, 8-pin modular ports, wired to T568A. Patch panels shall terminate the building cabling on Type 110 IDCs and shall utilize a printed circuit board interface. The rear of each panel shall have incoming cable strain-relief and routing guides. Panels shall have each port factory numbered and be equipped with laminated plastic nameplates above each port.

2.4.6.2 Fiber Optic Patch Panel

Provide panel for maintenance and cross-connecting of optical fiber cables. Panel shall be constructed of 11 gauge aluminum minimum and shall be rack mounted and compatible with a ECIA EIA/ECA 310-E 19 inches equipment rack. Each panel shall provide 12 single-mode adapters as duplex LC in accordance with TIA/EIA-604-10 with zirconia ceramic alignment sleeves, alignment sleeves. OSP fiber and backbone/ distribution fiber shall be installed in separate fiber optic patch panels with the OSP fiber being installed in the top 1U FOPP in the FBNEC cabinet. 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-D.1, and TIA-568-D.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-D.2 Category 6 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 T568A. UTP outlet/connectors shall comply with TIA-568-D.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. Outlets shall be the same color as the cable and by the same manufacturer as the patch panels.

2.5.2 Optical Fiber Adapters(Couplers)

Provide optical fiber adapters suitable for duplex LC in accordance with TIA/EIA-604-10 with zirconia ceramic alignment sleeves, as indicated. Provide dust cover for adapters. Optical fiber adapters shall comply with TIA-455-21 for 500 mating cycles.

2.5.3 Optical Fiber Connectors

Provide in accordance with TIA-455-21. Optical fiber connectors shall be duplex LC in accordance with TIA/EIA-604-10 with zirconia ceramic alignment sleeves, ferrule, epoxyless compatible with8/125 single-mode

fiber. The connectors shall provide a maximum attenuation of 0.3 dB at 1310 or 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, and TIA-568-D.1, TIA-568-D.2, TIA-568-D.3; flush design constructed of high impact thermoplastic material ivory in colorto match color of receptacle/switch cover plates specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide labeling in accordance with the paragraph LABELING in this section.

2.6 GROUNDING AND BONDING PRODUCTS

Provide in accordance with UL 467, TIA-607-C, and NFPA 70. Components shall be identified as required by TIA-606. Provide ground rods, bonding conductors, and grounding busbars as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.7 FIRESTOPPING MATERIAL

Provide as specified in Section 07 84 00 FIRESTOPPING.

2.8 MANUFACTURER'S NAMEPLATE

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

2.9 FIELD FABRICATED NAMEPLATES

ASTM D709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 0.125 inches thick, white with black center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be one by 2.5 inches. Lettering shall be a minimum of 0.25 inches high normal block style.

2.10 TESTS, INSPECTIONS, AND VERIFICATIONS

2.10.1 Factory Reel Tests

Provide documentation of the testing and verification actions taken by manufacturer to confirm compliance with TIA-568-D.1, TIA-568-D.2, TIA-568-D.3, 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-D.1, TIA-568-D.2, TIA-568-D.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-D.1, TIA-568-D.2, and TIA-568-D.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-D.1, TIA-568-D.2 and TIA-568-D.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 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 close to the outlet in the cable tray, in its natural lay, prior to entering the conduit stub-out.

3.1.2 Pathway Installations

Provide in accordance with TIA-569 and NFPA 70. Provide building pathway as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.1.3 Service Entrance Conduit, Underground

Provide service entrance underground as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.1.4 Cable Tray Installation

Install cable tray as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Only CMP and OFNP type cable shall be installed in a plenum.

3.1.5 Work Area Outlets

3.1.5.1 Terminations

Terminate UTP cable in accordance with TIA-568-D.1, TIA-568-D.2 and wiring configuration as specified.

3.1.5.2 Cover Plates

As a minimum, each outlet/connector shall be labeled as to its function and a unique number to identify cable link in accordance with the paragraph LABELING in this section.

3.1.5.3 Cables

Unshielded twisted pair and fiber optic cables shall have a minimum of 12 inches of slack cable close to the outlet in the cable tray, in its natural lay, prior to entering the conduit stub-out. Minimum manufacturer's bend radius for each type of cable shall not be exceeded.

3.1.5.4 Pull Cords

Pull cords shall be installed in conduit serving telecommunications outlets that do not have cable installed.

3.1.6 Telecommunications Space Termination

Install termination hardware required for Category 6 and optical fiber system. An insulation displacement tool shall be used for terminating copper cable to insulation displacement connectors.

3.1.6.1 Connector Blocks

Connector blocks shall be wall mounted in orderly rows and columns. Adequate vertical and horizontal wire routing areas shall be provided between groups of blocks. Install in accordance with industry standard wire routing guides in accordance with TIA-569.

3.1.6.2 Patch Panels

Patch panels shall be mounted in equipment 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 as recommended by the manufacturer to prevent movement of the cable.

b. Fiber Optic Patch Panel. Fiber optic cable loop shall be 3 feet in length. The outer jacket of each cable entering a patch panel shall be secured to the panel to prevent movement of the fibers within the panel, using clamps or brackets specifically manufactured for that purpose.

3.1.6.3 Equipment Support Frames

Install in accordance with TIA-569:

a. Racks, floor mounted modular type. Permanently anchor rack to the floor in accordance with manufacturer's recommendations.

b. Cabinets, freestanding modular type. When cabinets are connected together, remove adjoining side panels for cable routing between cabinets.

3.1.7 Electrical Penetrations

Seal openings around electrical penetrations through fire resistance-rated wall, partitions, floors, or ceilings as specified in Section 07 84 00 FIRESTOPPING.

3.1.8 Grounding and Bonding

Provide in accordance with TIA-607-C, 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 and Ft. Bragg NEC IDC. Handwritten labeling is unacceptable. Stenciled lettering for voice and data circuits shall be provided using thermal ink transfer process or laser printer.

3.2.2 Cable

Cables shall be labeled using color labels on both ends with identifiers in accordance with TIA-606.

3.2.3 Termination Hardware

Workstation outlets and patch panel connections shall be labeled using color coded labels with identifiers in accordance with TIA-606.

3.3 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent

surfaces or to meet the indicated or specified safety criteria. Painting shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.4 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-D.1, TIA-568-D.2, TIA-568-D.3. Test equipment shall conform to TIA-1152-A. 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-D.1, TIA-568-D.2, TIA-568-D.3. Visually confirm Category 6, 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-D.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 link tests in accordance with TIA-568-D.1 and TIA-568-D.2. Tests shall include wire map, length, insertion loss, NEXT, PSNEXT, ELFEXT, PSELFEXT, return loss, propagation delay, and delay skew.

. Optical fiber Links. Perform optical fiber end-to-end link tests in accordance with TIA-568-D.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. The Contractor shall provide test results of the installed ISP and/or OSP to the Ft. Bragg NEC for review. Once the NEC has received and reviewed the test results, the NEC will coordinate with the Army Corp of Engineers to schedule the date for verification testing and inspection to begin.

a. Voice Tests. These tests assume that dial tone service has been installed. Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and DSN telephone call.

b. Data Tests. These tests assume the Information Technology Staff has a network installed and are available to assist with testing. Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network.

-- End of Section --

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SECTION 27 51 16

AUDIO VISUAL SYSTEMS
05/20

PART 1 GENERAL

1.1 RELATED SECTIONS

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, applies to this section, with the additions and modifications specified herein. In addition, refer to the following sections for related work and coordination:

Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

1.2 SUMMARY

1.2.1 Scope

a. This work includes design and providing a new, complete, audio visual system as described herein for the SOF Headquarters. Provide a turnkey system capable of receiving, processing, and transmitting indicated input signals including the system wiring, raceways, pull boxes, terminal cabinets, outlet and mounting boxes, control equipment, amplifiers, microphones, speakers, mounting hardware and other accessories and miscellaneous items required for a complete operating system even though each item is not specifically mentioned or described. Provide system complete and ready for operation. See paragraph titled SYSTEM DESCRIPTION for additional requirements.

b. The system layout on the drawings show the intent of coverage and are shown in suggested locations. Submit plan view drawing showing all component locations, cable routing, junction boxes, other related equipment, conduit routing, and wire counts for all floors.

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.

ELECTRONIC COMPONENTS INDUSTRY ASSOCIATION (ECIA)

ECIA EIA/ECA 310-E	(2005) Cabinets, Racks, Panels, and Associated Equipment

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 802.3	(2018) Ethernet
IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage

(1000 V and Less) AC Power Circuits

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2019; TIA 19-1; TIA 19-2; TIA 19-3; TIA 19-4; ERTA 1 2019) National Electrical Code

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST SP 800-82 (2015; Rev 2) Guide to Industrial Control Systems (ICS) Security

U.S. DEPARTMENT OF DEFENSE (DOD)

DOD 8510.01 (2014; Change 1-2016; Change 2-2017) Risk Management Framework (RMF) for DoD Information Technology (IT)

UFC 4-010-06 (2016; with Change 1, 2017) Cybersecurity of Facility-Related Control Systems

U.S. FEDERAL COMMUNICATIONS COMMISSION (FCC)

FCC Part 15 Radio Frequency Devices (47 CFR 15)

UNDERWRITERS LABORATORIES (UL)

UL 1449 (2014; Reprint Jul 2017) UL Standard for Safety Surge Protective Devices

UL 1778 (2014; Reprint Sep 2017) UL Standard for Safety Uninterruptible Power Systems

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Qualifications; G

SD-02 Shop Drawings

Detail Drawings; G

System Layout; G

System Design; G

SD-03 Product Data

Spare Parts

SD-06 Test Reports

Approved Test Procedures; G

Acceptance Tests

Accreditation; G

SD-07 Certificates

Components

SD-10 Operation and Maintenance Data

Audio Visual System; G

Submit Data Package 5 for each component in accordance with the requirements of Section 01 78 23 OPERATION AND MAINTENANCE DATA.

1.5 SYSTEM DESCRIPTION

1.5.1 Design Requirements

Provide a Public Address System, capable of distributing the indicated audio signals from equipment including LAN controllers, communication links, cabling, battery backup, power line surge protection and all other necessary components to make a complete and operational system. Complete coverage will be provided for all interior public spaces and other spaces as indicated on the drawings.

Provide all headend interface, amplification components, conditioners and any other equipment necessary.

Provide all materials and labor needed for a complete and operational system for the services in this specification plus the additional system capabilities as indicated. This includes but not limited to all necessary equipment, interfaces, jumpers, terminations, cabling, amplifiers, conditioners, power supplies, battery backup, software and all components required for system operation.

1.5.2 System Application Design

Provide the system application design required to provide a audio visual system that complies with and satisfies all of the requirements specified in this Section and indicated on the Telecommunications Drawings for this application and project.

1.5.3 Standard Products

Provide an application design that utilizes standard system components that are the product of a Manufacturer regularly engaged in the manufacture of networked audio visual system, and that have been in satisfactory use for at least six months. Provide all major components from the same manufacturer. The System must be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the facility. Do not deliver material to the project site more than six months prior to the scheduled date of installation.

Provide hardware, software, and installation of a complete and engineered system. Provide a submitted design that is properly engineered for the operational requirements. Include all components required to meet this specification section in the design, other than a change in, or in addition to the operational frequencies identified herein.

1.5.4 Local Products

Incorporate local materials to the greatest extent possible. All proposed local products must meet all applicable hardware and software requirements set forth in these specifications.

1.5.5 Minimum Requirements

Specifications are minimum requirements. If the provided system requires enhanced specifications that exceed those specified herein in order to satisfy the specified design, configuration, capability, and performance requirements, then a provide a system with the enhanced specifications.

1.5.6 Current State-of-the-Art Technology

Provide application design and products that utilize current state-of-the-art products that provide the enhanced capability and performance specified herein. Provide design and products representing the latest manufacturer make and model.

1.5.7 Environmental Requirements

Provide equipment to be used indoors rated for continuous duty operation under ambient environmental conditions of 35 to 120 degrees F dry bulb and 10 to 95 percent reflective humidity, noncondensing. Provide all other equipment rated for continuous operation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified or normally encountered for the installed location.

1.5.8 Electrical Requirements

105 VAC to 130 VAC at 60 Hz operating voltage range, plus or minus 2 percent.

1.5.9 Power supplies

Provide power supplies that provide sufficient power for worst-case conditions of system operation that could occur without signal loss or perceptible degradation.

1.5.10 Power Line Surge Protection

Provide power line surge protection for all equipment connected to AC power. Provide surge protection integral to the equipment or installed as an accessory item in accordance to manufacturer's recommendations. Do not use fuses for surge protection.

1.5.11 Shielding and Grounding

Provide shielding and grounded as required by the system design, Manufacturer's instructions, FCC Part 15 listing, and regulatory requirements.

1.5.12 System Capability and Configuration

1.5.12.1 System Capability

Provide an audio visual system with capabilities to support input modules, controllers, and interface modules.

1.6 CYBERSECURITY

a. The Risk Management Framework (RMF) is the process by which information systems are accredited for operation by a designated official from the Using Military Department. It is the standard process under which all DoD information systems must achieve and maintain their Authority To Operate. The Cyber Security process is documented in DOD 8510.01 and NIST SP 800-82. Refer to UFC 4-010-06 for additional requirements.

b. All systems that are IP addressable or interface with the Assured Network must be certified to operate. Coordinate with the Government to initiate and complete the accreditation process.

c. Cybersecurity requires input from the system vendor or provider and support from the local IMD. The local IMD-IA office is the point of contact for all Cybersecurity requirements. The local CMIO is the point of contact for all clinical and functional system requirements.

1.7 QUALIFICATIONS

1.7.1 General Qualification Requirements

a. The System Contractor, Installer and Manufacturer must each have the minimum qualifications specified, related to the type of system specified for this project.

b. The Government reserves the right to accept or reject the System Contractor, Installer 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.

e. Include qualification documentation, but not limited to the information outlined below:

(1) A list of projects performed by the System Contractor and Installer during the last five years explicitly involving the type of system specified in this section, including:

(a) Name of facility where work was completed.

(b) Name, title, address and telephone number of a point of contact for the listed facility.

(c) The make and model of the system provided and total scope of work for the facility.

(d) Restrict list to the facilities where the same type of system was installed for the same purpose provided.

1.7.2 System Contractor Qualifications

a. Contractor qualifications must include the following:

(1) The Contractor is regularly engaged in the system application design, documentation, installation, testing, training, and maintenance of the type of system specified in this section.

(2) The Contractor has a minimum of five years experience providing these services for systems having the same level of features and functions as the system being provided.

(3) The Contractor has a minimum of five years as the manufacturer or an authorized distributor and service organization for the manufacturer of the system provided.

b. Contactor personnel qualifications must:

(1) Be factory trained or certified for the make and model of the system provided.

(2) Have a minimum of five years experience performing the services specified in this specification section.

(3) Maintain a full compliment of spare parts for the provided system with the ability to furnish on-call maintenance 24 hours per day, 365 days per year.

1.7.3 Installer Qualifications

a. The installer personnel must be regularly engaged in the installation of the type of system in this specification section.

b. The installation supervisor must be factory trained or certified for the make and model of the system provided.

c. The installation supervisor must have a minimum of five years experience providing services having the same level of features and functions for the system included in this specification section.

d. The installation personnel must have a minimum of three years experience providing services having the same level of features and functions for the system included in this specification section.

1.7.4 Manufacturer Qualifications

The system manufacturer must:

a. Have a minimum of five years experience in producing the products and type of system included in this specification section.

b. Produce a system that satisfies all specified features, functions and product requirements.

c. Guarantee the availability of the replacement parts for the designed system for a minimum of seven years from the date of final acceptance of the system by the Contracting Officer.

1.8 DELIVERY, STORAGE, AND HANDLING

Equipment placed in storage until installation shall be stored with protection from the weather, humidity and temperature variations, dirt and dust, and other contaminants.

1.9 EXTRA MATERIALS

Submit spare parts data for each different item of material and equipment specified, after approval of the detail drawings and not later than 2 months prior to the date of beneficial occupancy. The data shall include a complete list of parts and supplies, with current unit prices and source of supply.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

The audio visual system shall consist of an audio distribution network to include amplifiers, mixers, microphones, speakers, cameras, video displays, cabling, and ancillary components required to meet the required system configuration and operation. Submit Data Package 3 in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

2.1.1 Single-Channel System

The system shall control and amplify an audio program for distribution within the areas indicated. Components of the system shall include a mixer-preamplifier, mixer-amplifier, power amplifier, microphone, speaker system, cabling and other associated hardware.

2.1.2 System Performance

The system shall provide even sound distribution throughout the designated area, plus or minus 3 dB for the 1/1 octave band centered at 4000 Hz. The system shall provide uniform frequency response throughout the designated area, plus or minus 3 dB as measured with 1/3-octave bands of pink noise at locations across the designated area selected by the Contracting Officer. The system shall be capable of delivering 75 dB average program level with additional 10 dB peaking margin sound pressure level (SPL) in the area at an acoustic distortion level below 5 percent total harmonic distortion (THD). Unless otherwise specified the sound pressure reference level is 20 micro Pascal (0.00002 Newtons per square meter).

2.1.3 Detail Drawings

Submit detail drawings consisting of a complete list of equipment and material, including manufacturer's descriptive and technical literature, performance charts and curves, catalog cuts, and installation

instructions. Note that the contract drawings show layouts based on typical speakers. Check the layout based on the actual speakers to be installed and make necessary revisions in the detail drawings. Detail drawings shall also contain complete point to point wiring, schematic diagrams and other details required to demonstrate that the system has been coordinated and will properly function as a unit. Drawings shall show proposed layout of equipment and appurtenances, and equipment relationship to other parts of the work including clearances for maintenance and operation.

2.1.4 Network IP System Design

Submit system design consisting of a design analysis, calculations, and drawings as described in paragraph titled Detail Drawings. In the design analysis, describe all components, equipment, and appurtenances required for a fully functional system. Also include a detailed description of system operation to include interfaces with other systems, and all system inputs.

2.2 STANDARD PRODUCTS

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of such products, and that essentially duplicate material and equipment that have been in satisfactory use at least 2 years. All components used in the system shall be commercial designs that comply with the requirements specified. Submit copies of current approvals or listings issued by UL, or other nationally recognized testing laboratory for all components.

2.2.1 Identical Items

Items of the same classification shall be identical. This requirement includes equipment, modules, assemblies, parts, and components.

2.2.2 Nameplates

Each major component of equipment shall have the manufacturer's name, address, model and catalog number, and serial number on a plate secured to the equipment.

2.3 IP NETWORKED AUDIO VISUAL SYSTEM

Provide complete digital IP based audio network as required to deliver high quality audio signals to speakers as indicated on the drawings. Provide amplifiers of sufficient power to drive speakers.

2.3.1 System Components

Provide all system components as required for a complete and operational system to include the following minimum components.

2.3.1.1 Headend Equipment

Provide floor mounted equipment rack to house all headend equipment.

2.3.1.2 Auxiliary Inputs

Provide rack space and input modules for a minimum of two auxiliary inputs.

2.3.2 Distribution Equipment

Provide all distribution equipment necessary to process and distribute paging and music to zones as indicated on the drawings.

2.3.2.1 Monitor Panel

Provide system monitor panel with speaker and zone selection capability to check each output, voice input, and zone selection.

2.3.2.2 Loudspeaker System

Provide low power loudspeakers for uniform sound distribution at low volume levels. Space speakers as indicated on the drawings.

Provide speakers that are designed to provide even sound dispersion over the 20 Hz to 20 kHZ frequency range within the entire area the speaker covers.

2.3.2.3 Indoor Loudspeaker Assemblies

Provide cone type speakers with wall or ceiling enclosures and baffles as indicated on the drawings.

2.3.2.4 Microphones

Provide types and quantities of microphones as indicated on the drawings.

2.3.3 System Configuration

2.3.3.1 All Call

Provide all call paging capability. All call paging will have priority over all other paging zones. Provide access to all call paging via a microphone, telephone, or both. Microphone access will have priority over telephone access for all paging zone types.

2.3.4 System Performance

Provide system that evenly distributes sound throughout loudspeaker zones at plus or minus 3 dB for the 1/1 octave band centered at 4,000 Hz. Provide system that has uniform frequency response throughput loudspeaker zones of plus or minus 3 DB as measured with 1/3 octave bands of pink noise at locations as selected by the Contracting Officer. Provide system capable of delivering 75 dB average program level with additional 10 dB peaking margin sound pressure level without causing the associated amplifier to exceed normal operating specifications for power or distortion. Reference sound pressure level is 20 micropascal, unless otherwise indicated. Minimum audio sound pressure level must be at least +15 dB in all areas. System must not produce audible hum, noise, buzz, or rattles at any loudspeaker. Electoral/acoustic signal-to-noise ratio for the entire system must be at least 66 dB.

2.3.5 Electrical Power

Provide uninterruptable power supply (UPS) units that will support AC powered equipment for a minimum of 15 minutes of full power during an AC

power failure. Provide UPS units that comply with UL 1778 and FCC Part 15

2.4 ANALOG AUDIO SYSTEM

2.4.1 MIXER-PREAMPLIFIER

Mixer-preamplifier shall as a minimum conform to the following specifications:

Rated Output	18 dB
Frequency Response	Plus or Minus 1 dB, 20 - 20,000 Hz
Distortion	Less than 0.5 percent, 20 - 20,000 Hz
Signal to noise	Microphone - 60 dB
	Aux - 70 dB
Inputs	5 independent balanced low-impedance transformer-isolated
Input Sensitivity	Microphone - 0.003 volts
	Aux - 0.125 volts
	Magnetic Cartridge - 0.0005 volts
Input Channel Isolation	80 dB minimum
Tone Controls	Plus or Minus 10 dB range at 50 and 15,000 Hz
Power Requirement	110-125 Vac 60 Hz

2.4.2 POWER AMPLIFIERS

Power amplifiers as a minimum conform to the following specifications:

Rated power output	60 watts RMS
Frequency Response	Plus or Minus 3 dB, 20-20,000 Hz
Distortion	Less than 2 percent at RPO, 600-13,000 Hz
Input Impedance	50 k ohm unbalanced
Output Impedance	Balanced 4 and 8 ohms
Output voltage	25 and 70.7 volts
Power Requirement	110-125 Vac 60 Hz

2.4.3 MIXER AMPLIFIER

Mixer amplifier shall as a minimum conform to the following specifications:

Rated Power Output (RPO)	60 watts RMS
Frequency Response	Plus or Minus 3 dB, 20-20,000 Hz
Distortion	Less than 1 percent at RPO, 60 - 13,000 Hz
Inputs	2 microphones (high impedance or low-impedance unbalanced 2 Aux. (high-impedance)
Output Impedance	Balanced 4 and 8 ohms
Output Voltage	25 and 70.7 volts
Power Requirement	110-125 Vac 60 Hz

2.4.4 MICROPHONE INPUT MODULES

Microphone input modules shall as a minimum conform to the following specifications:

Rated Outputs	0.25 volts into 10,000 ohms
	1.0 volts into 10,000 ohms
Frequency Response	Plus or Minus 2 dB, 20 - 20,000 Hz
Distortion	Less than 0.5 percent 20 - 20,000 Hz
Inputs	4 transformer - coupled balanced 150 ohm
Input Sensitivity	0.003 volts
Input Channel Isolation	70 dB minimum

2.4.5 MICROPHONES

2.4.5.1 Desk Microphone

Microphones shall as a minimum conform to the following specifications:

Element	Dynamic
Pattern	Cardioid
Frequency Response	50 - 12,000 Hz

Impedance	Low impedance mic (150-400 ohms)
Front-to-back Ratio	20 dB
Selector switches	Selector switches for zone shall be be integral microphone or Separate console adjacent to microphone

2.4.5.2 Microphone Jack

Each outlet for microphones shall consist of a standard outlet box, flush-mounted, and fitted with a three-pole, polarized, locking-type, female microphone jack and a corrosion resistant-steel device plate.

2.4.5.3 Ceiling Microphones

Ceiling mounted microphone shall be white in color and provided with a minimum of 3 ft adjustable drop. Cable shall be adjusted to optimize sound input for the system. Microphone shall be capable of a frequency response of 100Hz to 16KHz. A dynamic range of greater than 90db.

2.5 LOUDSPEAKERS

2.5.1 Cone Speaker

The cone speaker shall as a minimum conform to the following specifications:

Application	Ceiling
Frequency range	60 to 12,000 Hz
Power Rating	Normal - 7 watts
	Peak - 10 watts
Voice Coil Impedance	8 ohms
Line Matching Transformer Type	25/ 70.7 volt line
Capacity	4 watts
Magnet	10 ounces or greater
Primary Taps	0.5, 1, 2 and 4 watts
Primary Impedance	25 volts - 1250, 625, and 312 ohms
	70.7 volts - 10k, 5k, and 2.5k ohms
Frequency Response	30 - 20,000 Hz
Insertion Loss	Less than 1 dB

2.5.2 Ceiling Speaker Enclosures

Ceiling speaker enclosure shall be constructed of heavy gauge cold steel with interior undercoating and 1-1/2 inch thick high density fiberglass 1-1/2 lbs/cu. ft. The unit shall be round and designed for recessed installations which will be accomplished via standard screw mounting. Recessed models shall have a rust-preventive, textured black coating and the surface mount unit finished in textured white . Enclosure shall include four triple compound conduit knockouts.

2.6 EQUIPMENT RACKS AND CABINETS

Equipment shall be mounted on floor mounted cabinets with 19 inch mounting rails as indicated on the drawings UL listed andin accordance with ECIA EIA/ECA 310-E and located as shown on drawings. Ventilated rear panels, solid side panels, and solid top panels shall be provided for cabinets. Equipment cabinets shall be provided with lockable front panels that limit access to equipment. The lockable front shall not cover items that require operator access. Cabinet cooling shall be through perforations or louvers in front panels to ensure adequate ventilation of equipment . The racks and cabinets shall be factory finished with a uniform baked enamel over rust inhibiting primer.

2.7 CABLES

2.7.1 Speaker Cable

Cables shall be of the gauge required depending upon the cable run length. In no case shall cable be used which is smaller than 18 AWG. Insulation on the conductors shall be polyvinyl chloride (PVC) or an equivalent synthetic thermoplastic not less than 0.009 inch. Cables shall be jacketed with a PVC compound. The jacket thickness shall be 0.02 inch minimum.

2.7.2 Microphone Cable

Cable conductor shall be stranded copper 20 AWG. Insulation on the conductors shall be polyvinyl chloride (PVC) or an equivalent synthetic thermoplastic not less than 0.009 inch. Cable shall be shielded 100 percent of aluminum polyester foil with a bare 22 gauge stranded soft copper drain conductor. Cables shall be jacketed with a PVC compound. The jacket thickness shall be 0.02 inch minimum.

2.8 TERMINALS

Terminals shall be solderless, tool-crimped pressure type.

2.9 SURGE PROTECTION

2.9.1 Power Line Surge Protection

Major components of the system such as power amplifiers, mixer-preamplifiers, and tuners, shall have a device, whether internal or external, which provides protection against voltage spikes and current surges originating from commercial power sources in accordance with IEEE C62.41.1/IEEE C62.41.2 B3 combination waveform and NFPA 70. Fuses shall not be used for surge protection. The surge protector shall be rated for a maximum let thru voltage of 350 Volts ac (line-to-neutral) and 350 Volt ac (neutral-to-ground). Surge protection device shall be UL

listed and labeled as having been tested in accordance with UL 1449.

2.9.2 SIGNAL SURGE PROTECTION

Major components of the system shall have internal protection circuits which protects the component from mismatched loads, direct current, and shorted output lines. Communication cables/conductors shall have surge protection installed at each point where it exits or enters a building.

2.10 TOUCH SCREEN CONTROLLER

The touch screen UI shall be composed of the following functional elements:

a. 7 inch TFT active-matrix color LCD touch screen 1024 by 600 WSVGA resolution display (for smaller rooms) and 10 inch TFT active-matrix color LCD touch screen 1024 by 600 WSVGA resolution display (for larger rooms)

b. Graphical touch video display

c. Programmable capacitive buttons

d. Ambient light sensor

e. Built-in camera, microphone, and speakers

f. Built-in Bluetooth device proximity beacon

2.10.1 Graphical Display

Graphical UI - Touch screen UI display shall support the following viewable elements:

a. Control buttons and objects

b. Feedback indication via text, button object change in color, animated object or graphical element.

c. H.264 or MJPEG Streaming video

d. Graphical UI shall automatically adjust screen brightness based on room ambient light levels.

2.10.2 Touch UI Functions

a. Touch Screen UI shall support Multi-Touch control interfacing.

b. Touch Screen UI shall support gesture driven controls through custom programming and configuration.

2.10.3 Functions - The Touch Screen UI

The Touch Screen UI shall include:

a. Custom Control UI - control of integrated system components through custom programming or preset configuration of the system control processor by same manufacturer.

b. System Integration - device shall support controls for compatible

integrated AV systems, HVAC and Lighting hardware, and scheduling and management systems.

2.10.4 Audio Feedback

Custom audio feedback via custom programming.

2.10.5 Internet Browsing

Internet Browsing shall be supported via Ethernet network. Internet access required and to be provided by integrator.

2.10.6 Communication and Power

Communication: Bidirectional 10/100 Mbps Ethernet communication. Power: IEEE 802.3af Class 3 PoE Powered Device

2.11 A/V SWITCHER

2.11.1 Audio

Any stereo input signal shall be routable to stereo analog output and digital HDMI outputs. The dual internal stereo switchers shall have multiple stereo inputs. Each internal stereo switcher input shall be internally connected to a 19-pin Type A HDMI female connector with stereo audio or 3.5mm TRS mini phone jack with stereo line level analog audio. The analog audio output and the digital audio outputs shall be capable of outputting independent audio mixes. All stereo sources shall be available simultaneously and have controllable levels in each of the two output mixes.

2.11.2 Video

Video switcher shall support auto signal detecting. Switcher shall have multiple inputs including, but not limited to four analog VGA inputs and four 4K HDMI inputs. All video input signals shall be routable to video outputs. Each input shall be internally connected to a DB15HD type female connector or 19-pin Type A HDMI female connector. Video transcoder shall be capable of converting video analog to digital at source resolution and at a rate of 10-bit 165 MHz.

2.11.3 Control Processor

The Central Switching and Control Unit shall include an integrated microprocessor based control processor. Utilize a real time, preemptive, multi-threaded/multi-tasking kernel; Transaction-Safe Extended FAT file system; supports up to 10 simultaneously running programs. Processor shall communicate directly with Ethernet, control ports and proprietary control network utilizing high-speed, parallel bus infrastructure. The control system shall be equipped with infrared/serial, Ethernet, and communication network inputs. Control System shall support the following Ethernet features:

a. 10/100/1000 Mbps

b. Auto-switching

c. Auto-negotiating

d. Auto-discovery

e. Full/half duplex

f. Industry-standard TCP/IP stack

g. UDP/IP

h. CIP

i. DHCP

j. Private Network Mode

k. SSL

l. IEEE 802.1X

m. SNMP

n. BACnet/IP

o. IPv4 or IPv6

p. Active Directory authentication

q. RSTP

r. SMTP e-mail client

s. IIS v.6.0 Web Server

t. Installer setup via manufacturer software or MSIE

2.12 AV CONTROLLER

Central control processor for automation and control systems. Control processor is capable of integrated system control including native intersystem communication with equipment and processors by same manufacturer as well as scheduling and management servers. Control processor shall be the central connecting point for equipment and devices under control in a specified system. As the central element of communication for system devices under control, and all devices and sensors providing status, and feedback, the control processor integrates multiple disparate devices and systems without requiring multiple third party protocol adaptors, translators, or gateways. The control processor is also capable of sharing status, state, and feedback information from other connected devices. Control processor shall have a transaction-safe extended FAT32 file system. Controller shall be standard 19 in rack mount, 2 rack units high.

2.12.1 Operating System

Modular architecture supports up to 10 simultaneous running programs. Vector floating point coprocessor. Real-time, preemptive multithreaded/ multitasking kernel. Utilize a real-time, event driven, multi-tasking, multi-threaded operating system.

2.12.2 Communication

Control processor shall support direct communication with connected Ethernet devices, BACNet IP devices (up to 2000 supported objects) and devices connected to built-in control ports. Control processor shall have two built-in 10/100/1000BaseT Ethernet ports, one for primary LAN connection and one for Subnet port. Control processor shall contain a IIS v.6.0 built-in web server, SNMP remote management, active directory support, IPv6 ready, TCP/IP communications, DHCP and DNS Support, native email client, remote diagnostics remote program loading and administration, support for user assigned or dynamic IP address.

2.12.3 Memory

Control Processor shall have a RAM memory no less than 1GB, a flash memory of no less than 4GB built-in with up to 32GB of expandable space. Control processor shall have an external storage capacity of no less than 1TB.

2.12.4 External Ports

Control processor shall be equipped with including but not limited to Infrared IR output, Serial Communication Type-1, Serial Communication Type-2, Input Output (I/O), Relay, Ethernet, Communication network, USB Type-1, USB Type-2.

2.13 VIDEO DISPLAY

The system shall include professional grade flat panel displays, size as noted on drawings, with a native resolution of 1920x1080, a native 16:9 wide-screen aspect ratio, remote control, and integral loudspeakers installed on professional grade flat wall mounts.

2.14 CAMERA

The camera shall be equipped with a minimum of 10X optical zoom, automatic or manual focus, brightness, and white balance. Camera shall be motorized for a minimum +20 degrees/-20 degrees tilt with a +/- 90 degree pan. Camera field of view shall be a minimum 80 degrees horizontal and 48.8 degrees vertical. Video aspect ratio shall be 16:9 with a 1080p resolution. Camera shall be equipped with an HDMI video output connector, RJ-45 connector, HD-SDI connector and 12 VDC power connector. No more than one camera will be provided for each classification of the system, where multiple classifications are used.

2.15 MIXER

Audio mixer shall be 19" rack mounted and capable of mix, route, combine, EQ, delay, and control for the system. Mixer shall contain a minimum of four mic/line inputs and six stereo program line inputs and six line outputs. Mixer shall contain Ethernet and Serial ports, pre-configured I/O with definable processing.

2.16 CODEC

Codec shall be capable of providing an end-to-end 1080p video and supporting H.264 and H.265 protocols. Codec shall be capable of up to four HD video sources and two microphone sources. Unit shall be rack mountable (1RU)

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with the details of the work and working conditions, verify dimensions in the field, and advise the Contracting Officer of any discrepancies before performing the work.

3.2 INSTALLATION

Install equipment as indicated and specified, and in accordance with the manufacturer's recommendations except where otherwise indicated. Equipment mounted out-of-doors or subject to inclement conditions shall be weatherproofed.

3.2.1 Equipment Racks

Mount racks side-by-side and bolt together. Group items of the same function together, either vertically or side-by-side. Arrange controls symmetrically at a height as indicated. Make audio input and interconnections with approved shielded cable and plug connectors; output connections may be screw terminal type. All connections to power supplies shall utilize standard male plug and female receptacle connectors with the female receptacle being the source side of the connection. Inputs, outputs, interconnections, test points, and relays shall be accessible at the rear of the equipment rack for maintenance and testing. Each item shall be removable from the rack without disturbing other items or connections. Empty space in equipment racks shall be covered by blank panels so that the entire front of the rack is occupied by panels.

3.2.2 Wiring

Install wiring in rigid steel conduit, intermediate metal conduit, cable trays, or electric metallic tubing as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Wiring for microphone, grounding, line level, speaker and power cables shall be isolated from each other by physical isolation and metallic shielding. Shielding shall be terminated at only one end.

3.3 GROUNDING

All grounding practices shall comply with NFPA 70. Equipment shall be grounded to the serving panelboard ground bus through a green grounding conductor. Metallic conduits serving the equipment shall be isolated on the equipment end with an insulating bushing to prevent noise from being transferred to the circuit. Equipment racks shall be grounded to the panelboard ground bus utilizing a 8 AWG conductor. Grounding conductor shall be terminated to the rack using connector suitable for that purpose.

3.4 TRAINING

Conduct a training course for members of the operating and maintenance staff as designated by the Contracting Officer. The training course will be given at the installation during normal working hours and shall start after the system is functionally complete but prior to final acceptance tests. The field instructions shall cover all of the items contained in the approved operating and maintenance manuals, as well as demonstrations of routine maintenance operations. Notify the Contracting Officer at least 14 days prior to the start of the training course.

3.5 ACCEPTANCE TESTS

Submit test reports in booklet form showing all field tests performed to adjust each component and to prove compliance with the specified performance criteria, upon completion and testing of the installed system. The reports shall include the manufacturer, model number, and serial number of test equipment used in each test. Each report shall indicate the final position of controls and operating mode of the system. After installation has been completed, conduct acceptance tests, utilizing the approved test procedures, to demonstrate that equipment operates in accordance with specification requirements. Submit test plan and test procedures for the acceptance tests. The test plan and test procedures shall explain in detail, step-by-step actions and expected results to demonstrate compliance with the requirements specified. The procedure shall also explain methods for simulating the necessary conditions of operation to demonstrate system performance. Notify the Contracting Officer 14 days prior to the performance of tests. In no case shall notice be given until after the Contractor has received written Contracting Officer approval of the test plans as specified.

3.5.1 Testing Requirements

Include the following minimum testing:

a. Operational Test: Perform tests that include originating program at microphone outlets, preamplifier program inputs, and other inputs. Verify proper routing and volume levels and that system is free of noise and distortion.

b. Signal-to-Noise Ratio Test: Measure signal-to-noise ratio of complete system at normal gain settings as follows:

   (1) Disconnect microphone at connector or jack closest to it and replace it in the circuit with a signal generator using a 1000-Hz signal. Replace all other microphones at corresponding connectors with dummy loads, each equal in impedance to microphone it replaces. Measure signal-to-noise ratio.

   (2) Minimum acceptance ratio is 50 dB

c. Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 50, 200, 400, 1000, 3000, 8000, and 12,000 Hz into each preamplifier channel. For each frequency, measure distortion in the all-call amplifier outputs. Maximum acceptable distortion at any frequency is 3 percent total harmonics.

d. Acoustic Coverage Test: Feed pink noise into system using octaves centered at 500 and 4000 Hz. Use sound-level meter with octave-band filters to measure level at five locations in each zone. For spaces with seated audiences, maximum permissible variation in level is plus or minus 2 dB.

e. Power Output Test: Measure electrical power output of each power amplifier at normal gain settings of 50, 1000, and 12,000 Hz. Maximum variation in power output at these frequencies must not exceed plus or minus 1 dB.

f. Inspection: Verify that units and controls are properly labeled and

interconnecting wires and terminals are identified. Prepare a list of final tap settings of paging speaker-line matching transformers.

System will be considered defective if it does not pass any of the required individual tests and inspections listed above.

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05/16

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SECTION 28 08 10

ELECTRONIC SECURITY SYSTEM ACCEPTANCE TESTING
05/16

PART 1 GENERAL

1.1 SUMMARY

This specification defines the process and procedures for initial acceptance testing of electronic security systems (ESS) to include intrusion detection, access control and video as well as associated power and communications. Requirements to plan, conduct, and document all testing activities are covered along with the Government responsibility to witness testing and review and approve submittals. During the course of the acceptance test, demonstrate that, without exception, the completed and integrated ESS complies with the contract requirements.

1.2 DEFINITIONS

The Government Representative is a qualified individual given specific authority to witness system acceptance testing and evaluate the results.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-05 Design Data

Test Plan; G

SD-06 Test Reports

Draft Test Report

Final Test Report; G

SD-07 Certificates

Qualifications

1.4 QUALITY ASSURANCE

1.4.1 Qualifications

1.4.1.1 General

The Test Director, Operator, and Technician must have prior experience with the specific equipment, hardware and software installed under the contract.

1.4.1.2 Test Director

The Test Director must have at least five years of hands-on ESS experience to include any combination of design, installation, testing and maintenance.

1.4.1.3 Operator

The Operator must have at least two years of hands-on experience installing and maintaining ESS workstations to include both hardware and software. The Operator must be capable of demonstrating all workstation features and capabilities.

1.4.1.4 Technician

The technician must have at least two years of hands-on experience installing and maintaining ESS field equipment to include sensors, card readers, cameras, local processors, and communications equipment. The Technician must be capable of demonstrating all features and capabilities of ESS field equipment. Qualifications may be met by the individual experience of one technician or by the combined experience of a team of technicians.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 TEST PLAN

Clearly establish the scope for ESS testing prior to beginning testing. Submit a Test Plan that addresses the following topics:

3.1.1 Personnel

Identify the Test Director, Operator, Technician, and any other personnel that will be performing test activities.

3.1.2 Equipment

List all equipment that is required to support testing. State the purpose of each piece of equipment. Describe equipment that will be used to enable voice communications between the monitoring location and the field.

3.1.3 Procedures

Provide a step-by-step procedure for conducting each functional test. Describe actions and expected results. Ensure that functional test procedures address performance standards described in contract specifications.

Download example procedures from http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphic and review for applicability and completeness. Adapt example procedures to meet specific project requirements and develop additional ones as needed. Follow TEST-MASTERTP0023-005 for Air Force projects.

3.1.4 Special Provisions

Discuss any special test provisions such as facility access, safety, integration with existing systems, and coordination with other work.

3.1.5 Test Logs

Provide logs for recording all data from functional testing and burn-in testing.

Download example logs from http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphic and review for applicability and completeness. Adapt example logs to meet specific project requirements and develop additional ones as needed.

3.1.6 Schedule

Provide an overall schedule that includes all testing milestones.

3.2 PRE-ACCEPTANCE TESTING

Conduct a complete test of all field equipment, workstations, and central system hardware and software in accordance with the approved Test Plan. The Test Director must be on site to conduct a pre-test inspection and oversee all testing activities. Prior to testing, visually inspect all ESS components and correct workmanship and neatness deficiencies as needed. During the pre-test inspection, verify the accuracy of redline drawings and update drawings as needed. Conduct testing in two phases - functional testing followed by burn-in testing.

3.2.1 Phased Testing

3.2.1.1 Functional Testing Phase

During the functional testing phase, verify system performance in accordance with approved Test Plan. Record results in approved Test Logs, and provide a written explanation of each failure to include cause, corrective action, and retest result. Continue functional testing until all tests have been successfully completed with no unresolved failures.

3.2.1.2 Burn-In Testing Phase

Begin burn-in testing after successful completion of all functional testing.During the burn-in testing phase, place the ESS in normal operating mode and evaluate system performance for a continuous 24-hour period. During this time, the ESS must be fully functional and programmed such that all features can be exercised and evaluated through normal use. Record all system anomalies in approved Test Logs. Include a description of each anomaly along with any actions taken in response. Immediately correct minor deficiencies observed during the course of testing and continue with burn-in testing. Determine the root cause of any failures and make necessary repairs or modifications to restore full functionality. After a failure is corrected repeat functional tests for components and features associated with the failure, and repeat the entire burn-in testing phase .

3.2.2 Draft Test Report

Prepare and submit a Draft Test Report detailing the results of the

testing. Refer to paragraph FINAL TEST REPORT for required content. Include a cover letter signed by the Test Director stating that pre-acceptance testing has been completed and that the system is ready for acceptance testing.

3.3 SYSTEM ACCEPTANCE

Test the ESS in accordance with the approved Test Plan in the presence of the Government Representative to certify acceptable performance. Verify that the total system meets all requirements of the specification and complies with the specified standards.

Begin acceptance testing upon arrival of the Government Representative at the project site. Place the ESS in normal operating mode and evaluate system performance during the testing period. Immediately report any deficiencies observed during testing to the Government Representative and discuss possible causes and corrective measures. Obtain Government approval prior to making any adjustments, repairs or modifications. The Government retains the right to terminate testing at any time the ESS is found to be incomplete or fails to perform as specified. Such termination of acceptance testing constitutes a FAILED system acceptance test.

3.3.1 Preparation

Nofity the Contracting Officer of system readiness 15 days prior to the expected start date of acceptance testing. Prior to acceptance testing, complete all clean-up and patch work requirements. Ensure that security equipment closets and similar areas are free of accumulation of waste materials or rubbish caused by prior installation work.

3.3.2 Personnel

Ensure that the following personnel are on site to perform test activities: Test Director, Operator, Technician, and Test Intruder. Ensure that the Quality Control Manager is on site during acceptance testing.

3.3.3 Visual Inspection

Assist the Government Representative in conducting a visual inspection of ESS equipment and wiring. This inspection will focus on the general neatness and quality of workmanship and compliance with applicable codes and manufacturers' recommended installation methods. Provide a comprehensive listing of installed equipment and software along with a complete set of ESS red line drawings to be used during the inspection. Document deficiencies identified during the inspection.

3.3.4 Functional Testing

Comply with requests from the Government Representative to repeat functional tests performed previously during pre-acceptance testing. The Government reserves the right to request the Contractor to repeat all functional tests or a representative sampling thereof as a means of performance verification. Add all test results to approved Test Logs.

3.3.5 System Activity Reports

Retrieve archived data from the system and provide activity reports as requested by the Government Representative. Reports may address any type

of activity to include alarms, portal transactions, and video archives. Assist with analyzing reports to identify trends and anomalies.

3.3.6 Corrective Actions

Correct any deficiencies in coordination with the Government Representative. Maintain a punch list and review status at the end of each day. Work diligently to complete corrective actions the same day that deficiencies are observed. Add deficiencies not corrected on the same day to the rework items list maintained by the Quality Control Manager. Failure to resolve punch list items to the satisfaction of the Government constitutes a FAILED system acceptance test.

3.4 FINAL TEST REPORT

Submit a Final Test Report following the successful completion of acceptance testing to include resolution of all punch list items. Address the following topics in the Final Test Report:

3.4.1 Summary

Provide a chronological summary of all testing. Describe test activities and results in narrative form.

3.4.2 Personnel

Provide a list of all Contractor and Government personnel who participated in the testing.

3.4.3 Test Logs

Provide all completed test logs along with a test log verification signed by the Test Director.

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SECTION 28 10 05

ELECTRONIC SECURITY SYSTEMS (ESS)

05/16

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SECTION 28 10 05

ELECTRONIC SECURITY SYSTEMS (ESS)
05/16

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ASC/X9 X9.52	(1998) Triple Data Encryption Algorithm Modes of Operation

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM B32	(2008; R 2014) Standard Specification for Solder Metal
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 802.3	(2018) Ethernet
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code

INTELLIGENCE COMMUNITY STANDARD (ICS)

ICS 705-1	(2010) Physical and Technical Security Standard for Sensitive Compartmented Information Facilities

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ANSI ISO/IEC 7816	(R 2009) Identification Cards - Integrated Circuit Cards

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2018) Enclosures for Electrical Equipment (1000 Volts Maximum)

NEMA ICS 1	(2000; R 2015) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2	(2000; R 2005; Errata 2008) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2017; ERTA 1-2 2017; TIA 17-1; TIA 17-2; TIA 17-3; TIA 17-4; TIA 17-5; TIA 17-6; TIA 17-7; TIA 17-8; TIA 17-9; TIA 17-10; TIA 17-11; TIA 17-12; TIA 17-13; TIA 17-14; TIA 17-15; TIA 17-16; TIA 17-17) National Electrical Code

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST FIPS 140-2	(2001) Security Requirements for Cryptographic Modules
NIST FIPS 197	(2001) Advance Encryption Standard
NIST FIPS 201-2	(2013) Personal Identity Verification (PIV) of Federal Employees and Contractors

OPEN NETWORK VIDEO INTERFACE FORUM (ONVIF)

ONVIF	(2017) Core Specification Version 17.06

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-222	(2005G; Add 1 2007; Add 2 2009; Add 3 2014; Add 4 2014; R 2014; R 2016) Structural Standards for Steel Antenna Towers and Antenna Supporting Structures
TIA-568-D.2	(2018) Balanced Twisted-Pair Telecommunications Cabling and Components Standards
TIA-606	(2017c) Administration Standard for the Telecommunications Infrastructure

U.S. DEPARTMENT OF DEFENSE (DOD)

DODI 8500.01	(2014) Cybersecurity

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

47 CFR 15	Radio Frequency Devices

UNDERWRITERS LABORATORIES (UL)

UL 50	(2015) UL Standard for Safety Enclosures

	for Electrical Equipment, Non-Environmental Considerations
UL 294	(2018; Reprint Oct 2018) UL Standard for Safety Access Control System Units
UL 634	(2007; Reprint Mar 2015) Connectors and Switches for Use with Burglar-Alarm Systems
UL 636	(2018) UL Standard for Safety Holdup Alarm Units and Systems
UL 639	(2007; Reprint May 2012) Standard for Intrusion Detection Units
UL 681	(2014) Installation and Classification of Burglar and Holdup Alarm Systems
UL 796	(2016) UL Standard for Safety Printed-Wiring Boards
UL 969	(2017; Reprint Mar 2018) UL Standard for Safety Marking and Labeling Systems
UL 1037	(2016; Reprint Sep 2017) UL Standard for Safety Antitheft Alarms and Devices
UL 1076	(2018) UL Standard for Safety Proprietary Burglar Alarm Units and Systems
UL 1610	(2016) UL Standard for Safety Central-Station Burglar-Alarm Units

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

ESS Components; G

Overall System Schematic; G

SD-03 Product Data

Premise Control Unit; G

Detection Sensors; G

Access Control Unit; G

Access Control Devices; G

Cameras; G

Camera Lenses; G

Camera Housing and Mounts; G

Video Recording; G

Communications Interface Devices; G

Network Switch; G

Video and ESS Transmission; G

Uninterruptible Power Supply (UPS); G

Component Enclosure; G

Equipment Rack; G

SD-05 Design Data

Backup Battery Capacity Calculations; G

Access Control Throughput Rates; G

CCTV Storage Calculations

SD-07 Certificates

Contractor Qualifications; G

Instructor Qualifications; G

Data Encryption; G

SD-10 Operation and Maintenance Data

Training Plan; G

Training Content; G

ESS Components and ESS Software: Data Package 4; G

ESS Software and ESS Components: Data Package 4; G

Submit data package in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA

SD-11 Closeout Submittals

As-Built Drawings; G

1.3 QUALITY ASSURANCE

1.3.1 Regulatory Requirements

The advisory provisions in each of the publications referred to in this specification are mandatory. Interpret these publications as though the

word "must" has been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer.

Equipment, materials, installation, and workmanship must be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.3.2 Standard Products

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

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

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

c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer.

d. Provide commercial off-the-shelf (COTS) products in which the manufacturer allows a network of qualified distributors to sell, install, integrate, maintain, and repair the hardware and software products that make up the system.

1.3.2.1 Alternative Qualifications

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

1.3.2.2 Material and Equipment Manufacturing Date

Products manufactured more than one year prior to date of delivery to the site are not acceptable.

1.3.2.3 Product Safety

System components are to conform to applicable rules and requirements of NFPA 70. Equip system components with instruction stickers including warnings and cautions describing physical safety, and special or important procedures to be followed in operating and servicing system equipment.

1.3.3 Shop Drawings

1.3.3.1 ESS Components

Submit the ESS Components, Data Package 4 with the ESS Software submittal package in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.Submit drawings that clearly and completely indicate each ESS component function that includes:

a. Termination device points

b. Interconnections required for system operation

c. Interconnections between modules and devices

d. Proposed wireway or conduit systems to be used including:

(1) Locations

(2) Sizes

(3) Types

e. Drawings showing:

(1) Device locations and spacing

(2) Mounting and positioning details

(3) Riser Diagrams with cable sizes and types

(4) Bill of Materials (Device make, model and quantities)

(5) Alarm and access control zones

(6) CCTV and sensor coverage areas

(7) Spare capacity

1.3.3.2 Overall System Schematic

Indicate the relationship of integrated components on one-line diagram and show:

a. Power source

b. System controls

c. Impedance matches

d. Interconnecting wire data including:

(1) Number

(2) Size

(3) Identification

(4) Maximum lengths

1.3.4 Evidence of Experience and Qualifications

1.3.4.1 Contractor Qualifications

Submit experience and certified qualifications data prior to installation. Show that specific installers who will perform the work have a minimum of 2 years of experience successfully installing ESS of the same type and similar design as specified. Include the names, locations,

and points of contact of at least two installations of similar type and design as specified in this document where the installer has installed such systems. Indicate the type of each system installed. Certify that each system has performed satisfactorily in the manner intended for a period of at least 12 months.

1.3.4.2 Instructor Qualifications

Submit the instructor's experience and certified qualifications data prior to installation. Show that the instructor has received a minimum of 24 hours of ESS training from a technical organization such as the National Burglar and Fire Alarm Association, and 2 years experience in installing the specified ESS type.

1.4 Environmental Conditions

1.4.1 Interior Conditions

Equipment installed in environmentally protected interior areas must meet performance requirements specified for the following ambient conditions:

1.4.1.1 Temperature

32 to 120 degrees F. Components installed in unheated security protected areas must meet performance requirements for temperatures as low as 0 degrees F

1.4.1.2 Pressure

Sea level to 15,000 feet above sea level

1.4.1.3 Relative Humidity

5 to 95 percent

1.4.1.4 Fungus

Components must be constructed of nonfungus nutrient materials or be treated to inhibit fungus growth

1.4.1.5 Acoustical Noise

Components must be suitable for use in high noise areas above 100 dB, without adversely affecting their performance

1.4.2 Exterior Conditions

Components in enclosures must meet performance requirements when exposed to the following ambient conditions:

1.4.2.1 Temperature

Minus 25 to 140 degrees F

1.4.2.2 Pressure

Sea level to 15,000 feet above sea level

1.4.2.3 Solar Radiation

Six hours of solar radiation per day at dry bulb temperature of 120 degrees F including 4 hours of solar radiation at 104 watts per square foot

1.4.2.4 Sand and Dust

Wind driven for up to 6 miles per hour (mph)

1.4.2.5 Rain

2 inches per hour and 5 inches per hour cyclic with wind plus one period of 12 inches per hour

1.4.2.6 Humidity

5 to 95 percent

1.4.2.7 Wind

Continual velocity up to 50 mph with gusts to 66 mph, except that fence sensors must detect intrusions up to 35 mph

1.4.2.8 Acoustical Noise

Components must be suitable for use in high noise areas above 110 dB without adversely affecting their performance. Examples areas include flight lines, runup pads, and generator sites.

1.5 SYSTEM CALCULATIONS AND ANALYSIS

1.5.1 Backup Battery Capacity Calculations

Submit calculations showing that backup battery capacity exceeds sensor operation, communications supervision, and alarm annunciation power requirements for proposed equipment plus 25 percent spare capcity.

1.5.2 CCTV Storage Calculations

Submit calculations showing the required storage capacity for each video storage device.

1.6 ESS SOFTWARE, DATA PACKAGE 4

Submit the ESS software, Data Package 4 with the ESS Components submittal package in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Describe the functions of all software in the software manual and include:

a. All information necessary to enable proper loading, testing, and operation

b. Terms and functions definitions

c. Use of system and application software

d. Procedures for system initialization, start-up and shutdown

e. Alarm reports

f. Reports generation

g. Database format and data entry requirements

h. Directory of all files

i. All communication protocol descriptions, including data formats, command characters, and a sample of each type of data transfer

j. Interface definition

k. List of software keys

1.7 AS-BUILT DRAWINGS

Maintain a separate set of drawings, elementary diagrams, and wiring diagrams of the system to be used for as-built drawings. Keep this set accurately and neatly up-to-date with all changes and additions. This set is not to be used for installation purposes.

Finish the final drawings submitted with the endurance test report in accordance with Section 01 78 00 CLOSEOUT SUBMITTALS for as-built requirements.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide a complete and integrated electronic security system (ESS) that the meet requirements of ICS 705-1. ESS must be compatible with the Installation's central monitoring system and monitored within the secure/protected area . ESS consisting of the following subsystems and features:

a. Intrusion Detection System (IDS)

b. Access Control System (ACS)

c. Closed-circuit Television System (CCTV)

d. Security Command Center (SCC)

e. Communications System

f. Security Lighting Systems

g. Medical Facility Systems

Include materials not normally furnished by the manufacturer with the ESS equipment as specified in:

a. Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION

b. Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM

2.2 PERFORMANCE REQUIREMENTS

Integrate the installed and operating subsystems into the overall ESS

system to detect intrusion, control access, provide CCTV surveillance, provide visual verification, and perform as an entity, as specified below. Provide electronic equipment that complies with 47 CFR 15 and are suitable for the environment where they will be installed.

2.2.1 Growth Capability

Provide capability for modular ESS expansion of inputs, outputs, card readers, and remote control stations with minimal equipment modification. Software must be able to handle design requirements plus 25 percent spare capacity. Growth capability is not to be limited by the provided products.

2.2.2 Network Certification

Certify all Platform Information Technology (PIT) in accordance with DODI 8500.01 and the individual service implementation policy.

2.2.3 Maintainability

Provide components that can be maintained using commercially available tools and equipment. Arrange and assemble components to be readily accessible to maintenance personnel without compromising system defeat resistance and with no degradation in tamper protection, structural integrity, EMI or RFI attenuation, or line supervision after maintenance when it is performed in accordance with manufacturer's instructions.

2.2.4 Availablity

Provide components rated for continuous operation. Provide solid-state electronic components mounted on printed circuit boards, conforming to UL 796. Provide boards that are plug-in, quick-disconnect type. Do not impede maintenance with densely packed circuitry. Provide power-dissipating components with safety margins of not less than 25 percent with respect to dissipation ratings, maximum voltages, and current-carrying capacity. Provide solid-state type or hemetically sealed electromechanical type light duty relays and similar switching devices.

2.2.5 Fail-Safe Capability

Provide fail-safe capability in critical elements of the ESS including, but not be limited to, the capability to monitor communication link integrity and to provide self-test. Provide fault annunciation when diminished functional capabilities are detected. Annunciate fail-safe alarms to clearly distinguish from other types of alarms.

2.2.6 Line Supervision

Provide the same geographic resolution for fault isolation at the systems level as provided for intrusion detection. Provide either a static or dynanmic system with active mode for line supervision of communication links of the ESS.

a. The static system must represent "no-alarm" always by the same signal, which is different than the originally transmitted signal.

b. The dynamic system must represent "no-alarm" with a signal which continually changes with time.

2.2.7 Power Loss Detection

Detect AC and DC power loss and generate an alarm when a critical component of the system experiences temporary or permanent loss of power. Annunciate the alarm in the Secured Area to clearly identify the component experiencing power loss.

2.2.8 Controls and Designations

Provide controls and designations as specified in NEMA ICS 1.

2.2.9 Special Test Equipment

Provide all special test equipment, special hardware, software, tools, and programming or initialization equipment needed to start or maintain any part of the system and its components. Special test equipment is defined as any test equipment not normally used in an electronics maintenance facility.

2.2.10 Electromagnetic Interference (EMI)

Configure and provide ESS components employing electromagnetic radiation constructed to provide minimal vulnerability to electronic countermeasures.

2.2.11 Electromagnetic Radiation (EMR)

Provide only ESS communication components which are Federal Communications Commission (FCC) licensed and approved. Provide system components which are electromagnetically compatible.

2.2.12 Interchangeability

Use off-the-shelf components which are physically, electrically, and functionally interchangeable with equivalent components as complete items. Equivalent, replacement components must not require new or other component modification. Do not use custom designed or one-of-a-kind items. Interchangeable components or modules must not require trial and error matching in order to meet integrated system requirements, system accuracy, or restore complete system functionality.

2.3 INTRUSION DETECTION SYSTEM (IDS)

The IDS primary function is to detect intrusion into secured areas. Utilize a single database for all IDS programming data that seamlessly integrates with the ESS under a single operating environment. The IDS events must be viewable as separate or as a combined list of all ESS events. Control the IDS alarm monitoring through software control from the ESS.

a. Provide both supervised and non-supervised alarm point monitoring.

b. Arm or disarm alarm points both manually and automatically by time of day, day of week or by operator command.

2.3.1 IDS Components

Provide components:

a. Premise Control Units (PCU)

b. Detection Sensors

c. Tamper Switches

2.3.2 Detection Sensitivity

The sensitivity of the IDS must allow for the following:

a. Locating intrusions within 300 feet zones along a line or perimeter

b. Locating intrusions at individually protected assets or at an individual portal

c. Locating intrusions within the coverage on a single volumetric sensor

d. Locating failures or tampering at individual sensors

2.3.3 Detection Alarm and Reporting Capacity

Collect, communicate, and display sensor zone alarms and to enable control of card reader for arming and disarming outside of the protected area with instant alarm.

Identify individual sensors in alarm if the sensor zone is a multiple alarm source combination. Annunciate a single alarm within 2 seconds maximum, after sensor transducer or other detection device activation.

2.3.4 False Alarm Rate

The false alarm rate for each interior IDS zone must not exceed one false alarm per 30-day period. The false alarm rate for each exterior IDS zone must not exceed one false alarm per 24-hour period.

2.3.5 Nuisance Alarm Rate

The nuisance alarm rate for each interior IDS zone must not exceed three nuisance alarms per 30-day period. The nuisance alarm rate for each exterior IDS zone must not exceed three nuisance alarms per 24-hour period.

2.3.6 Premise Control Unit (PCU)

Install the PCU command processor in a tamper resistant enclosure that is specified in paragraph "Component Enclosure". Package the following with the PCU:

a. Power transformer

b. Battery(s)

c. Network connection cable

d. Keypad(s)

e. Keypad connection cable(s)

f. Additional components as required for full functionality

2.3.6.1 PCU Capabilities

Provide the PCU at a minimum but not limited to, the following capabilities;

a. Expansion to a total of at least 10,000 user codes with 99 user profile definitions.

b. Support 4 keypads with alphanumeric display. Each keypad must be capable of arming and disarming any system area based on a pass code or access control card and or key FOB authorization. Provide keypad alphanumeric display with complete prompt messages during all stages of operation and system programming and display all relevant operating and test data.

c. Four 4 shift schedules per area.

d. A total of at least 100 programmable output relay schedules.

e. 32 individual reporting areas.

f. Data line supervision.

g. Two-man access code or credentials.

h. Support programming to require the same or different access code entered within a programmed delay time of 1 to 15 minutes after disarming before activating a silent ambush alarm.

i. Support area programming that disables schedule and time-of-day changes while system is armed so that area can only be disarmed during scheduled times.

j. Provide a minimum of a 4,000 event log buffer per PCU. Record and hold alarm activity information in the log buffer until the ESS is connected and receives the information. Provide a software-configurable warning log buffer filling notification for PCU(s) configured with network switch capabilities.

k. Support a Network Interface Card (NIC) plug-in module with built in network router capable of 128 Bit AES Rijndael Encryption process certified by NIST (National Institute of Standards and Technology).

2.3.6.2 Overcurrent Protection and Indication

When overcurrent more than it is rated for is detected by the PCU, communication bus(es) and keypad(s) are to be shut down and an overcurrent notification LED lit to indicate the situation.

2.3.6.3 Manual and Self-Test

All testing from any alphanumeric keypad include testing for: standby battery, alarm bell or siren, and communication to the Security Command Center (SCC). Include provisions for an automatic, daily, weekly, 30 day, or up to 60 day communication link test from the PCU installation site to the SCC. Include a provision for displaying the internal system power and wiring conditions.

Include the following for internal monitoring points:

a. The bell circuit

b. AC power

c. Battery voltage level

d. Charging voltage

e. Panel box tamper

f. Phone trouble line 1

g. Phone trouble line 2

h. Transmit trouble

i. Network trouble

A battery test must be automatically performed to test the integrity of the standby battery by disconnecting the standby battery from the charging circuit and placing a load on the battery. Perform this test at an interval no greater than 180 days.

2.3.7 Detection Sensors

a. Sensors are to detect facility perimeter or protected zone penetrations by unauthorized personnel or intruders and transmit an alarm signal to the alarm annunciation system upon change detection. Accomplish this with a probability of detection (PD) of 0.9 with a 95 percent confidence level and conforming to UL 639 where applicable.

b. Required sensor power is 12 VDC unless otherwise specified.

c. An interior IDS zone is a room or space within a building that can be armed and disarmed independently from all other zones.

d. Provide line supervision for all sensors with an end-of-line resistor at the sensor or within a tampered junction box with conduit from the junction box to the sensor.

d. Provide sensors and components rated for operation in the installed environment. The sensors must transmit an alarm signal to the alarm annunication system upon change detection. Provide all sensors with a tamper switch and elements housed in a tamper-alarmed enclosure in accordance of paragraph "Component Enclosure".

2.3.7.1 Interior Sensors

2.3.7.1.1 High Security Balanced Magnetic Switch (BMS)

Mount the BMS inside the secure location and on the opening side of the door. BMS sensors do not have the capability to incorporate an end-of-line (EOL) resistor.

2.3.7.1.1.1 Level 1 Switch

UL 634. Level 1 High Security

2.3.7.1.1.2 Level 2 Switch

UL 634. Level 2 High Security

2.3.7.1.2 Passive Infrared Sensors

UL 639.

2.3.7.1.3 Dual Technology Sensors

UL 639. Provide sensor combining passive infrared (PIR) and microwave sensors configured and manufactured specifically to be mounted in a single tamper alarmed enclosure. The sensor must provide selectable "AND" logic or "OR" logic for alarm indication configured in the "OR" logic state. Provide sensors that have a local means of indicating detection for use during installation and calibration with a means of disabling the indication.

The sensor is to have an LED walk test indicator which is not visible during normal operations. When visible, the walk test indicator will light when the sensor detects an intruder. Provide a sensor equipped with a manual control, located within the sensor's housing, to enable and disable the test indicator or with the test indicator located within the sensor housing so that it can only be seen when the housing is open or removed.

2.3.7.2 Duress Alarms (Hold Up Switch)

UL 636. Duress alarm switches must provide the means for an individual to covertly notify the alarm annunciation system that a duress situation exists with no visible or audible signal in the secure area.

2.3.7.2.1 Hardwire Duress Alarms

Alarms must be capable of being secretly activated by the foot or hand of an average adult in both standing and seated positions. Upon activiation the alarm signal is to lock-in until manually reset with a key or similar device and be readily identifiable by the ESS.

Provide sensors that are easy to operate and configured to minimize the possibility of accidental activation. Hardwire duress alarms must be rated for a minimum lifetime of 50,000 operations. Securely mount sensors in rugged, corrosion-resistant housing.

2.3.7.3 Tamper Switches

a. Corrosion-resistant tamper switches are required for the following IDS and CCTV equipment with hinged doors or removable covers that contain open circuits:

   (1) Enclosures

   (2) Cabinets

   (3) Housings

   (4) Boxes

   (5) Raceways

(6) Fittings

(7) Sensors

b. Tamper switches are to initiate an alarm signal when the door or cover is moved as little as 1/4 inch from the normally closed position. Mechanically mount tamper switches to maximize defeat time when enclosure covers are opened or removed. One second is the minimum amount of time required to depress or defeat the tamper switch after opening or removing the cover. Enclosure and tamper switch must prevent direct line of sight to internal components and prevent switch or circuit tampering. Conceal mounting hardware so switch cannot be observed from enclosure exterior.

c. Tamper switches on doors which are opened to make normal maintenance adjustments to the system and to service power supplies must have a maintenance position.

2.3.7.3.1 Tamper Switch Performance Requirements

Tamper switches are to be:

a. Inaccessible until switch is activated.

b. Under electrical supervision at all times, irrespective of the protection mode in which the circuit is operating.

c. Annunciated to be clearly distinguishable from intrusion detection alarms and exempt from being disarmed, shunted, or silenced.

d. Spring-loaded and held in the closed position by the door, or cover protected.

e. Wired to break the circuit when the door or cover is disturbed.

f. Wired so that each sensor and device is annunciated individually at the central reporting processor.

2.4 ACCESS CONTROL SYSTEM (ACS)

Provide an access control system based upon a modular distributed microprocessor architecture complete with access control cards and ready for operation.

a. The ACS card credentials are required to be Common Access Cards (CAC), and CAC cards are being provided by the Government. Interface system with and provide alarm and other status to the overall ESS. Provide ACS that meets the communications requirements of UL 1076 and UL 294 and has the capability of controlling up to 4 card readers and keypads per card reader controller, 128 alarm inputs, or 128 relay outputs or any components combination.

b. System is to grant or deny access or exit based upon:

(1) Keypad identification data

(2) CAC card identification data

(3) Video

(4) Biometric reader identification data

(5) Smart card identification data

(6) Identification technologies combination

(7) Input through the access control devices compared to data stored within the system

(8) Time of day, day of week, and special day and holiday scheduling with card validation override.

c. Decision to grant or deny access or exit is to be based upon authorization for such data to be input at a specific location for the current time period.

d. Provide ACS that supports the configuration and simultaneous monitoring of multiple access control devices when TCP/IP communication interfaces are used between the ESS and the primary Access Control Unit (ACU). The events of the ACS are to be viewable as separate or as a combined list of all ESS events. Provide overall control of the ACS, alarm monitoring, and photo identification through software control of the ESS.

e. Access control, photo imaging, and programming data must reside on a single database and instantly accessible to every networked PC workstation connected to the ESS.

f. Provide both supervised and non-supervised alarm point monitoring.

g. Provide the capability to arm or disarm alarm points both manually and automatically by time of day, day of week or by operator command and the capability to disarm alarm points based on a valid access event.

h. When used for elevator control, the ACS is to grant access to elevator floors based on a valid credential.

i. Provide programmable 'delay' setting for all alarm points. The alarm points are not to report an ENTRY type alarm until the delay setting has expired and not report a dwell type alarm condition until the alarm has been active for the full delay period.

j. Provide the capability to place ACU(s) in an off-line mode. In the off-line mode, the ACU(s) must retain a historical summary of all ACU activity transactions, up to the maximum capacity of the ACU memory buffer. Provide the ability for manual operator control of system output relays with the manual functions to energize, de-energize, enable or disable.

2.4.1 ACS Programming

Provide software capable of, but not limited to, the following programming:

2.4.1.1 Time Schedules

Provide up to 256 user-definable time schedules. These time schedules are to determine the day(s) and times that access will be granted or a scheduled event is to occur. Any and all of the time schedules are to be

available for defining access privileges and scheduled events. Provide ALWAYS and NEVER schedules that cannot be altered or removed from the system. Each user-defined time schedule must have the option of reacting or not reacting to user-defined special days, with the ability to react uniquely to each type of special day.

2.4.1.2 Special Days

Provide an unlimited number of user definable special days to be used for configuring exceptions to the normal operating rules, typically for specifying holiday operating rules. Allow for each special day to be assigned to a user-defined type.

2.4.1.3 ACU Daylight Savings Time Adjustment

Provide a software-configurable, user defined adjustment for Daylight Savings Time. The ACU must not need to be connected to a PC workstation in order for the adjustment to occur.

2.4.1.4 Scheduled Events

Any access controlled reader is to be capable of scheduled unlock periods to allow for card-free access. The access controlled reader is to also be capable of requiring one valid access event before beginning a scheduled unlock period.

Any access control point is to be capable of requiring a valid card as well as a PIN code via keypad on a scheduled basis for high security areas. The use of PIN via keypad functions must not reduce the number of card readers or alarm points available in the ACU(s). Any designated alarm input must be able to be scheduled Armed and Disarmed. Any relay output must be capable of scheduled ON and OFF periods to allow for automatic input and output system control.

2.4.1.5 Maximum User Capability

Up to 64,000 individual users may be given access cards or codes and have their access controlled and recorded.

2.4.1.6 Access Groups

Each system user must be assignable to a maximum of 4 of 256 possible access groups. An access group is defined as one or more people who are allowed access to the same areas at the same days and time periods.

2.4.1.7 Active and Expire Dates

Any card or user may be configured with activation and expiration dates. The card can be assigned to any valid access group and will be activated and expired according to the specified dates.

2.4.1.8 Maximum Use Settings

Any card or user may be configured with maximum number of uses for that card. The card can be assigned to any valid access group and will be expired according to the specified number of card uses.

2.4.1.9 Door Outputs

Provide each access control reader with one dedicated relay outputs. Both relays are to provide Normally Open and Normally Closed contacts. Use the first relay for electric lock control while the second is software configurable to activate for door forced open, door left open too long, duress, passback violations, invalid access attempts and valid unlock conditions. Allow for both relays to be separately programmable for energize times from 1 second to 10 minutes. The second relay must allow a delay time to be specified, causing its activation to be delayed after an activating condition occurs.

2.4.1.10 User List or Who's In (Muster Reports)

Provide the capability to generate dynamic lists of users in certain access-controlled areas, based either upon selected users or selected areas. The lists must have the option of automatically refreshing after a user-selected interval of time.

2.4.1.11 Crisis Mode

Provide support for a "crisis mode", in which user-selected alarm point activations cause changes to user access privileges. The changes to user access privileges must be configurable to restrict normal access to no access or limited access.

2.4.1.12 Door Groups

Allow up to 256 door groups to be configured. Doors belonging to the same group are be able to be locked, unlocked, disabled, and enabled on command from the ACS.

2.4.1.13 Door Interlocking

Allow a group of doors to be software configured so that if any door in the group is unsecure, all other doors are automatically disabled. This feature is also known as a "mantrap" configuration. The interlocking features must not require the ACS to be on-line for proper operation.

2.4.1.14 PIN Required

Provide support for the required use of a keypad code, in addition to a valid credential during user-selected schedules.

2.4.1.15 Remote Door Control

Provide the ESS operator the capability of manually controlling any access point by issuing a simple command from the ACS. Provide the operator the ability to lock, unlock, enable, and disable any door or Door Group in this manner. This activity is to cause an entry to be logged displaying the door name, number and time that it was performed.

2.4.1.16 Key Control

When interfaced with an approved key-control system, the system is to allow users to deny access to certain doors for any users who have keys in their possession.

2.4.1.17 Reader Disable

Provide support for disabling readers in reaction to a user-selected number of invalid access attempts.

2.4.1.18 Disable Event Messages

Allow users to disable user-selected event messages (Door Forced Open, Door Open Too Long, Door Closed, Request to Exit) for user-selected doors. Allow users to disable certain messages (Door Forced Open, Door Open Too Long) according to a user-selected schedule.

2.4.1.19 Input and Output Groups

Allow for up to 256 user-defined (input and output) groups to be defined. Each Input device is to be able to be linked to these groups for arming, disarming, shunting and unshunting as well as output control.

2.4.1.20 Delays

Each alarm device must allow a delay to be specified which is either an entry type or a dwell type. An entry-type delay is to prevent the input from issuing an alarm event until the delay elapses. If unarmed during the delay period, the alarm is to be ignored. A dwell-type delay requires the input to remain in the alarm state for the full delay duration before issuing an alarm.

2.4.1.21 Output Configuration

Allow each output relay to be software configurable as:

(1) Follows

(2) Latch

(3) Timeout

(4) Scheduled

(5) Timeout Re-triggerable

(6) Limit

(7) Counter

Allow for a time schedule to automatically control the activiation and de-activation of the Scheduled type with all other types configured to activate based on input and output group conditions. Additionally, a time schedule must be specified to configure when the output is to actively monitor the input and output groups.

2.4.1.22 Remote Output Control

Provide the operator the capability of manually controlling any output point by issuing a simple command from the SCC. Based upon the output type, provide the ESS operator the ability to ENABLE, DISABLE, turn ON and turn OFF any output in this manner. A FOLLOWS type output must not be capable of being turned OFF or ON. Log an entry when this activity is performed displaying the output name and time performed. Manual control

of outputs are not permissible in ICS 705-1 applications.

2.4.1.23 Remote Reset Command

Provide the capability for any ACU to reset manually or by command issued from the ACS with the option of simulating the ACU reset settings, or forcing a reset type as specified by the user. The remote reset command is not to cause the ACU to degrade its level of protection to any access points defined.

2.4.1.24 Time Zone

Allow the user to select the time zone in which the ACU is located, so that event times displayed for that ACU will match the local time where the ACU is located.

2.4.1.25 User-Selected LED Behavior

Allow the user to select different behaviors for the LEDs of each access controlled reader.

2.4.1.26 Traced Cards

Provide the capability of selecting any number of cardholders for the purpose of limiting reports to only traced users displaying all traced cardholder events in a user-selected alternate color.

2.4.1.27 Badge Print Tracking

Support setting a print limit for any badge. The software will track the number of times any badge has been printed, as well as display the date and time of the most recent printing.

2.4.2 Error and Throughput Rates

Rates must be portal to portal performance averages obtained when processing individuals one at a time. Features are not to reduce capability to meet throughput requirements when serial verification techniques or multiple attempts are required to satisfy error performance requirements.

A Type I error denies access to an authorized enrolled individual. A Type II error grants access to an unauthorized individual. Subsystem Type I and Type II error rates must both be less than 0.1 percent. At the error rates, subsystem access throughput rate must be minimum of 12 individuals per minute through one card reader and keypad access control device.

2.4.3 Access Control System Central Processing

a. Provide serial management and control of system processing. Provide a microprocessor control device able to monitor and control units and up to 32 card reader and keypad access control devices. Central processor must interrogate and receive responses from each ACU within 100 milliseconds. Failure to respond to an interrogation is to cause an alarm.

b. Provide the central processor with a Ethernet interface port to communicate with the printer. Provide an operator interface to control system operating functions. Provide the central processor

with a facility-tailorable data base for a minimum of 1000 cardholders with by-name alphanumeric printout, and for automated subsystem or IDS monitoring, management, and control functions.

c. Provide enrollment equipment as required in paragraph ENROLLMENT CENTER EQUIPMENT.

d. Provide system configuration controls and electronic diagnostic aids for subsystem setup and troubleshooting with the central processor. Components are not to be accessible to operations personnel and must be tamper alarmed.

2.4.4 Access Control Unit(ACU)

UL 294. Provide micro-processor based ACU with all access and input and output decisions to be made by the individual ACU(s). Provide modular solution which will allow for present security requirements and the capability to expand. Configure all field ACU panels to intercommunicate via TCP/IP or fiber-optic communication. Equip all field ACU(s) with a tamper contact.

Designate one ACU as "Primary", responsible for all ACS-to-ACU communications. All other ACU(s) up to a maximum of 16 are to be designated as "Secondary" and communicate with the "Primary" via an TCP/IP network or fiber-optic configuration. Provide ACU capable of, but not limited to, the following:

a. Built-in surge suppression circuitry on plug-in modular circuit boards with surge suppression, configured as an integral component of the system and self-sacrificing in the event of extreme surges or spikes.

b. Capable of supporting at least 2 ports and be expandable in increments of two ports up to a maximum of 16 ports per ACU.

c. Each port configured by ACS to support any one of the following peripheral devices:

(1) Card reader

(2) Alarm Monitoring Module

(3) Output Relay Module

(4) Elevator Reader

(5) Elevator Output Module

Any device combination can be supported on each ACU, up to a total of 16 devices per ACU.

d. Capability of supporting multiple card reader technologies simultaneously, including:

(1) Keypad

(2) Card and Keypad

(3) CAC compatible

(4) Biometrics

This capability must be an integral part of the ACU and will not require special external equipment.

e. Built-in battery back-up of programmed information sustainable for a period of at least 90 days.

f. Powered by a 12 VDC power source rated at a minimum of 2 amperes with a battery back-up for complete system operation in the event of power failure. Provide battery backup for all ACU(s) to sufficiently power the ACU for 8 hours continuous service.

g. Electric strikes, other locking devices and ancillary peripherals on a separate power supply with battery back-up for continued operation in the event of power failure as specified in paragraph "Backup Power".

h. A minimum of a 10,300 event log buffer per ACU to record and hold access and alarm activity information until the ACS is connected and receives the information. Provide a software-configurable warning log buffer filling notification for ACU(s) configured with network switch capabilities.

2.4.5 Access Control Devices

UL 294. The card, card reader, and panels must meet encryption requirements that are specified in paragraph DATA ENCRYPTION. Devices are to be tamper alarmed, tamper and vandal resistant, and solid state, containing no electronics which could compromise the access control subsystem should the subsystem be attacked.

2.4.5.1 Card Readers

Provide surface card readers as indicated for each individual location. Provide contactless type card readers capable of reading CAC cards type of access control cards.

Keypads must contain an alphanumeric and special symbols keyboard with symbols arranged in ascending ASCII code ordinal sequence. Provide keypad as a stand-alone device.

2.4.5.1.1 Contact Card Readers

Provide contact card readers that can read credential CAC cards whose characteristics of size and technology meet those defined by ANSI ISO/IEC 7816 and are in compliance with NIST FIPS 201-2.

Provide readers with "flash" download capability to accommodate card format changes and the capability of reading the card data and transmitting the data, or a portion thereof, to the ESS control panel.

2.4.5.1.2 Contactless Card Readers

Provide contactless card readers that can read credential CAC cards whose characteristics of size and technology meet those defined by ANSI ISO/IEC 7816 in close proximity to the card reader and are in compliance with NIST FIPS 201-2.

Provide readers with "flash" download capability to accommodate card

format changes and the capability of reading the card data and transmitting the data, or a portion thereof, to the ESS control panel.

2.4.5.1.3 Card Reader Display

Provide card readers with an LED or other visual indicator display which indicate power ON and OFF and whether user passage requests have been accepted or rejected.

2.4.5.1.4 Card Reader Response Time

The card reader is to respond to passage requests by generating a signal to the local processor.

2.4.5.1.5 Card Reader Power

Power the card reader from the source as shown on the drawings. The card reader must not dissipate more than 5 Watts.

2.4.5.1.6 Card Reader Mounting Method

Provide card readers suitable for surface mounting as required.

2.4.5.2 Keypads

Entry control keypads are to use unique alphanumeric and other symbol combinations as an identifier. Keypads must contain an integral alphanumeric and special symbols keyboard with symbols arranged in ascending ASCII code ordinal sequence. Communications protocol is to be compatible with the local processor.

2.4.5.2.1 Keypad Display

Keypads are to include an LED or other type of visual indicator display and provide visual status indications indicating power ON and OFF and whether user passage requests have been accepted or rejected.

The maxiumum horizontal and vertical viewing angles are to be limited by the keypad display or enclosure. The maximum horizontal viewing angle must be no more than plus and minus 5 degrees off a vertical plane perpendicular to the plane of the face of the keypad display. The maximum vertical viewing angle must be no more than plus and minus 15 degrees off a horizontal plane perpendicular to the plane of the face of the keypad display.

2.4.5.2.2 Keypad Response Time

The keypad is to respond to passage requests by generating a signal to the local processor.

2.4.5.2.3 Keypad Power

Power the keypad from the source as shown on the drawings. The keypad must not dissipate more than 5 Watts.

2.4.5.2.4 Keypad Mounting Method

Provide keypads suitable for surface mounting as required.

2.4.5.2.5 Keypad Duress Codes

Provide a means for users to indicate a duress situation by entering a special code into the keypad.

2.4.5.3 Card Readers with Integral Keypad

Equip contact and contactless card readers with integral keypads as specified in paragraph "Keypads".

2.4.6 Elevator Control

2.4.6.1 Control Elevator Operation with Entry Control Terminal Devices

The elevator's standard control equipment, components, and actuators have to serve as the facility interface. System components and subsystems must interface with standard elevator control equipment without elevator control equipment modification. The system is to provide a means to define access controlled floors of a facility, deny access to these floors by unauthorized individuals, and implement all other system functions as specified.

2.5 CLOSED-CIRCUIT TELEVISION (CCTV) SYSTEM

Select system components that conform to the Open Network Video Interface Forum (ONVIF) specification. Provide compatible UL listed CCTV components to provide visual assessment of ESS alarms automatically upon alarm or upon SCC operator selection. Otherwise, the subsystem is to continuously display the coverage area. Display alphanumeric camera location ID on all monitors. Provide the number of alarm monitors as required. The scene from each camera must appear clear, crisp, and stable on the respective monitor during both daytime and nighttime operation. Provide component equipment that minimizes both preventive and corrective maintenance. Provide components from a single manufacturer or justify mixing manufacturer components and demonstrate compatibility in submittal information.

2.5.1 Cameras

2.5.1.1 CCTV Camera

Provide cameras of digital fixed, pan-tilt-zoom (PTZ), or panoramic type as identified on the drawings.

a. Day-Night Color fixed, PTZ or panoramic cameras are to be used in all outdoor environments. Standard fixed, PTZ, or panoramic cameras are to be used for all indoor applications except when backlighting issues are observed. Use Day-Night cameras or standard cameras with backlighting compensation for backlighting or high contrast applications.

b. Provide PTZ cameras with a direct drive motor assembly. Belt driven PTZ camera units are not acceptable. Equip PTZ cameras with a slip ring assembly having an optical interface and be rated for continuous duty. PTZ cameras have to be fully integrated units. The pan-tilt mechanism must be an integral part of the camera.

c. Provide cameras that operate over a voltage range of 12 VDC VAC at 60 Hz Power over Ethernet (PoE) IEEE 802.3.

d. All cameras must be constructed to provide rigid support for electrical and optical systems so that unintentional changes in alignment or microphonic effects do not occur during operation, movement, or lens adjustments.

e. Video Frame Rate: 30 frames per second (fps)

f. Minimum essential requirements for cameras include the following:

2.5.1.1.1 Sensitivity

Minimum Illumination: 0.08 foot-candles at F1.4 color mode; 0.01 foot-candles at F1.4 in the B&W mode.

2.5.1.1.2 Signal-To-Noise Ratio

Show a signal-to-noise ratio of not less than 50 decibels (dB) at Automatic Gain Control (AGC) "Off", weight "On".

2.5.1.1.3 Resolution

Provide a minimum of 2.1 megapixel resolution. The imager must have a minimum of 1920 horizontal x 1080 picture in progressive scan format. Resolution is to be maintained over the specified input voltage and frequency range, and not vary from minimum specification over the specified operating temperature range.

2.5.1.1.4 Synchronization

Provide cameras that have internal and line lock.

2.5.1.1.5 Low Light Level

Provide Day-Night cameras that have a B-W mode that may be automatically engaged on low light level and permit the use of an external infrared illuminator. Electronic removal of the color signal is not acceptable. The camera must have an infrared cut filter capable of being removed automatically upon low light threshold or manually.

2.5.1.2 Camera Lenses

Camera lenses are to be all glass with coated optics. Provide lens mount that is integrated with the cameras. Provide lens with the camera that have a maximum f-stop opening of f/1.2 or the maximum available for the focal length specified. The lens is to have an auto-iris mechanism unless otherwise specified. Lenses having auto iris, manual iris, or zoom and focus functions are to be supplied with connectors, wiring, receiver and driver units, and controls as needed to operate the lens functions. Provide lenses with sufficient circle of illumination to cover the image sensor evenly. Lenses are not to be used on a camera with an image format larger than the lens is configured to cover. Provide lens with focal lengths as indicated or specified in the manufacturer's lens selection tables.

2.5.1.3 Camera Housing and Mounts

The camera and lens are to be enclosed in a tamper resistant housing installed on a camera support. Any ancillary housing mounting hardware

needed to install the housing at the camera location is to be provided as part of the housing. The camera support must be capable of supporting the mounted equipment and withstanding wind and ice loads normally encountered at the site.

2.5.1.3.1 Environmentally Sealed Camera Housing

The housing is to provide an environment needed for camera operation and be condensation free; dust and water tight; keep the viewing window free of fog, snow, and ice, and be fully operational in 100 percent condensing humidity. Provide housing equipped with a sunshield. Both the housing and sunshield are to be white. Purge the housing of atmospheric air and pressurized with dry nitrogen, equipped with a fill valve, overpressure valve, and include a humidity indicator visible from the exterior. Housing must not have a leak rate greater than 2 psi at sea level within a 90 day period.

Provide housing equipped with supplementary camera mounting blocks or supports needed to position the camera and lens to maintain the proper optical centerline. All electrical and signal connections required for camera and lens operation are to be supplied. Provide a mounting bracket as part of the housing which allows weight adjustment to center the weight of the assembly.

2.5.1.3.2 Indoor Camera Housing

Provide housing with a tamper resistant enclosure for indoor camera operation and with the proper mounting brackets for the specified camera and lens. The housing and appurtenances color are not to conflict with the building interior color scheme.

2.5.1.3.3 Interior Mount

Provide camera mount suitable for either wall or ceiling mounting and have an adjustable head for mounting the camera. The wall mount and head must be constructed of aluminum or steel with a corrosion-resistant finish. Provide adjustable head with 360 degrees of pan and plus or minus 90 degrees of tilt.

2.5.1.3.4 Low Profile Ceiling Mount

Provide tamperproof ceiling housing which is low profile and suitable for use in 2 by 2 foot ceiling tiles. The housing must be equipped with a camera mounting bracket and allows a 360 degree viewing setup.

2.5.1.3.5 Interior Dome Housing

The dome housing is to be capable of being mounted as shown on the drawings. The lower dome is to be black opaque acrylic and have a light attenuation factor of not more than 1 f-stop. Provide housing with:

a. Integral pan-tilt complete with wiring

b. Wiring harnesses

c. Connectors

d. Permanent lubrication

j. Motors that are thermally or impedance protected against overload damage.

k. Any other hardware and equipment as needed to provide a fully functional pan-tilt dome. Provide pan movement of 360 degrees and tilt movement of at least plus or minus 90 degrees. Pan speed must be at least 20 degrees per second and tilt speed be at least 10 degrees per second.

2.5.1.3.6 Exterior Dome Housing

Provide dome housing capable of being mounted by pendant, pole, ceiling, surface, or corner as shown on the drawings and constructed to be dust and water tight, and fully operational in 100 percent condensing humidity. Purge the housing of atmospheric air and pressurize with dry nitrogen. Provide a fill valve and overpressure valve with a pressure indicator visible from the exterior. The housing is to be equipped with supplementary camera mounting blocks or supports as needed to position the specified camera and lens to maintain the proper optical centerline.

Provide all electrical and signal connections required for camera and lens operation. The housing is to provide the environment needed for camera operation. The lower dome is to be black opaque acrylic with a light attenuation factor of not more than 1 f-stop. Provide housing with:

a. Integral pan-tilt complete with wiring

b. Wiring harnesses

c. Connectors

d. Permanent lubrication

e. Motors that are thermally or impedance protected against overload damage.

f. Any other hardware and equipment as needed to provide a fully functional pan-tilt dome. Provide pan movement of 360 degrees and tilt movement of at least plus or minus 90 degrees. Pan speed must be at least 20 degrees per second and tilt speed be at least 10 degrees per second.

2.5.1.3.7 Exterior Wall Mount

Provide exterior camera wall mount that is 16 inches long, and has an adjustable head for mounting the camera. The wall mount and head must be constructed of aluminum, stainless steel, or steel with a corrosion-resistant finish. Provide adjustable head for at least plus and minus 90 degrees of pan, and at least plus and minus 45 degrees of tilt. If to be used in conjunction with a pan-tilt, provide bracket without the adjustable mounting head, and a bolt hole pattern to match the pan-tilt base.

2.5.1.3.8 Pan-Tilt Mount

a. Provide pan-tilt mount capable of supporting the camera, lens, and housing specified that is weatherproof and sized to accommodate the camera, lens and housing weight plus maximum wind loading encountered at the installation site if the pan-tilt is to be mounted outdoors.

Provide pan-tilt with:

(1) Heavy duty bearings

(2) Hardened steel gears

(3) Externally adjustable limit stops for pan and tilt

(4) Mechanical, dynamic, or friction brakes

(5) Permanent lubrication

(6) Motors that are thermally or impedance protected against overload damage.

b. Provide pan movement of 360 degrees pan rotation, a minimum tilt movement of plus and minus 90 degrees. Manual pan speed must be a minimum of 0 to 80 degrees per second, and a minimum tilt speed of 10 degrees per second. A minimum automatic pan speed of 280 degree per second and tilt speed of 160 degree per second.

c. The pan-tilt is to be supplied complete with wiring, wiring harnesses, connectors, receiver-driver, pan-tilt control system, pre-position cards, or any other hardware and equipment as needed to provide a fully functional pan-tilt mount to fulfill the site design requirements.

2.5.2 Video Analytics (VA)

2.5.2.1 Software

Provide capability range from basic activity detection to the search through databases to pre-empt serious incidents. The VA is to provide graphic identified movement identification, user-selectable monitored areas, compensation for environmental movement, and other features specified when provided as a capability of the DVR. Provide the following feaures:

2.5.2.1.1 Basic Motion Detection

a. Adaptive Motion

b. Abandoned Object

c. Object Removal

d. Camera Sabotage

e. Directional Motion

f. Object Counting

g. Loitering Detection

h. Stopped Vehicle

2.5.3 Color Video Monitors

Except as specified, provide video monitors that:

a. Are rated for continuous operation and incorporate printed circuit board modular construction.

b. Have printed circuit modules that are easily replaceable.

c. Use solid-state devices for electronic circuits.

d. Are constructed to provide rigid support for electrical systems so that unintentional changes in alignment or microphonic effects will not occur during operation or movement.

e. Incorporate circuit safety margins of not less than 25 percent where possible, with respect to power dissipation ratings, voltage ratings, and current carrying capacity.

f. Have a diagonal viewing angle that nominally measures 19 inches for monitors, LCD or LED displays.

g. Provide adequate safeguards to protect personnel from exposure to line voltage during operation or adjustment.

h. Have at least the following essential requirements:

(1) Resolution for LCD or LED monitors to be: 17 inch monitors - 1280x1024, 500 TV lines (maximum); 20.1 inch monitors - 1600x1200 (maximum)

(2) Geometry: No point in the active raster is to deviate from its correct position by more than 2 percent of raster height.

2.5.3.1 Mounting and Identification

a. Mount monitors and other devices to facilitate easy replacement.

b. The printed circuit board functions and component numbers or markings are to be easily read.

c. Mount monitors in a desk top console.

d. Protect monitors from circuit overloads by fuse or fuses in the power source line. Mount power source line fuses in finger-operated extractor fuse posts. Fuse holders are to be located in a readily accessible position.

2.5.3.2 Video and Signal Input

Monitors are to operate with video input requiring a one HDMI or DVI nominal composite video signal switchable to either loop-through or internal 75-ohm terminating impedance.

Signal input connectors must be HDMI or DVI type.

2.5.4 Ancillary Equipment

Equipment is to consist of the items specified below:

2.5.4.1 Video Date and Time Generator

The video time and date is to originate from either the camera, video, video recorder.

2.5.4.2 Camera Identifiers

Label video signal from each camera using alphanumeric identifiers. Camera alphanumeric identifiers may originate from either the camera or the video recorder.

2.5.4.3 Video Recording

2.5.4.3.1 Digital Video Recorder (DVR)

Provide DVR. The DVR will record all cameras onto a hard drive and allow remote network viewing via internet or intranet browser. Hard drive capability must be sized to store all cameras recording 24 hour a day, 7 days a week at 30 frames per second per camera for 2 weeks.

2.5.5 Camera Mounting Structures

Provide camera mounting structures designed specifically for CCTV cameras. The structure is to accommodate appropriate wiring pathways for power and communication as well as proper grounding and surge protection. Design loads for the camera mounting structure must conform to TIA-222 and all applicable addendums of the TIA standard. Allowable pole deflection is determined from the point of the camera mount and must not exceed 0.5 percent of the pole height under adjusted maximum wind load conditions. Adjusted maximum wind load conditions for deflection calcualtions must be 30 miles per hour (mph) or 35 percent of the basic wind speed as determined by TIA-222, whichever is greater. Confirm compliance to TIA standards by structure manufacturer data or by analysis. Provide additional measures as required to stabilize the camera if placed in an environment that is subject to induced vibrations such as heavy winds or excessive traffic.

2.6 SECURITY COMMAND CENTER (SCC)

The SCC must integrate all subsystems and communications, and provide operator control interface to the ESS system. The components are as follows:

a. ESS Software

b. Monitoring Display Software

c. Graphical Map Software

d. Printers

e. Controls and Display Integration

f. Enrollment Center Equipment

2.6.1 ESS Software

a. Provide commercial off-the-shelf ESS software that utilizes a single database for the subsystem integrations provided under a single

operating environment. The system is to archive all events in a database stored either on a local hard drive or a networked database server. The software has to support configuration and simultaneous monitoring of all subsystems.

b. Allow the networked PC workstation configurations connected via a TCP/IP network. Administrative tasks including configuration, monitoring, schedules, report generation and graphic display are provided from any PC workstation on the network. All system programming data must be instantly accessible to every PC Workstation connected to the network. The system is to utilize a non-proprietary SQL-based, ODBC-compliant database, managed by Sybase Adaptive Server Anywhere, Microsoft SQL Server, or Oracle.

c. Utilize a preemptive multi-tasking operating system, such as the latest Microsoft Windows Professional environment, that is multitasking, with many processes running at the same time without interference with each other and with higher priority tasks taking precedence over lower priority tasks.

d. Provide capabilities to define visual exclusion areas.

2.6.1.1 Alarm Call up

Support responses to alarms entering the system with each alarm capable of initiating one or more of the following actions:

a. Sending alarm commands to a CCTV system interface

b. Triggering DVR event recording

c. Activating output devices

d. Playing PC audio files

e. Controlling doors

f. Display graphical maps associated with the alarm device

Provide mode of system operation that requires an operator to acknowledge any alarm. While alarm is still active, the alarm cannot be cleared.

2.6.1.2 Programming

Provide the capability of, but not limited to, the following programming and functionality:

2.6.1.2.1 Daylight Savings Time Adjustment

The ACU(s) and PCU(s) must not need to be connected to the ESS in order for the adjustment to occur.

2.6.1.2.2 Operator Privileges

Support an unlimited number of system operators, each with a unique login and password combination. Operators are to be assigned privileges based on the loops, commands, or programming features that are available to each individual operator.

2.6.1.2.3 Alarm Priorities

Provide the ability for each alarm device to be user configured to belong to one of 10,000 priority levels which are assigned to an alarm based on alarm importance. These priorities are to define which alarm events to display on individually specified ESS workstations.

2.6.1.2.4 Reports

Include integrated reporting capabilities as well as the ability to run Crystal Report templates.

2.6.1.2.5 User Interface

The ESS programming is to be menu-driven, with "wizards" to assist with software configuration, and include 'Help' information.

2.6.1.2.6 Messages

Permit the use of user-selected colors for event messages.

2.6.1.2.7 Graphics

Provide the capability to display a floor-plan graphic for card activity and alarm events as part of the ESS integration.

2.6.1.2.8 Device Status

Provide the capability to display the dynamic status of a user-selected list of devices, including doors, inputs, and outputs.

2.6.1.2.9 Diagnostics

Include diagnostic software tools that interface and query the hardware for information and to issue commands.

2.6.1.2.10 Mandatory Data Fields

Require any cardholder data field to be selected by the user as mandatory.

2.6.1.2.11 User Defined Data Fields

Provide 20 unassigned data fields for storing user-defined data that support user-defined labels, and are user-configurable as plain text fields or drop-down selection lists.

2.6.1.2.12 Archive Database

Include a connection to an archive database which stores purged events and deleted programming and which can be accessed for reporting.

2.6.1.2.13 Programmable Database Backup

Include the capability of performing user-scheduled database backups without the use of third-party backup software.

2.6.1.2.14 Programmable Database Purging

Include the capability of performing user-scheduled database purging,

moving selected events to an archive database when the events have aged a user-specified number of days.

2.6.1.2.15 Database Importing

Include the capacity to import user data from an ODBC data source (Access, Excel, text).

2.6.1.2.16 Data Exporting

Include the capacity to export data from any table in the database to either a text, HTML, Excel, or Access file in any user-selected order.

2.6.1.2.17 Event Log Output

Include the capacity to send a continuous stream of user-selected types of event messages to a text file, serial port, or TCP/IP address.

2.6.1.2.18 Data Audit Trail

Record changes to programming, recording the date and time stamp of the change, the name of the operator making the change, and the nature of the change. This data audit is to be available in history for reporting.

2.6.2 ESS Monitor Display Software

ESS Monitor display software is to provide for text and graphic map displays that include zone and device status integrated into the display. Different colors are to be used for the various components and real time data. Colors must be uniform on all displays. Follow the color coding as follows.

a. FLASHING RED to alert an operator that a zone has gone into an alarm or that primary power has failed.

b. RED to alert an operator that a zone is in alarm and that the alarm has been acknowledged.

c. YELLOW to advise an operator that a zone is in access.

d. GREEN to indicate that a zone is secure or that power is on.

2.6.3 Graphical Map Software

a. ESS graphical map software is to show the graphic and visual data of all subsystem devices. Use a 19 inches, LCD or LED flat screen display with messages displayed in the English language. Provide graphical maps showing a layout of all the protected facilities. Highlight zones corresponding to those monitored by the ESS on the graphical maps. Display status of each zone using graphical icons as required within each designated zone.

b. Provide capability for graphical maps to be linked together using a layered tree structure. For example, a top-level map might be a top view of the site and its buildings, the next level the individual buildings floor, followed by a map of the area on a floor containing the device in alarm. Allow for 3 layers of maps to be defined for any given ESS device. To speed an incident location, each map level contains a clearly visible indicator as to which sub map the operator

should select next to find the device that is in alarm.

c. The ESS may also be configured to display a map automatically on a new alarm presentation, providing the operator with prompt visual indication that an alarm has occurred.

d. The status of intrusion devices, access control readers, doors, auxiliary monitor points, and auxiliary outputs is to be able to be requested from any map by simply selecting the icon representing the device and its current state will be displayed. CCTV camera control, digital video review, alarm panel transactions and intercom requests are to be available for inclusion on the map with the associated management module installed.

e. Allow for SCC operators to change a current setting by pressing the right mouse button anywhere on the screen or on a specific system device icon. Pressing the right mouse button is to cause the appropriate command options list to appear for selection. Confirmation is provided by reflecting the change in status on the display after a command is selected.

f. The display of intrusion or auxiliary door alarms may be automatically enabled or disabled by the use of timed commands, either by device or by a group of devices. This may be used, for example, to disable all door alarms on internal doors, during normal office hours.

g. Create maps using standard office tools allowing drawings to be imported in Jpeg, Bitmap, Windows metafile, PDF or DXF file formats to provide maximum flexibility.

2.6.4 Control and Display Integration

Integrate human engineer SCC controls so the entire SCC can be operated by a single or multiple operator(s). Integrate switching and monitoring components of the assessment subsystem with the SCC so that SCC operator(s) can effectively monitor, assess alarms and control the ESS.

2.6.5 Enrollment Center Equipment

Provide enrollment stations to enroll personnel into, and disenroll personnel from, the system database. The enrollment equipment is to only be accessible to authorized entry control enrollment personnel. Provide credential cards for all personnel to be enrolled at the site plus an extra 25 percent for future use. The enrollment equipment is to include subsystem configuration controls and electronic diagnostic aids for subsystem setup and troubleshooting with the SCC. Provide a printer for the enrollment station which meets the requirements of paragraph "Report Printer.

2.6.5.1 Enrollment Center Accessories

a. Provide a steel desk-type console and equipment racks. The console is to be as specified in ECIA EIA/ECA 310-E and as indicated.

b. Rack-mount all equipment in the console and equipment racks, except for printer. Color coordinate the console and equipment racks and cabinets, obtaining approved by the Contracting Officer.

c. Provide a locking cabinet approximately 6 feet high, 3 feet wide, and

2 feet deep with three adjustable shelves, and two storage racks for storage of CDs, DVDs, printouts, printer paper, ink/toner, manuals, and other documentation.

2.6.5.2 Enrollment Center I.D. Production

a. Equip the enrollment center with a high-resolution digital camera structurally mounted, or provided with a reliable tripod. The camera model is to be as recommended by the manufacturer of the ESS. Provide commercial off-the-shelf components.

b. Design and provide a lighting system sufficient for quality, still-video capture.

c. Equip the enrollment center with a die-sublimation printer capable of printing directly to the access control or I.D. credential. Provide printer toner kits and other printing supplies to complete the initial enrollment by 200 percent.

2.6.5.3 Enrollment Center Software

Provide database management functions for the system, and allow an operator to change and modify the data entered in the system as needed. The enrollment station is not to have any alarm response or acknowledgment functions as a programmable system function. Multiple, password-protected access levels are to be provided at the enrollment station. Database management and modification functions are to require a higher operator access level than personnel enrollment functions. Provide a means for disabling the enrollment station when it is unattended to prevent unauthorized use.

Provide a method to enter personnel identifying information into the entry control database files through enrollment stations to include a credential unit in use at the installation. In the case of personnel identity verification subsystems, this data is to include biometric data. Allow entry of this data into the system database files through the use of simple menu selections and data fields. The data field names is to be customized to suit user and site needs. All personnel identity verification subsystems selected for use with the system are to fully support the enrollment function and be compatible with the entry control database files.

2.7 COMMUNICATIONS

a. Communications are to link together subsystems of the ESS and be in accordance with Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM. Interfaces between subsystems cannot be accomplished by use of an electro-mechanical relay assembly. Communications links must be supervised. Provide common communications interface devices throughout the ESS. Provide dry contact sensor to control unit interface that is normally OPEN or normally CLOSED, except as specified otherwise.

b. Use digital, asynchronous, or multiplexed data control unit for central alarm reporting and display processor interface. Group individual data bits into word format and transmit as coded messages. Implement interface with network switches which function as a communications controller, perform data acquisition and distribution, buffering message handling, error checking, and signal regeneration as

required to maintain communications.

c. Provide totally automatic status changes communication, commands, field initiated interrupts, and any other communications required for proper system operation. Do not require system communication operator initiation or response. System communication is to return to normal after any partial or total network interruption including power loss or transient upset. Automatically annunciate communication failures to the operator with communication link identification that has experienced a partial or total failure.

2.7.1 Link Supervision

2.7.1.1 Hardwire Direct Current Line Supervision

Provide only for the sensor to control unit links which are within the ESS protected area. Supervise circuits by monitoring changes in the current that flows through the detection circuit and a terminating resistor of at least 2.2 K ohms. Supervision circuitry is to initiate an alarm in response to opening, closing, shorting, or grounding of conductors by employing Class C standard line security. Class C circuit supervisor units are to provide an alarm response in the annunciator in not more than one second as a result of the following changes in normal transmission line current:

a. Five percent or more in normal line signal when it consists of direct current from 0.5 through 30 milliamperes.

b. Ten percent or more in normal line signal when it consists of direct current from 10 microamperes to 0.5 milliamperes.

c. Five percent or more of an element or elements of a complex signal upon which security integrity of the system is dependent. This tolerance will be applied for frequencies up to 100 Hz.

d. Fifteen percent or more of an element or elements of a complex signal upon which the security integrity of the system is dependent. This tolerance will be applicable for all frequencies above 100 Hz.

2.7.1.2 Hardwire Alternating Current Supervision

Supervision is not to be capable of compromise by use of resistance, voltage, or current substitution techniques. Use this method on circuits which employ a tone modulated frequency-shift keying (FSK), interrogate-and-reply communications method. Supervisory circuit are to be immune to transmission line noise, crosstalk, and transients. Terminate detection circuit by complex impedance. Maintain line supervision by monitoring current amplitude and phase. Size complex impedance so that current leads or lags the driving voltage by 45 plus or minus 5 degrees.

Alarm when rms current changes by more than 5 percent, or phase changes by more than 5 degrees for supervision current of 0.5 to 30 milliamperes rms. Alarm when rms current changes by more than 10 percent, or phase changes by more than 8 degrees for lines with supervision currents of 0.01 to 0.5 milliamperes. Identified line supervision alarm must be communicated within one second of the alarm.

2.7.1.3 Hardwire Digital Supervision

Local processors are to exchange digital data to indicate secure or alarm at least every 2 seconds. Alarm if data is missed for more than one second for passive supervisory circuits. Coding used for data cannot be decipherable by merely viewing data on an oscilloscope. Supervisory circuits are to asynchronously transmit bursts of digital data for transponder schemes. Data pattern is to be random in nature. Remote detectors are to receive data and encode a response based on a proprietary coding scheme.

Provide a unique encoding scheme; an industry-wide or vendor standard is not acceptable. Transmit encoded response back to supervisory circuit. Supervisory circuit is to compare the response to an anticipated response. Alarm on failure of the detector to return a data burst or return an incorrect response.

2.7.2 Hardwire

2.7.2.1 Electrical Conductor Lines

a. Use electrical conductor lines for hardwire that rely on current path except for electrical wires; neutral conductors of electrical distribution systems cannot be used as signal transmitters.

b. Conductors outside the protected area are to be installed in electrical metallic tubing (EMT) as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Supervision circuitry is not to initiate nuisance alarms in response to normal line noise, transients, crosstalk, or in response to normal parametric changes in the line over a temperature range of minus 30 to 125 degrees F.

c. Ambient current levels chosen for line supervision must be sufficient to detect tampering and be within the normal operating range of electrical components. Report line supervision and tamper alarms regardless of mode of operation.

d. Provide hardwire links as specified in UL 1076 and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM for interior applications with additions and modifications specified. Conductors are to be copper. Conductors for links which also carry AC voltage, are to be No. 12 AWG minimum; single conductors for low-voltage DC links are to be No. 14 AWG minimum. Conductors are to be color coded. Conceal wiring in finished areas of new construction and wherever practical in existing construction if not otherwise precluded by the Government.

e. Identify conductors within each enclosure where a tap, splice, or termination is made. Identify conductors by plastic-coated, self-sticking, printed markers or by heat-shrink type sleeves. Connect sensors, control units, and communication devices so that removal will cause a tamper alarm to sound. Pigtail or "T" tap connections are not acceptable. Each conductor used for identical functions is to be distinctively color-coded. Each circuit color-coded wire is to remain uniform throughout circuit. Tamper switches meet requirements of paragraph TAMPER SWITCHES.

2.7.3 Data Encryption

Incorporate data encryption equipment on data transmission circuits as

shown on the drawings. The algorithm used for encryption must be the Advanced Encryption Standard (AES) algorithm described in NIST FIPS 197 of ASC/X9 X9.52, as a minimum. Data encryption must be in accordance with NIST FIPS 140-2.

2.7.4 Network Switch

The small form-factor pluggable (SFP) is to provide full-duplex 1000/100/10-Mbps connectivity between switches over single mode (SM) infrastructures. Provide mounting accessories for a typical rack. Rack requirements as specified in paragraph EQUIPMENT RACK.

2.7.4.1 Inside Plant

Provide a network switch for ESS system with 12 SFP Ethernet ports. Allow dynamic port base security and rapid spanning tree protocol with VLAN assignments for specific users regardless of where the switch is connected. The switch will use AC input voltage nominal of 120 VAC at 60 Hz. The switch is to be less than 2 Rack Units (RU) and Layer 3 capable. The switch is to have the capability of commanding a self-healing ring configuration. 1000Base-LX SFP Fast Ethernet Interface Converter is to be a hot swappable device that plugs into a Gigabit fiber SFP uplink port on the switch. The switch is to be a fully managed power over Ethernet (PoE) to all ports. Provide switch capable of using a Layer 3 (routed) port to connect to a LAN gateway port for Internet and web base access. The Mean Time Between Failure (MTBF) must be greater than 210,000 hours.

2.7.5 Video and ESS Transmission

Transmission is to be by optical fiber dedicated to the associated circuit. Video and ESS transmission cables must conform to the industry standards in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM 33 82 00 TELECOMMUNICATIONS OUTSIDE PLANT (OSP).

Install interior cable in Electrical Metallic Tubing (EMT) conduit unless indicated otherwise. Cable is to be rated for the installation method intended. Install exterior cable underground installed in Schedule 40 Polyvinyl chloride (PVC) conduits.

2.7.6 Wire and Cable

Provide all wire and cable not indicated as Government-furnished equipment. Wiring must meet NFPA 70 standards and as indicated in the Wire and Cable Data Sheets Attachment at the end of this section.

2.7.7 Digital Data Interconnection Wiring

Interconnecting cables carrying digital data between equipment located at the SCC or at a secondary control and monitoring site is to be optical fiber cable. Interconnecting cables conform to the industry standards in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM 33 82 00 TELECOMMUNICATIONS OUTSIDE PLANT (OSP).

2.7.8 Aboveground Sensor Wiring

Sensor wiring is to be 20 AWG minimum, twisted and shielded, 2, 3, 4, or 6 pairs to match hardware. Provide multiconductor wire with a PVC outer jacket.

2.7.9 Direct Burial Sensor Wiring

Sensor wiring is to be 20 AWG minimum, twisted and shielded, 2, 3, 4, or 6 pairs to match hardware.

2.7.10 Local Area Network (LAN) Cabling

Cabling must be in accordance with TIA-568-D.2, Category 6.

2.7.11 Cable Construction

Provide all cable components that will withstand the environment in which the cable is installed for a minimum of 20 years.

2.8 SECURITY LIGHTING INTERFACE

Provide an interface for control of the security lighting system. Coordinate with Sandhills Utility Services.

2.9 BACKUP POWER

a. Intrusion alarms are not to be generated as a result of power switching; however, Provide a power switching indication and on-line source at the alarm monitor.

b. The system is to automatically switch back to the primary source upon primary power restoration. Detect and report failure of an on-line battery as a fault condition. Power products must be in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

c. Provide backup power to the primary power by uninterruptible power supply (UPS).

2.9.1 Uninterruptible Power Supply (UPS)

Backup power required for uninterrupted ESS operation until a diesel engine generator set can assume the full load is to be provided by a UPS.

The UPS is to consist of a rectifier, battery and support racks, a static inverter, static switch transfer, and a manual bypass switch. Provide UPS with a continuous output to supply the maximum load requirements of the ESS. Size the battery to sustain the UPS at full rated load until diesel engine generator set can assume the load.

2.10 SURGE SUPPRESSION DEVICES

Comply with requirements in Section 33 82 00 TELECOMMUNICATION OUTSIDE PLANT (OSP).

2.11 COMPONENT ENCLOSURE

Alarm enclosures with a tamper switch(es). Refer to paragraph "Tamper Switch". Enclosures is to be formed and assembled to be sturdy and rigid. These include:

a. Consoles

b. Annunciator housings

c. Power supply enclosures

d. Sensor control and terminal cabinets

e. Control units

f. Wiring gutters

g. Other component housings

2.11.1 Interior Sensor

Provide sensors to be used in an interior environment with a housing that provides protection against dust, falling dirt, and dripping noncorrosive liquids. Refer to paragraph "Interior Enclosures" for enclosure ratings.

2.11.2 Exterior Sensor

Provide sensors to be used in an exterior environment with a housing that provides protection against windblown dust, rain and splashing water, and hose directed water. Sensors are not to be damaged by the ice formation on the enclosure. Refer to pargraph "Exposed-to-Weather Enclosures" and "Corrosion-Resistant Enclosures" for enclosure ratings.

2.11.3 Interior Enclosures

Enclosures to house equipment in an interior environment must meet the requirements of NEMA 250 Type 1.

2.11.4 Exposed-to-Weather Enclosures

Enclosures to house equipment in an outdoor environment must meet the requirements of NEMA 250 Type 3R.

2.11.5 Corrosion-Resistant Enclosures

Enclosures to house equipment in a corrosive environment must meet the requirements of NEMA 250 Type 4X.

2.11.6 Hazardous Environment Equipment

All system electronics to be used in a hazardous environment must be housed in a metallic enclosure which meets the requirements of paragraph "Hazardous Locations."

2.11.7 Metal Thickness

Thicknesses of metal in cast and sheet metal enclosures of all types must be not less than those listed in Tables 8.1, 8.2, and 8.3 of UL 1610 for alarm components, and NEMA ICS 2 and NEMA ICS 6 for other enclosures. Sheet steel used in enclosure fabrication is to be at least 16 gage; consoles are to be at least 18 gage.

2.11.8 Doors and Covers

a. Doors and covers are to be flanged. Provide tight pin hinges or the ends of hinge pins are to be tack welded to prevent ready removal where doors are mounted on hinges with exposed pins.

b. Provide doors having a latch edge length of less than 24 inches with a single lock. Provide the door with a three-point latching device with lock where latch edge of a hinged door is 24 inches or more in length; or alternatively with two locks, one located near each end.

c. The covers of provided junction boxes to facilitate initial system installation are to be held in place by tack welding, brazing, or one-way screws.

2.11.9 Ventilation

Ventilation openings in enclosures and cabinets must conform to requirements of UL 1610.

2.11.10 Mounting

Sheet metal enclosures are to be rated for wall mounting with top hole slotted, unless otherwise indicated. Mounting holes are to be in positions which remain accessible when major operating components are in place and door is open, and be inaccessible when door is closed.

2.11.11 Labels

Label boxes containing connections that they contain ESS connections and indicate that the box is part of the ESS system.

2.11.12 Test Points

Provide readily visibile and accessibile with minimum disassembly of equipment to test points, controls, and other adjustments inside enclosures. Test points and other maintenance controls must be readily accessible to operator personnel.

2.12 EQUIPMENT RACK

Provide standard 19 inch electronic rack cabinets conforming to UL 50 for the ESS system at the SCC and remote control and monitoring sites as shown on the drawings. Equipment rack must be in accordance with Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

2.12.1 Labels

Provide a labeling system for cabling as required by TIA-606 and UL 969. Provide stenciled lettering for voice and data circuits using laser printer.

2.13 FIELD FABRICATED NAMEPLATES

Nameplates must comply with ASTM D709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified or as indicated on the drawings. Each nameplate inscription is to identify the function and, when applicable, the position.

Nameplates are to be melamine plastic, 0.125 inch thick, white with black center core. Surface is to be matte finish. Corners are to be square. Accurately align lettering and engrave into the core. Minimum size of nameplates must be 1 by 2.5 inches. Provide lettering a minimum of 0.25 inch high normal block style. Nameplates are not be required for devices smaller than 1 x 3 inches.

2.13.1 Manufacturer's Nameplate

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

2.14 FACTORY APPLIED FINISH

Electrical equipment is to have factory-applied painting systems which meetsthe requirements of the NEMA 250 corrosion-resistance test as a minimum.

PART 3 EXECUTION

3.1 INSTALLATION

Install the system in accordance with safety and technical standards NFPA 70, UL 681, UL 1037, and UL 1076. Configure components within the system with appropriate service points to pinpoint system trouble in less than 20 minutes.

Install all system components, including any equipment that is furnished by the Government, and appurtenances in accordance with the manufacturer's instructions, IEEE C2 and as shown on the drawings, and furnish all necessary connectors, terminators, interconnections, services, and adjustments required for a complete and operable system.

3.1.1 Existing Equipment

Connect to and utilize existing equipment, control signal transmission lines, and devices as shown on the drawings. Any equipment and signal lines that are usable in their original configuration without modification may be reused with Government approval.

Make written requests and obtain approval prior to disconnecting any signal lines and equipment that creates equipment outage. Such work can proceed only after receiving Government approval of these requests. If any device fails after work has commenced on that device, signal, or control line, diagnose the failure and perform any necessary corrections to the equipment. The Government is responsible for maintenance and repair of Government equipment. The Contractor will be held responsible for repair costs due to negligence or abuse of Government equipment on their part.

3.1.2 Software Installation

Load software as specified and required for an operational system, including databases and specified programs. Provide original and backup copies on optic discs of all accepted software, including diagnostics, upon successful endurance test completion.

3.1.3 Enclosure Penetrations

Enclosures are to be penetrated from the bottom unless shown otherwise. Penetrations of interior enclosures having transitions of conduit from interior to exterior, and penetrations of exterior enclosures are to be sealed with rubber silicone sealant to preclude the entry of water. Terminate conduit risers in a hot-dipped galvanized metal cable terminator

that is filled with a sealant as recommended by the cable manufacturer, and in a manner that does not damage the cable.

3.1.4 Cable and Wire Runs

Perform required cable and wire routings per NFPA 70 and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, and ICS 705-1, and as specified. Terminate conduits including flexible metal and armored cable in the sensor or device enclosure. Fit ends of conduit with insulated bushings. Exposed conductors at ends of conduits external to sensors and devices are not acceptable.

3.1.5 Soldering

Soldered electrical connections must use composition Sn60, Type AR or S, for general purposes; use composition Sn62 or Sn63, Type AR or S, for special purposes. Flux must conform to ASTM B32 when Type S solder is used for soldering electrical connections.

3.1.6 Galvanizing

Ferrous metal is to be hot-dip galvanized in accordance with ASTM A123/A123M. Provide screws, bolts, nuts, and other fastenings and supports that are corrosion resistant.

Field welds or brazing on factory galvanized boxes, enclosures, conduits, and so on, are to be coated with a cold galvanized paint containing at least 95 percent zinc by weight.

3.1.7 Conduits

Install interior conduits in accordance with NFPA 70, Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM and ICS 705-1. Install exterior conduits in accordance with NFPA 70, Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION and ICS 705-1.

3.1.8 Underground Cable Installation

Install underground conductors connecting protected structures and objects to the central alarm updating and display unit as direct burial or in conduit as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Coaxial cable cannot be spliced.

3.1.9 Field Applied Painting

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting must be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.2 ADJUSTMENT, ALIGNMENT, SYNCHRONIZATION, AND CLEANING

a. Clean each system component of dust, dirt, grease, or oil incurred during and after installation or accrued subsequent to installation from other project activities subsequent to installation.

b. Prepare for system activation by manufacturer's recommended procedures for adjustment, alignment, or synchronization.

c. Prepare each component in accordance with appropriate provisions of

component installation, operations, and maintenance manuals.

d. Remove large vegetation that may sway in the wind and touch fencing.

e. Adjust sensors so that coverage is overlapping and maximized without mutual interference.

3.3 SYSTEM STARTUP

Do not apply power to the system until after:

a. Set up system equipment items and communications in accordance with manufacturer's instructions.

b. Conduct a system visual inspection to ensure that defective equipment items have not been installed and that there are no loose connections.

c. Test and verify system wiring as correctly connected.

d. Verify system grounding and transient protection systems as properly installed.

e. Verify the correct voltage, phasing, and frequency of the system power supplies.

Satisfication of the requirements above does not relieve the contractor of responsibility for incorrect installations, defective equipment items, or collateral damage as result of Contractor work or equipment.

3.4 SUPPLEMENTAL CONTRACTOR QUALITY CONTROL

Provide the services of technical representatives who are familiar with all components and installation procedures of the installed system; and are approved by the Contracting Officer. These representatives are to be present on the job site during the preparatory and initial phases of quality control to provide technical assistance. These representatives are also to be available on an as needed basis to provide assistance with follow-up phases of quality control. These technical representatives are to participate in the system testing and validation and provide certification that their respective system portions meet the contractual requirements.

The above requirements supplement the quality control requirements specified elsewhere in the contract.

3.5 ESS SYSTEM TESTING

All ESS Testing requirements are specified in Section 28 08 10 ELECTRICAL SECURITY SYSTEM ACCEPTANCE TESTING.

3.6 ESS TRAINING

Conduct training courses for 10 designated personnel in system maintenance and operation. Coordinate training with the Government. The training is to be oriented to the specific system being installed. Training content is to include training manuals and audio-visual materials. Deliver training manuals for each trainee with 2 additional copies delivered for archiving at the project site. The manuals are to include an agenda, defined objectives for each lesson, and a detailed subject matter

description for each lesson.

Furnish audio-visual equipment and other training materials and supplies. Deliver copies of the audio-visual materials to the Government either as a part of the printed training manuals or on the same media as that used during the training sessions when course portions are presented using audio-visual material.

3.6.1 ESS Training Outline

Submit a training plan for the training phases, including type of training to be provided, outline of training manuals, training course agendas, and a list of reference material, for Government approval.

3.6.2 Typical Training Day

A training day is defined as:

a. Eight hours of classroom instruction, with

(1) Two 15-minute breaks

(2) One hour lunch break

b. Conducted:

(1) Monday through Friday

(2) During the daytime shift in effect at a Government-provided training facility

For guidance in planning the required instruction, assume that attendees will have a high school education or equivalent, and are familiar with ESS. Approval of the planned training schedule is to be obtained from the Government at least 30 days prior to the training.

3.6.3 ESS Administrator Training

a. ACS and IDS Administrator Training includes:

(1) Two eight-hour on-site training sessions

(2) Operating system procedures and configuration

(3) Operator functions

(4) Database functions and setup

(5) Card holder input and deletion procedures

(6) Report generation

(7) Applications programs (as applicable)

(8) Graphics generation and manipulation

(9) Items unique to the ACS and IDS interfaces with other systems

(10) System backup and restore

b. CCTV System Administrator Training includes:

(1) One eight-hour session on site

(2) Training is to include all administrator and operator functions, and items unique to the installed CCTV System, and interfaces with other systems.

3.6.4 ESS Operator Training

Coordinate the operator training syllabus with the Government prior to conducting operator training.

a. ACS and IDS Operator Training includes:

(1) Four (one-day) 8 hour on-site training sessions

(2) System operating procedures

(3) System configuration orientation

(4) Alarm acknowledgment

(5) Alarm response logging

(6) Graphics functionality

(7) Items unique to the ACS and IDS interfaces with other systems

b. CCTV Operator Training includes:

(1) Two (one-day) 8 hour on-site training sessions

(2) System operating procedures

(3) System configuration

(4) Video call-up

(5) Camera and monitor control

(6) Graphics functionality

(7) Basic device terminology and troubleshooting

3.6.5 Maintenance Personnel Training

The system maintenance course is to be taught at the project site after endurance test completion for a period of five training days. A maximum of five personnel, designated by the Government, will attend the course. The training includes:

a. Physical layout of each piece of hardware.

b. Troubleshooting and diagnostics procedures.

c. Component repair and replacement procedures.

d. Maintenance procedures and schedules to include system testing after repair.

e. Calibration procedures. Upon course completion, the students are to be proficient in system maintenance.

f. Review of site-specific drawing package, device location, communication, topology, and flow.

3.6.6 Follow-up Training

a. Provide One hour training session each month for two months after initial training.

b. Follow-up training is to begin one month after initial training.

c. Training is to include testing for system competence.

3.7 NAMEPLATE MOUNTING

Provide nameplate number, location, and letter designation as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or rivets.

-- End of Section --

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INTERIOR FIRE ALARM AND MASS NOTIFICATION SYSTEM
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PART 1 GENERAL

1.1 RELATED SECTIONS

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, applies to this section, with the additions and modifications specified herein. In addition, refer to the following sections for related work and coordination:

Section 21 13 13.00 20 WET PIPE SPRINKLER SYSTEM, FIRE PROTECTION

Section 14 24 23 HYDRAULIC PASSENGER ELEVATORS for additional work related to elevators.

Section 07 84 00 FIRESTOPPING for additional work related to firestopping.

1.2 SUMMARY

1.2.1 Scope

a. This work includes completion of design and providing a new, complete, fire alarm and mass notification system as described herein and on the contract drawings for the SOF Headquarters. Include in the system wiring, raceways, pull boxes, terminal cabinets, outlet and mounting boxes, control equipment, alarm, and supervisory signal initiating devices, alarm notification appliances, supervising station fire alarm system transmitter, and other accessories and miscellaneous items required for a complete operating system even though each item is not specifically mentioned or described. Provide system complete and ready for operation.

b. Provide equipment, materials, installation, workmanship, inspection, and testing in strict accordance with the required provisions of UFC 3-600-01 Fire Protection Engineering for Facilities, NFPA 72, ISO 7240-16, IEC 60268-16, except as modified herein. The system layout on the drawings show the intent of coverage and are shown in suggested locations. Submit plan view drawing showing device locations, terminal cabinet locations, junction boxes, other related equipment, conduit routing, wire counts, circuit identification in each conduit, and circuit layouts for all floors. Drawings shall comply with the requirements of NFPA 170. Final quantity, system layout, and coordination are the responsibility of the Contractor.

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.

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S3.2	(2009; R 2014) Method for Measuring the Intelligibility of Speech Over Communication Systems (ASA 85)

ASME INTERNATIONAL (ASME)

ASME A17.1/CSA B44	(2016) Safety Code for Elevators and Escalators

FM GLOBAL (FM)

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

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 60268-16	(2003; ED 4.0) Sound System Equipment - Part 16: Objective Rating Of Speech Intelligibility By Speech Transmission Index

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 7240-16	(2007) Fire Detection And Alarm Systems — Part 16: Sound System Control And Indicating Equipment
ISO 7240-19	(2007) Fire Detection and Alarm Systems — Part 19: Design, Installation, Commissioning and Service of Sound Systems for Emergency Purposes

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 170	(2018) Standard for Fire Safety and Emergency Symbols
NFPA 70	(2017; ERTA 1-2 2017; TIA 17-1; TIA 17-2; TIA 17-3; TIA 17-4; TIA 17-5; TIA 17-6; TIA 17-7; TIA 17-8; TIA 17-9; TIA 17-10; TIA 17-11; TIA 17-12; TIA 17-13; TIA 17-14) National Electrical Code
NFPA 72	(2016; Errata 1 2018) National Fire Alarm and Signaling Code
NFPA 90A	(2018) Standard for the Installation of

	Air Conditioning and Ventilating Systems
U.S. DEPARTMENT OF DEFENSE (DOD)	
UFC 3-600-01	(25 March 2018, with Change 2) Fire Protection Engineering for Facilities
UFC 3-601-02	(2010) Operations and Maintenance: Inspection, Testing, and Maintenance of Fire Protection Systems
UFC 4-021-01	(2008; with Change 1) Design and O&M: 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 1480	(2016; Reprint Sep 2017) UL Standard for Safety Speakers for Fire Alarm and Signaling Systems, Including Accessories
UL 1971	(2002; Reprint Oct 2008) Signaling Devices for the Hearing Impaired
UL 2017	(2008; Reprint Jan 2016) General-Purpose Signaling Devices and Systems
UL 268	(2016; Reprint Jul 2016) UL Standard for Safety Smoke Detectors for Fire Alarm Systems
UL 464	(2016; Reprint Sep 2017) UL Standard for Safety Audible Signaling Devices for Fire Alarm and Signaling Systems, Including Accessories
UL 521	(1999; Reprint Dec 2017) UL Standard for Safety Heat Detectors for Fire Protective Signaling Systems
UL 864	(2014; Reprint Mar 2018) UL Standard for Safety Control Units and Accessories for Fire Alarm Systems
UL Electrical Constructn	(2012) Electrical Construction Equipment Directory
UL Fire Prot Dir	(2012) Fire Protection Equipment Directory

1.4 DEFINITIONS

Wherever mentioned in this specification or on the drawings, the equipment, devices, and functions shall 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 Remote Fire Alarm and Mass Notification Control Unit

A control panel, electronically remote from the fire alarm and mass notification control panel, 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 control panel.

1.4.3 Fire Alarm Control Unit and Mass Notification Autonomous Control Unit (FMCP)

A master control panel having the features of a fire alarm and mass notification control unit and fire alarm and mass notification control units are interconnected. The panel has central processing, memory, input and output terminals, and LCD, LED Display units.

1.4.4 Local Operating Console (LOC)

A unit designed to allow emergency responders and/or building occupants to operate the MNS including delivery or recorded and/or live messages, initiate strobe and textural visible appliance operation and other relayed functions.

1.4.5 Terminal Cabinet

A steel cabinet with locking, hinge-mounted door that terminal strips are securely mounted.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Nameplates; G, AE

Instructions; G, AE

Wiring Diagrams; G, AE

System Layout; G, AE

System Operation; G, AE

Notification Appliances; G, AE

Amplifiers; G, AE

SD-03 Product Data

Technical Data And Computer Software; G, AE

Fire Alarm Control Unit and Mass Notification Control Unit (FMCP); G, AE

LCD, LED Display Unit (VDU); G, AE

Terminal Cabinets; G, AE

Manual Stations; G, AE

Transmitters (including housing); G, AE

Batteries; G, AE

Battery Chargers; G, AE

Smoke Sensors; G, AE

Heat Detectors; G, AE

Notification Appliances; G, AE

Addressable Interface Devices; G, AE

Amplifiers; G, AE

Tone Generators; G, AE

Digitalized Voice Generators; G, AE

Radio Transmitter and Interface Panels; G, AE

Digital Alarm Communicator Transmitter (DACT); G, AE

Local Operating Console (LOC); G, AE

SD-05 Design Data

Battery Power; G, AE

Battery Chargers; G, AE

SD-06 Test Reports

Field Quality Control

Testing Procedures; G, AE

Smoke Sensor Testing Procedures; G, AE

SD-07 Certificates

Installer

Formal Inspection and Tests

Final Testing

SD-09 Manufacturer's Field Reports

System Operation; G, AE

Fire Alarm/Mass Notification System

SD-10 Operation and Maintenance Data

Operation and Maintenance (O&M) Instructions; G, AE

Instruction of Government Employees; G, AE

SD-11 Closeout Submittals

As-Built Drawings

1.6 TECHNICAL DATA AND COMPUTER SOFTWARE

Technical data and computer software (meaning technical data that relates to computer software) that are specifically identified in this project, and may be defined/required in other specifications, shall be delivered, strictly in accordance with the CONTRACT CLAUSES. Identify data delivered by reference to the particular specification paragraph against which it is furnished. Data to be submitted shall include complete system, equipment, and software descriptions. Descriptions shall show how the equipment will operate as a system to meet the performance requirements of this contract. The data package shall also include the following:

a. Identification of programmable portions of system equipment and capabilities.

b. Description of system revision and expansion capabilities and methods of implementation detailing both equipment and software requirements.

c. Provision of operational software data on all modes of programmable portions of the fire alarm and detection system.

d. Description of Fire Alarm and Mass Notification Control Panel equipment operation.

e. Description of auxiliary and remote equipment operations.

f. Library of application software.

g. Operation and maintenance manuals.

1.7 QUALITY ASSURANCE

Equipment and devices shall be compatible and operable with existing station fire alarm system and shall not impair reliability or operational functions of existing supervising station fire alarm system. The fire alarm control panel shall be compatible with the existing monitoring equipment at Fort Bragg Integrated Incident Management Center (I2MC), which is currently Monaco D21 or Honeywell EBI. The fire alarm system shall be compatible with the mass notification system receiver and be able

to relay outputs from the receiver over the voice evacuation system to the selected speakers. The contractor shall coordinate with the base to ensure the receiver is compatible with the base-wide mass notification system. Mass notification signals shall take precedence over fire alarm signals. Building MNS shall communicate with the central control unit of the wide area MNS to provide status information, receive commands, activate pre-recorded messages and originate live voice messages. The central control unit at Fort Bragg Integrated Incident Management Center (I2MC) is currently Federal Signal.

a. Interpret reference to "authority having jurisdiction" to mean the Contracting Offices Designated Representative (COR).

b. The recommended practices stated in the manufacturer's literature or documentation shall be considered as mandatory requirements.

c. Devices and equipment for fire alarm service must be listed by UL Fire Prot Dir or approved by FM APP GUIDE.

1.7.1 Qualifications

1.7.1.1 Design Services

Installations requiring completion of installation drawings and specification or modifications of fire detection, fire alarm, mass notification system, fire suppression systems or mass notification systems shall require the services and review of a qualified engineer. For the purposes of meeting this requirement, a qualified engineer is defined as an individual meeting one of the following conditions:

a. A registered professional engineer having a Bachelor of Science or Masters of Science Degree in Fire Protection Engineering from an accredited university engineering program, plus a minimum of four years work experience in fire protection engineering.

b. A registered professional engineer (P.E.) in fire protection engineering.

c. Registered Professional Engineer with verification of experience and at least five years of current experience in the design of the fire protection and detection systems.

1.7.1.2 Supervisor

NICET Fire Alarm Technicians to perform the installation of the system. A NICET Level 3 (minimum) Fire Alarm Technician shall supervise the installation of the fire alarm system/mass notification system. The Fire Alarm technicians supervising the installation of equipment shall be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.

1.7.1.3 Technician

Fire Alarm Technicians with a minimum of four years of experience utilized to install and terminate fire alarm/mass notification devices, cabinets and panels. The Fire Alarm technicians installing the equipment shall be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.

1.7.1.4 Installer

NICET Level II technician to assist in the installation of fire alarm/mass notification devices, cabinets and panels. An electrician shall be allowed to install wire, cable, conduit and backboxes for the fire alarm system/mass notification system. The Fire Alarm installer shall be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.

1.7.1.5 Test Personnel

Fire Alarm Technicians with a minimum of eight years of experience minimum (NICET Level III)utilized to test and certify the installation of the fire alarm/mass notification devices, cabinets and panels. The Fire Alarm technicians testing the equipment shall be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.

1.7.1.6 Manufacturer's Representative

The fire alarm and mass notification equipment manufacturer's representative shall be present for the connection of wiring to the control panel. The Manufacturer's Representative shall be an employee of the manufacturer with necessary technical training (NICET Level III)on the system being installed.

1.7.1.7 Manufacturer

Components shall be of current design and shall 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 otherwise or additionally specified herein.

1.7.2 Regulatory Requirements

1.7.2.1 Requirements for Fire Protection Service

Equipment and material shall have been tested by UL and listed in UL Fire Prot Dir or approved by FM and listed in FM APP GUIDE. Where the terms "listed" or "approved" appear in this specification, they shall mean listed in UL Fire Prot Dir or FM APP GUIDE. The omission of these terms under the description of any item of equipment described shall not be construed as waiving this requirement. All listings or approval by testing laboratories shall be from an existing ANSI or UL published standard.

1.7.2.2 Fire Alarm/Mass Notification System

Furnish equipment that is compatible and is UL listed, FM approved, or listed by a nationally recognized testing laboratory for the intended use. All listings by testing laboratories shall be from an existing ANSI or UL published standard. Submit a unique identifier for each device, including the control panel and initiating and indicating devices, with an indication of test results, and signature of the factory-trained technician of the control panel manufacturer and equipment installer. With reports on preliminary tests, include printer information. Include the NFPA 72 Record of Completion and NFPA 72 Inspection and Testing Form, with the appropriate test reports.

1.7.2.3 Fire alarm Testing Services or Laboratories

construct fire alarm and fire detection equipment in accordance with UL Fire Prot Dir, UL Electrical Constructn, or FM APP GUIDE.

1.8 DELIVERY, STORAGE, AND HANDLING

Protect equipment delivered and placed in storage from the weather, humidity, and temperature variation, dirt and dust, and other contaminants.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Submit annotated catalog data as required in the paragraph SUBMITTAL, in table format on the drawings, showing manufacturer's name, model, voltage, and catalog numbers for equipment and components. Submitted shop drawings shall not be smaller than ISO A1. Also provide UL or FM listing cards for equipment provided.

2.1.1 Standard Products

Provide materials, equipment, and devices that have been tested by a nationally recognized testing laboratory, such as UL or FM Approvals, LLC (FM), and listed or approved 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 shall be the standard products of a manufacturer regularly engaged in the manufacture of the products for at least two years prior to bid opening.

2.1.2 Nameplates

Major components of equipment shall 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 plate permanently affixed to the item or equipment. Major components include, but are not limited to, the following:

a. FMCPs

b. Automatic transmitter/transceiver

c. Terminal Cabinet

Furnish nameplate illustrations and data to obtain approval by the Contracting Officer before installation. Obtain approval by the Contracting Officer for installation locations. Nameplates shall be etched metal or plastic, permanently attached by screws to panels or adjacent walls.

2.1.3 Keys

Keys and locks for equipment shall be identical. Provide not less than six keys of each type required. Master all keys and locks to a single key as required by the Installation Fire Department.

LOC is not permitted to be locked or lockable.

2.2 GENERAL PRODUCT REQUIREMENT

All fire alarm and mass notification equipment shall be listed for use under the applicable reference standards. Interfacing of Listed UL 864 or similar approved industry listing with Mass Notification Panels listed to UL 2017 shall be done in a laboratory listed configuration, if the software programming features cannot provide a listed interface control. If a field modification is needed, such as adding equipment like relays, the manufacturer of the panels being same or different brand from manufacturer shall provide the installing contractor for review and confirmation by the installing contractor. As part of the submittal documents, provide this information.

2.3 SYSTEM OPERATION

The Addressable Interior Fire Alarm and Mass Notification System shall be a complete, supervised, noncoded, analog/addressable fire alarm and mass notification system conforming to NFPA 72, UL 864 , and UL 2017. The system shall be activated into the alarm mode by actuation of any alarm initiating device. The system shall remain in the alarm mode until the initiating device is reset and the control panel is reset and restored to normal. The system may be placed in the alarm mode by local microphones, LOC, or remotely from authorized locations/users.

Submit data on each circuit to indicate that there is at least 25 percent spare capacity for notification appliances, 25 percent spare capacity for initiating devices. Annotate data for each circuit on the drawings. Submit a complete description of the system operation in matrix format on the drawings. Submit a complete list of device addresses and corresponding messages.

2.3.1 Alarm Initiating Devices and Notification Appliances (Visual, Voice, Textural)

a. Connect alarm initiating devices to signal line circuits (SLC) Class "A" and installed in accordance with NFPA 72.
b. Connect alarm notification appliances and speakers to notification appliance circuits (NAC) Class "A .

c. The system shall operate in the alarm mode upon actuation of any alarm initiating device or a mass notification signal. The system shall remain in the alarm mode until initiating device(s) or mass notification signal is/are reset and the control panel is manually reset and restored to normal. Audible, and visual appliances and systems shall comply with NFPA 72 and as specified herein. Fire alarm system/mass notification system components requiring power, except for the control panel power supply, shall operate on 24 Volts dc.

2.3.2 Functions and Operating Features

The system shall provide the following functions and operating features:

a. The FMCP shall provide power, annunciation, supervision, and control for the system. Addressable systems shall be microcomputer (microprocessor or microcontroller) based with a minimum word size of eight bits with sufficient memory to perform as specified.

b. For Class "A" or "X" circuits with conductor lengths of 3m (10 feet) or less, the conductors shall be permitted to be installed in the same raceway in accordance with NFPA 72.

c. Provide signaling line circuits for each floor.

d. Provide signaling line circuits for the network.

e. Provide notification appliance circuits. The visual alarm notification appliances shall have the flash rates synchronized as required by NFPA 72.

f. Provide electrical supervision of the primary power (AC) supply, presence of the battery, battery voltage, and placement of system modules within the control panel.

g. Provide an audible and visual trouble signal to activate upon a single break or open condition, or ground fault (or short circuit for Class "X"). The trouble signal shall also operate upon loss of primary power (AC) supply, absence of a battery supply, low battery voltage, or removal of alarm or supervisory panel modules. Provide a trouble alarm silence feature that shall silence the audible trouble signal, without affecting the visual indicator. After the system returns to normal operating conditions, the trouble signal shall again sound until the trouble is acknowledged. A smoke sensor in the process of being verified for the actual presence of smoke shall not initiate a trouble condition.

h. Provide program capability via switches in a locked portion of the FACP to bypass the automatic notification appliance circuits, fire reporting system, air handler shutdown, and elevator recall features. Operation of this programming shall indicate this action on the FACP display and printer output.

i. Alarm, supervisory, and/or trouble signals shall be automatically transmitted to the fire department..

j. Alarm functions shall override trouble or supervisory functions. Supervisory functions shall override trouble functions.

k. The system shall be capable of being programmed from the panels keyboard. Programmed information shall be stored in non-volatile memory.

l. The system shall be capable of operating, supervising, and/or monitoring both addressable and non-addressable alarm and supervisory devices.

m. There shall be no limit, other than maximum system capacity, as to the number of addressable devices, that may be in alarm simultaneously.

n. Where the fire alarm/mass notification system is responsible for initiating an action in another emergency control device or system, such as an HVAC system or an elevator system, the addressable fire alarm relay shall be in the vicinity of the emergency control device.

o. An alarm signal shall automatically initiate the following functions:

(1) Transmission of an alarm signal to the fire department.

(2) Visual indication of the device operated on the control panel (FACP/MNCP), and on the LCD, LED Display unit (VDU),. Indication on the graphic annunciator shall be by floor, zone or circuit, and type of device.

(3) Continuous actuation of all alarm notification appliances.

(4) Recording of the event via electronically in the history log of the fire control system unit.

(5) Release of doors held open by electromagnetic devices.

(6) Release of power to electric locks (delayed egress locks) on doors that are part of the means of egress.

(7) Operation of a smoke sensor in an elevator lobby or other location associated with the automatic recall of elevators, shall recall the elevators in addition to other requirements of this paragraph.

(8) Operation of a duct smoke sensor shall 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.

(9) Operation of a sprinkler waterflow switch serving an elevator machinery room or elevator shaft shall operate shunt trip circuit breaker(s) to shut down power to the elevators in accordance with ASME A17.1/CSA B44.

p. A supervisory signal shall automatically initiate the following functions:

(1) Visual indication of the device operated on the FACP and VDU and sound the audible alarm at the respective panel.

(2) Transmission of a supervisory signal to the fire department.

(3) Recording of the event electronically in the history log of the control unit.

q. A trouble condition shall automatically initiate the following functions:

(1) Visual indication of the system trouble on the FACP and VDU and sound the audible alarm at the respective panel.

(2) Transmission of a trouble signal to the fire department.

(3) Recording of the event in the history log of the control unit.

r. The maximum permissible elapsed time between the actuation of an initiating device and its indication at the FACP is 10 seconds.

s. The maximum elapsed time between the occurrence of the trouble condition and its indication at the FACP is 200 seconds.

t. Activation of a LOC pushbutton shall activate the audible and visual alarms in the facility. The audible message shall be the one

associated with the pushbutton activated.

2.4 SYSTEM MONITORING

2.4.1 Valves

Each valve affecting the proper operation of a fire protection system, including automatic sprinkler control valves, standpipe control valves, sprinkler service entrance valve, valves at fire pumps, isolating valves for pressure type waterflow or supervision switches, and valves at backflow preventers, whether supplied under this contract or existing, shall be electrically monitored to ensure its proper position. Provide each tamper switch with a separate address.

2.4.2 Independent Fire Detection System

Each existing independent smoke detection subsystem, kitchen fire extinguishing system, and releasing system (e.g. AFFF) shall be monitored both for the presence of an alarm condition and for a trouble condition. Provide each monitored condition with a separate address.

2.5 MASS NOTIFICATION SYSTEM FUNCTIONS

2.5.1 Notification Appliance Network

The audible notification appliance network consists of speakers located to provide intelligible instructions at areas as indicated. The Mass Notification System announcements shall take priority over all other audible announcements of the system including the output of the fire alarm system in a normal or alarm state. When a mass notification announcement is activated during a fire alarm, all fire alarm system functions shall continue in an alarm state except for the output signals of the fire alarm audible and visual notification appliances.

2.5.2 Strobes

Provide strobes to alert hearing-impaired occupants.

2.5.3 Text Displays

LED text displays (textural visible appliances) for hearing impaired occupants. The textual displays shall be programmable and shall display the same content of the voice message being played. The signs shall be able to provide a minimum of 100 mm 4 inch high letters and be located in high traffic areas easily seen by building occupants. The system shall interface with the Programmable sign controller to activate the proper message.

2.5.4 Wide Area MNS

The Wide Area MNS system (if available) in the area of the building shall not be activated by the in-building MNS.

2.5.5 Voice Notification

An autonomous voice notification control unit is used to monitor and control the notification appliance network and provide consoles for local operation. Using a console, personnel in the building can initiate delivery of pre-recorded voice messages, provide live voice messages and

instructions, and initiate visual strobe and optional textual message notification appliances. The autonomous voice notification control unit will temporarily override audible fire alarm notification while delivering Mass Notification messages to ensure they are intelligible.

2.5.6 Installation-Wide Control

The autonomous control unit shall communicate with the central control unit of the installation-wide system. The autonomous control unit shall receive commands/messages from the Federal Signal central control unit and provide status information.

2.6 OVERVOLTAGE AND SURGE PROTECTION

2.6.1 Signaling Line Circuit Surge Protection

For systems having circuits located outdoors, communications equipment shall be protected against surges induced on any signaling line circuit and shall comply with the applicable requirements of IEEE C62.41.1 and IEEE C62.41.2. Cables and conductors, that serve as communications links, shall have surge protection circuits installed at each end that meet the following waveform(s):

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. Protection shall be provided at the equipment. Additional triple electrode gas surge protectors, rated for the application, shall be installed on each wireline circuit within 3 feet of the building cable entrance. Fuses shall not be used for surge protection.

2.6.2 Sensor Wiring Surge Protection

Digital and analog inputs and outputs shall be protected against surges induced by sensor wiring installed outdoors and as shown. The inputs and outputs shall be tested with the following waveforms:

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

b. An 8 by 20 microsecond waveform with a peak voltage of 1000 volts and a peak current of 500 amperes. Fuses shall not be used for surge protection.

2.7 ADDRESSABLE INTERFACE DEVICES

The initiating device being monitored shall be configured as a Class "A" initiating device circuits. The system shall 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, independent smoke detection systems, relays for output function actuation, etc. The module shall be UL or FM listed as compatible with the control panel. The monitor module shall provide address setting means compatible with the control panel's SLC supervision and store an internal identifying code. Monitor module shall 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.

2.8 ADDRESSABLE CONTROL MODULE

The control module shall be capable of operating as a relay (dry contact form C) for interfacing the control panel with other systems, and to control door holders or initiate elevator fire service. The module shall be UL or FM listed as compatible with the control panel. The indicating device or the external load being controlled shall be configured as a Class "B" notification appliance circuits. The system shall be capable of supervising, audible, visual and dry contact circuits. The control module shall have both an input and output address. The supervision shall detect a short on the supervised circuit and shall prevent power from being applied to the circuit. The control model shall provide address setting means compatible with the control panel's SLC supervision and store an internal identifying code. The control module shall contain an integral LED that flashes each time the control module is polled and is visible through the device cover plate. Control Modules shall be located in environmental areas that reflect the conditions to which they were listed.

2.9 SMOKE SENSORS

2.9.1 Photoelectric Smoke Sensors

Provide addressable photoelectric smoke sensors as follows:

a. Provide analog/addressable photoelectric smoke sensors utilizing the photoelectric light scattering principle for operation in accordance with UL 268. Smoke sensors shall be listed for use with the fire alarm control panel.

b. Provide self-restoring type sensors that do not require any readjustment after actuation at the FACP to restore them to normal operation. Sensors shall be UL listed as smoke-automatic fire sensors.

c. Components shall be rust and corrosion resistant. Vibration shall have no effect on the sensor's operation. Protect the detection chamber with a fine mesh metallic screen that prevents the entrance of insects or airborne materials. The screen shall not inhibit the movement of smoke particles into the chamber.

d. Provide twist lock bases for the sensors. The sensors shall maintain contact with their bases without the use of springs. Provide companion mounting base with screw terminals for each conductor. Terminate field wiring on the screw terminals. The sensor shall have a visual indicator to show actuation.

e. The sensor address shall identify the particular unit, its location within the system, and its sensitivity setting. Sensors shall be of the low voltage type rated for use on a 24 VDC system.

f. An operator at the control panel, having a proper access level, shall have the capability to manually access the following information for each initiating device.

(1) Primary status

(2) Device type

(3) Present average value

(4) Present sensitivity selected

(5) Sensor range (normal, dirty, etc.)

2.9.2 Duct Smoke Sensors

Duct-mounted photoelectric smoke detectors shall be furnished and installed where indicated and in accordance with NFPA 90A. Units shall consist of a smoke detector as specified in paragraph Photoelectric Detectors, mounted in a special housing fitted with duct sampling tubes. Detector circuitry shall be mounted in a metallic enclosure exterior to the duct. (It is not permitted to cut the duct insulation to install the duct detector directly on the duct). Detectors shall have a manual reset. Detectors shall be rated for air velocities that include air flows between 500 and 4000 fpm. Detectors shall be powered from the fire alarm panel.

a. Sampling tubes shall run the full width of the duct. The duct detector package shall conform to the requirements of NFPA 90A, UL 268 A, and shall be UL listed for use in air-handling systems. The control functions, operation, reset, and bypass shall be controlled from the fire alarm control panel.

b. Lights to indicate the operation and alarm condition; and the test and reset buttons shall be visible and accessible with the unit installed and the cover in place. Remote indicators shall be provided where required by NFPA 72 and these shall be provided with test and reset switches.

c. Remote lamps and switches as well as the affected fan units shall be properly identified in etched plastic placards. Detectors shall 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 shall be located within 3 feet of the controlled circuit or appliance. The detectors shall be supplied by the fire alarm system manufacturer to ensure complete system compatibility.

2.9.3 Smoke Sensor Testing

Smoke sensors shall be tested in accordance with NFPA 72 and manufacturer's recommended calibrated test method. Submit smoke sensor testing procedures for approval. In addition to the NFPA 72 requirements, smoke detector sensitivity shall be tested during the preliminary tests.

2.10 HEAT DETECTORS

2.10.1 Heat Detectors

Heat detectors shall be designed for detection of fire by combination fixed temperature and rate-of-rise principle. The alarm condition shall be determined by comparing sensor valve with the stored values. Heat detector spacing shall be rated in accordance with UL 521. Detectors located in areas subject to moisture, exterior atmospheric conditions, or hazardous locations as defined by NFPA 70, shall be types approved for such locations.

2.10.1.1 Combination Fixed-Temperature and Rate-of-Rise Detectors

Detectors shall be designed for surface outlet box mounting and supported independently of wiring connections. Contacts shall be self-resetting after response to rate-of-rise principle. Under fixed temperature actuation, the detector shall have a permanent external indication that is readily visible. Detector units located in boiler rooms, showers, or other areas subject to abnormal temperature changes shall operate on fixed temperature principle only. The UL 521 test rating for the fixed temperature portion shall be 135 degrees F. The UL 521 test rating for the Rate-of-Rise detectors shall be rated for 50 by 50 feet.

2.10.2 Self-Test Routines

Automatic self-test routines shall be performed on each sensor that will functionally check sensor sensitivity electronics and ensure the accuracy of the value being transmitted. Any sensor that fails this test shall indicate a trouble condition with the sensor location at the control panel.

2.10.3 Operator Access

An operator at the control panel, having the proper access level, shall have the capability to manually access the following information for each heat sensor:

a. Primary status

b. Device type

c. Present average value

d. Sensor range

2.10.4 Operator Control

An operator at the control panel, having the proper access level, shall have the capability to manually control the following information for each heat sensor:

a. Alarm detection sensitivity values

b. Enable or disable the point/device

c. Control sensors relay driver output

2.11 ELECTRIC POWER

2.11.1 Primary Power

Power shall be 120 VAC service for the FMCP from the AC service to the building in accordance with NFPA 72.

2.12 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 shall be automatic and shall not cause transmission of a false alarm.

2.12.1 Batteries

Provide sealed, maintenance-free, sealed lead acid batteries as the source for emergency power to the FMCP. Batteries shall contain suspended electrolyte. The battery system shall be maintained in a fully charged condition by means of a solid state battery charger. Provide an automatic transfer switch to transfer the load to the batteries in the event of the failure of primary power.

2.12.1.1 Capacity

Battery size shall be the greater of the following two capacities.

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.

2.12.1.2 Battery Power Calculations

a. Verify that battery capacity exceeds supervisory and alarm power requirements.

(1) Substantiate the battery calculations for alarm, alert, and supervisory power requirements. Include ampere-hour requirements for each system component and each panel component, and compliance with UL 864.

(2) Provide complete battery calculations for both the alarm, alert, and supervisory power requirements. Submit ampere-hour requirements for each system component with the calculations.

(3) A voltage drop calculation to indicate that sufficient voltage is available for proper operation of the system and all components, at the minimum rated voltage of the system operating on batteries.

b. For battery calculations use the following assumptions: 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. Calculate the nominal battery voltage after operation on batteries for the specified time period. Using this voltage perform a voltage drop calculation for circuit containing device and/or appliances remote from the power sources.

2.12.2 Battery Chargers

Provide a solid state, fully automatic, variable charging rate battery charger. The charger shall be capable of providing 120 percent of the connected system load and shall maintain the batteries at full charge. In the event the batteries are fully discharged (20.4 Volts dc), the charger shall 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.

2.13 FIRE ALARM CONTROL UNIT AND MASS NOTIFICATION CONTROL UNIT (FMCP)

Provide a complete control panel fully enclosed in a lockable steel cabinet as specified herein. Operations required for testing or for normal care and maintenance of the systems shall be performed from the front of the enclosure. If more than a single unit is required at a location to form a complete control panel, the unit cabinets shall match exactly. If more than a single unit is required, and is located in the lobby/entrance, notify the Contracting Offices Designated Representative (COR), prior to installing the equipment.

a. Each control unit shall provide power, supervision, control, and logic for the entire system, utilizing solid state, modular components, internally mounted and arranged for easy access. Each control unit shall be suitable for operation on a 120 volt, 60 hertz, normal building power supply. Provide each panel with supervisory functions for power failure, internal component placement, and operation.

b. Visual indication of alarm, supervisory, or trouble initiation on the fire alarm control panel shall be by liquid crystal display or similar means with a minimum of 80 characters. The mass notification control unit shall have the capability of temporarily deactivate the fire alarm audible notification appliances while delivering voice messages.

c. Provide secure operator console for initiating recorded messages, strobes and displays; and for delivering live voice messages. Provide capacity for at least eight pre-recorded messages. Provide the ability to automatically repeat pre-recorded messages. Provide a secure microphone for delivering live messages. Provide adequate discrete outputs to temporarily deactivate fire alarm audible notification, and initiate/synchronize strobes. 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.

2.13.1 Cabinet

Install control panel components in cabinets large enough to accommodate all components and also to allow ample gutter space for interconnection of panels as well as field wiring. The enclosure shall be identified by an engraved laminated phenolic resin nameplate. Lettering on the nameplate shall say "Fire Alarm and Mass Notification Control Panel" and shall not be less than 1 inch high. Provide prominent rigid plastic or metal identification plates for lamps, circuits, meters, fuses, and switches. The cabinet shall be provided in a sturdy steel housing, complete with back box, hinged steel door with cylinder lock, and surface mounting provisions.

2.13.2 Control Modules

Provide power and control modules to perform all functions of the FACP. Provide audible signals to indicate any alarm, supervisory, or trouble condition. The alarm signals shall be different from the trouble signal. Connect circuit conductors entering or leaving the panel to screw-type terminals with each terminal marked for identification. Locate diodes and resistors, if any, on screw terminals in the FACP. Circuits operating at 24 VDC shall not operate at less than the UL listed voltage at the sensor

or appliance connected. Circuits operating at any other voltage shall not have a voltage drop exceeding 10 percent of nominal voltage

2.13.3 Silencing Switches

2.13.3.1 Alarm Silencing Switch

Provide an alarm silencing switch at the FMCP that shall silence the audible and visual. This switch shall be overridden upon activation of a subsequent alarm.

2.13.3.2 Supervisory/Trouble Silencing Switch

Provide supervisory and trouble silencing switch that shall silence the audible trouble and supervisory signal, but not extinguish the visual indicator. This switch shall be overridden upon activation of a subsequent alarm, supervision, or trouble condition. Audible trouble indication must resound automatically every 24 hours after the silencing feature has been operated.

2.13.4 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. Circuits shall be manually reset by switch from the FACP after the initiating device or devices have been restored to normal.

2.13.5 Audible Notification System

The Audible Notification System shall comply with the requirements of NFPA 72 for Emergency Voice/Alarm Communications System requirements ISO 7240-16, IEC 60268-16, except as specified herein. The system shall be a two-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 prerecorded messages. Audible appliances shall produce a temporal code 3 tone for three cycles followed by a voice message that is repeated until the control panel is reset or silenced. Automatic messages shall be broadcast through speakers throughout the building/facility but not in stairs or elevator cabs. A live voice message shall override the automatic audible output through use of a microphone input at the control panel or the LOC.

a. When using the microphone, live messages shall be broadcast throughout a selected floor or floors or all call The system shall be capable of operating all speakers at the same time. The microprocessor shall 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 shall automatically cause the code 3 temporal tone to take over all functions assigned to the failed unit in the event an alarm is activated.

b. The Mass Notification functions shall override the manual or automatic fire alarm notification or Public Address (PA) functions. Other fire alarm functions including transmission of a signal(s) to the fire department shall remain operational. The system shall have the capability of utilizing LOC with redundant controls of the

notification system control panel. Notification Appliance Circuits (NAC) shall be provided for the activation of strobe appliances. The activation of the NAC Circuits shall follow the operation of the speaker NAC circuits. Audio output shall be selectable for line level. Amplifier outputs shall be not greater than 100 watts RMS output. The strobe NAC Circuits shall provide at least 2 amps of 24 VDC power to operate strobes and have the ability to synchronize all strobes. A hand held microphone shall be provided and, upon activation, shall take priority over any tone signal, recorded message or PA microphone operation in progress, while maintaining the strobe NAC Circuits activation.

2.13.5.1 Outputs and Operational Modules

All outputs and operational modules shall 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 panel shall not generate nor cause any trouble alarms to be generated with the Fire Alarm system.

2.13.5.2 Mass Notification

a. Mass Notification functions shall take precedence over all other function performed by the Audible Notification System. Messages shall utilize a female voice and shall be similar to the following:

(1) 1000 Hz tones (as required in 18.4.2.1 of NFPA 72)

(2) "May I have your attention please. May I have your attention please. An fire emergency has been reported in the building. Please leave the building by the nearest exit or exit stairway. Do not use the elevators." (Provide a 2 second pause.) "May I have your attention please, (repeat the message)."

Coordinate messages with Contracting Officer prior to shop drawing submital.

b. Installation specific messages:

(1) Do not use main exits: "ATTENTION FOR AN EMERGENCY MESSAGE! AN EMERGENCY HAS BEEN REPORTED. EVACUATE THE BUILDING USING ALTERNATE EXITS. DO NOT USE THE MAIN ENTRANCEWAY TO EXIT. ALL OCCUPANTS EVACUATE THE BUILDING IMMEDIATELY."

(2) Tornado Warning: "ATTENTION FOR AN EMERGENCY MESSAGE! A TORNADO WARNING HAS BEEN ISSUED FOR THIS AREA! SEEK SHELTER IN AN INTERIOR ROOM OR HALLWAY ON THE LOWEST LEVEL AND AWAY FROM EXTERIOR WINDOWS. GET UNDER A PIECE OF STURDY FURNITURE."

(3) Severe Weather: "ATTENTION FOR AN EMERGENCY MESSAGE! THE NATIONAL WEATHER SERVICE HAS ISSUED A SEVERE THUNDERSTORM WARNING FOR OUR AREA. THIS STORM MAY PRODUCE LARGE HAIL, HIGH WINDS OR DANGEROUS LIGHTNING. TUNE IN TO A LOCAL WEATHER STATION FOR MORE INFORMATION."

(4) Bomb Threat: "ATTENTION FOR AN EMERGENCY MESSAGE! A BOMB THREAT ALERT HAS BEEN ISSUED FOR THIS BUILDING. ALL PERSONNEL ARE TO EVACUATE IMMEDIATELY USING THE NEAREST EXIT. FURTHER INSTRUCTIONS

WILL BE ISSUED OUTSIDE THE BUILDING BY EMERGENCY RESPONSE TEAMS."

(5) Hazardous Material: "ATTENTION FOR AN EMERGENCY MESSAGE! A HAZARDOUS MATERIAL DANGER EXISTS IN THE AREA. REMAIN IN THE BUILDING. KEEP ALL DOORS AND WINDOWS CLOSED AND ACTIVATE YOUR EMERGENCY HVAC SHUT DOWN BUTTON. PLEASE WAIT FOR FURTHER INSTRUCTIONS FROM EMERGENCY SERVICES."

(6) Shelter In Place: "ATTENTION FOR AN EMERGENCY MESSAGE! A FORCE PROTECTION ANTITERRORISM THREAT HAS BEEN ISSUED FOR THIS AREA. EFFECTIVE IMMEDIATELY, WE ARE OPERATING, 'SECURE AND LOCKDOWN PROCEDURES.' ALL PERSONNEL SHOULD REMAIN CALM AND PROCEED TO A ROOM THAT CAN BE SECURED. PLEASE WAIT FOR FURTHER INSTRUCTIONS."

(7) All Clear: "ATTENTION FOR AN EMERGENCY MESSAGE! THE BUILDING EMERGENCY CONDITION HAS BEEN CLEARED. YOU MAY RETURN TO YOUR NORMAL ACTIVITIES."

(8) Test: "ATTENTION! THIS IS A TEST OF THE EMERGENCY MASS NOTIFICATION SYSTEM. THIS IS ONLY A TEST."

c. The LOC shall incorporate a Push-To-Talk (PTT) microphone, redundant controls and system status indicators of/for the system. The unit shall incorporate microphone override of any tone generation or prerecorded messages. The unit shall be fully supervised from the control panel. The housing shall contain a latch (not lock).

d. Auxiliary Input Module shall be designed to be an outboard expansion module to either expand the number of optional LOC's, or allow a telephone interface.

e. LOC shall incorporate a Push-To-Talk (PTT) microphone, and controls to allow Public Address paging in the facility. The Public Address paging function shall not override any alarm or notification functions and shall be disabled by such signals. The microphone shall be handheld style. All wiring to the LOC shall be supervised in accordance with UFC 4-021-01. Systems that require field modification or are not supervised for multiple LOC's shall not be approved.

f. When an installation has more than one LOC, the LOC's shall be programmed to allow only one LOC to be available for page 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. Also, it must be possible to override or lockout the LOC's from the Master Command Panel (in accordance with NFPA 72.)

2.13.6 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 shall not be considered as equal to non-volatile processors, PROMS, or EPROMS.

2.13.7 Field Programmability

Provide control units and control panels that are fully field programmable for control, initiation, notification, supervisory, and trouble functions of both input and output. The system program configuration shall be menu

driven. System changes shall be password protected and shall be accomplished using personal computer based equipment. Any proprietary equipment and proprietary software needed by qualified technicians to implement future changes to the fire alarm system shall be provided as part of this contract.

2.13.8 Input/Output Modifications

The FMCP shall contain features that allow the bypassing of input devices from the system or the modification of system outputs. These control features shall consist of a panel mounted keypad. Any bypass or modification to the system shall indicate a trouble condition on the FMCP.

2.13.9 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.

2.13.10 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 FACP. The card shall 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 shall be approved by the Contracting Officer before being posted.

2.13.11 Walk Test

The FACP shall have a walk test feature. When using this feature, operation of initiating devices shall result in limited system outputs, so that the notification appliances operate for only a few seconds and the event is indicated on the system printer, but no other outputs occur.

2.13.12 History Logging

In addition to the required printer output, the control panel shall have the ability to store a minimum of 400 events in a log. These events shall be stored in a battery-protected memory and shall remain in the memory until the memory is downloaded or cleared manually. Resetting of the control panel shall not clear the memory.

2.13.13 Remote LCD Text Display

An LCD text display shall be provided at locations as shown on the drawings. The size shall not exceed 16 inches length by 3 inches deep with a height necessary to meet the requirements of Chapter 24 of NFPA 72). The text display shall as a minimum meet the following requirements:

a. Two lines of information for high priority messaging.

b. Minimum of 20 characters per line (40 total) displayed.

c. Text shall be no less than height requirements in Table 24.4.2.20.14.5 of NFPA 72 and color/contrast requirements of 24.4.2.20 of NFPA 72.

d. 32K character memory.

e. Display shall be wall or ceiling mounted.

f. Mounting brackets for a convenient wall/cubicle mount.

g. During non-emergency periods, display date and time.

h. All programming shall be accomplished from the Mass Notification network. No user programming shall be required.

An LCD text display shall be provided at locations as shown on the drawings. The LCD text display shall spell out the words "EVACUATE" and "ANNOUNCEMENT" and the remainder of the emergency instructions. The design of LCD text display shall be such that it cannot be read when not illuminated.

2.14 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 shall be housed in a remote FMCP, terminal cabinet, or in the FMCP. Submit data to indicate that the amplifiers have sufficient capacity to simultaneously drive all notification speakers at the maximum rating plus 50 percent spare capacity. Annotate data for each circuit on the drawings.

2.14.1 Operation

The system shall 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 shall operate only when the microphone is used to deliver live messages.

2.14.2 Construction

Amplifiers shall utilize computer grade solid state components and shall 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.

2.14.3 Inputs

Equip each system with separate inputs for the tone generator, digitalized voice driver and panel mounted microphone. Microphone inputs shall be of the low impedance, balanced line type. Both microphone and tone generator input shall be operational on any amplifier.

2.14.4 Tone Generator

The tone generator shall be of the modular, plug-in type with securely attached labels to identify the component as a tone generator and to identify the specific tone it produces. The tone generator shall produce a code 3 temporal tone and shall be constantly repeated until interrupted by either the digitalized voice message, the microphone input, or the alarm silence mode as specified. The tone generator shall 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.

2.14.5 Protection Circuits

Each amplifier shall be constantly supervised for any condition that could render the amplifier inoperable at its maximum output. Failure of any component shall cause automatic transfer to a designated backup amplifier, illumination of a visual "amplifier trouble" indicator on the control panel, appropriate logging of the condition on the system printer, and other actions for trouble conditions as specified.

2.15 LCD, LED DISPLAY UNIT (VDU)

a. The VDU shall be the secondary operator-to-system interface for data retrieval, alarm annunciation, commands, and programming functions. The desk mounted VDU shall consist of a LCD monitor and a keyboard. The VDU shall have a 17 inch minimum screen, capable of displaying 25 lines of 80 characters each. Communications with the FACP shall be supervised. Faults shall be recorded on the printer. Power required shall be 120 VAC, 60 Hz from the same source as the fire alarm control panel.

b. To eliminate confusion during an alarm situation, the screen shall have dedicated areas for the following functions:

(1) Alarm and returns to normal

(2) Commands, reports, and programming

(3) Time, day, and date

c. Use Full English language throughout to describe system activity and instructions. Full English language descriptors defining system points shall be 100 percent field programmable by factory trained personnel, alterable and user definable to accurately describe building areas.

d. Alarms and other changes of status shall be displayed in the screen area reserved for this information. Upon receipt of alarm, an audible alarm shall sound and the condition and point type shall flash until acknowledged by the operator. Returns to normal shall also be annunciated and shall require operator acknowledgment. The following information shall be provided in English:

(1) Condition of device (alarm, trouble, or supervisory).

(2) Type of device (manual pull, waterflow, etc.)

(3) Location of device plus numerical system address.

e. The system shall have multiple levels of priority for displaying alarms to conform with UL 864. Priority levels shall be as follows:

(1) Level 1 - Mass Notification

(2) Level 2 - Fire Alarms

(3) Level 3 - Supervisory Alarms

(4) Level 4 - Trouble Signals

f. Provide the system with memory so that no alarm is lost. A highlighted message shall advise the operator when unacknowledged alarms are in the system.

g. Multiple levels of access shall be provided for operators and supervisors via user-defined passwords. Provide the following functions for each level:

(1) Operator level access functions:

(a) Display system directory, definable by device.

(b) Display status of an individual device.

(c) Manual command (alarm device with an associated command shall use the same system address for both functions).

(d) Report generation, definable by device, output on either the VDU or printer, as desired by the operator.

(e) Activate building notification appliances.

(2) Supervisory level access functions:

(a) Reset time and date.

(b) Enable or disable event initiated programs, printouts, and initiators.

(c) Enable or disable individual devices and system components.

h. The above supervisory level functions shall not require computer programming skills. Changes to system programs shall be recorded on the printer and maintained in the control panel as a trouble condition.

2.16 ANNUNCIATOR

2.16.1 Annunciator Panel

Provide an annunciator that includes an LCD display. The display shall indicate the device in trouble/alarm or any supervisory device. Display the device name, address, and actual building location.

A building floor plan shall be provided mounted (behind plexiglass or similar protective material) at the annunciator location. The floor plan shall indicate all rooms by name and number including the locations of stairs and elevators. The floor plan shall show all devices and their programmed address to facilitate their physical location from the LCD display information.

2.16.2 Programming

Where programming for the operation of the annunciator is accomplished by a separate software program than the software for the FMCP, the software program shall not require reprogramming after loss of power. The software shall be reprogrammable in the field.

2.17 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 shall 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 shall be finished in fire-engine red with molded raised lettering operating instructions of contrasting color. The use of a key or wrench shall be required to reset the station. Manual stations shall be mounted at 44 inches. Stations shall have a separate screw terminal for each conductor.

2.18 NOTIFICATION APPLIANCES

2.18.1 Fire Alarm/Mass Notification Speakers

Audible appliances shall conform to the applicable requirements of UL 464. Appliances shall be connected into notification appliance circuits. Surface mounted audible appliances shall be painted red. Recessed audible appliances shall be installed with a grill that is painted red.

a. Speakers shall conform to the applicable requirements of UL 1480. Speakers shall 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. Tap settings shall include taps of 1/8, 1/4, 1/2, 1, and 2 watt. Speakers shall incorporate a high efficiency speaker for maximum output at minimum power across a frequency range of 150 Hz to 10,000 Hz, and shall have a sealed back construction. Speakers shall be capable of installation on standard 4 inch square electrical boxes. Where speakers and strobes are provided in the same location, they may be combined into a single unit. All inputs shall be polarized for compatibility with standard reverse polarity supervision of circuit wiring via the FMCP.

b. Provide speaker mounting plates constructed of cold rolled steel having a minimum thickness of 16 gauge or molded high impact plastic and equipped with mounting holes and other openings as needed for a complete installation. Fabrication marks and holes shall be ground and finished to provide a smooth and neat appearance for each plate. Each plate shall be primed and painted.

c. Speakers shall utilize screw terminals for termination of all field wiring.

2.18.2 Visual Notification Appliances

Visual notification appliances shall conform to the applicable requirements of UL 1971 and conform to the Architectural Barriers Act (ABA). Notification Appliances shall have clear high intensity optic lens, xenon flash tubes, and be marked "Alert". The light pattern shall be disbursed 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 shall be 1 flash per second and a minimum of 15 candela (actual output after derating for tinted lens) based on the UL 1971 test. Strobe shall be surface or semi-flush mounted. Where more than two appliances are located in the same room or corridor or field of view, provide synchronized operation. Devices shall use screw terminals for all field wiring.

2.19 ENVIRONMENTAL ENCLOSURES OR GUARDS

Environmental enclosures shall be provided to permit Fire Alarm or Mass Notification components to be used in areas that exceed the environmental limits of the listing. The enclosure shall be listed for the device or appliance as either a manufactured part number or as a listed compatible accessory for the UL category that the component is currently listed. Guards required to deter mechanical damage shall be either a listed manufactured part or a listed accessory for the category of the initiating device or notification appliance.

2.20 INTERFACE TO THE BASE WIDE MASS NOTIFICATION NETWORK

2.20.1 Radio

The radio transceiver shall 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 shall 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 shall transmits a unique identity code as part of all messages; the code is set by the user at the transceiver.

2.20.1.1 Radio Frequency Communications

Use of radio frequency-type communications systems shall comply with National Telecommunications and Information Administration (NTIA) requirements.

2.20.1.2 Licensed Radio Frequency Systems

An approved DD Form 1494 for the system is required prior to operation.

2.21 AUTOMATIC FIRE TRANSMITTERS

2.21.1 Radio Transmitter and Interface Panels

If selected, transmitters shall be compatible with proprietary supervising station receiving equipment. Each radio alarm transmitter shall be the manufacturer's recognized commercial product, completely assembled, wired, factory tested, and delivered ready for installation and operation. Transmitters shall be provided in accordance with applicable portions of NFPA 72, Federal Communications Commission (FCC) 47 CFR 90 and Federal Communications Commission (FCC) 47 CFR 15. Transmitter electronics module shall be contained within the physical housing as an integral, removable assembly. The proprietary supervising station receiving equipment is Monaco D21 and the transceiver shall be fully compatible with this equipment. At the contractors option, and if UL or FM listed, the transmitter may be housed in the same panel as the fire alarm control panel. The transmitter shall be Narrowband radio, with FCC certification for narrowband operation and meets the requirements of the NTIA (National

Telecommunications and Information Administration) Manual of Regulations and Procedures for Federal Frequency Management.

2.21.1.1 Operation

Operate each transmitter from 120-volt ac power. In the event of 120-volt ac power loss, the transmitter shall automatically switch to battery operation. Switchover shall be accomplished with no interruption of protective service, and shall automatically transmit a trouble message. Upon restoration of ac power, transfer back to normal ac power supply shall also be automatic.

2.21.1.2 Battery Power

Transmitter standby battery capacity shall 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.

2.21.1.3 Transmitter Housing

Use NEMA Type 1 for housing. The housing shall contain a lock that is keyed identical to radio alarm transmitter housings on the base. Radio alarm transmitter housing shall be factory painted with a suitable priming coat and not less than two coats of a hard, durable weatherproof enamel.

2.21.1.4 Antenna

Antenna shall be omnidirectional, coaxial, halfwave dipole antennas for radio alarm transmitters with a driving point impedance to match transmitter output. The antenna and antenna mounts shall 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.

2.21.2 Digital Alarm Communicator Transmitter (DACT)

If selected, provide DACT that is compatible with the existing supervising station fire alarm system (Honeywell EBI). Transmitter shall have a means to transmit alarm, supervisory, and trouble conditions via a single transmitter. Transmitter shall have a source of power for operation that conforms to NFPA 72. Transmitter shall be capable of initiating a test signal daily at any selected time. Transmitter shall be arranged to seize telephone circuits in accordance with NFPA 72.

2.22 WIRING

Provide wiring materials under this section as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM with the additions and modifications specified herein. NFPA 70 accepted fire alarm cables that do not require the use of raceways except as modified herein are permitted.

2.22.1 Alarm Wiring

The SLC wiring shall be solid copper cable in accordance with the manufacturers requirements. Copper signaling line circuits and initiating device circuit field wiring shall be No. 18 AWG size twisted and shielded solid conductors at a minimum. Visual notification appliance circuit conductors, that contain audible alarm appliances, shall be solid copper No. 14 AWG size conductors at a minimum. Speaker circuits shall be copper

No. 16 AWG size twisted and shielded conductors at a minimum. Wire size shall be sufficient to prevent voltage drop problems. Circuits operating at 24 VDC shall not operate at less than the UL listed voltages for the sensors and/or appliances. Power wiring, operating at 120 VAC minimum, shall 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 shall comply with NFPA 70.

PART 3 EXECUTION

3.1 INSTALLATION OF FIRE ALARM INITIATING DEVICES AND NOTIFICATION APPLIANCES

3.1.1 FMCP

Locate the FMCP 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 shall be labeled and a drawing containing conductors, their labels, their circuits, and their interconnection shall be permanently mounted in the FMCP.

3.1.2 Manual Stations:

Locate manual stations as required by NFPA 72 and as indicated on the drawings. Mount stations so that their operating handles are 4 feet above the finished floor. Mount stations so they are located no farther than 5 feet from the exit door they serve, measured horizontally.

3.1.3 Notification Appliance Devices

Locate notification appliance devices as required by NFPA 72 and where indicated. Mount assemblies on walls as required by NFPA 72 and to meet the intelligibility requirements. Ceiling mounted speakers shall conform to NFPA 72.

3.1.4 Smoke and Heat Sensors

Locate sensors as required by NFPA 72 and their listings and as indicated on a 4 inch mounting box. Locate smoke and heat sensors on the ceiling. Install heat sensors not less than 4 inches from a side wall to the near edge. Heat sensors located on the wall shall have the top of the sensor at least 4 inches below the ceiling, but not more than 12 inches below the ceiling. Smoke sensors are permitted to be on the wall no lower than 12 inches from the ceiling with no minimum distance from the ceiling. In raised floor spaces, install the smoke sensors to protect 225 square feet per sensor. Install smoke sensors no closer than 5 feet from air handling supply outlets.

3.1.5 Annunciator

Locate the annunciator as shown on the drawings. Flush mount the panel, with the top of the panel 6 feet above the finished floor or center the panel at 5 feet, whichever is lower.

3.1.6 Water Flow Detectors and Tamper Switches

Connect to water flow detectors and tamper switches.

3.1.7 Local Operating Console (LOC)

Locate the LOC as required by NFPA 72 and as indicated. Mount the console so that the top message button is no higher than 44 inches above the floor.

3.2 SYSTEM FIELD WIRING

3.2.1 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 shall 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. Conform wiring to 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 shall show connections from field devices to the FACP and remote fire alarm 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.

3.2.2 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 shall be appropriate for the size of the wiring to be connected. Conductor terminations shall be labeled and a drawing containing conductors, their labels, their circuits, and their interconnection shall be permanently mounted in the terminal cabinet. Minimum size is 8 inches by 8 inches. Only screw-type terminals are permitted.

3.2.3 Alarm Wiring

Voltages shall not be mixed in any junction box, housing, or device, except those containing power supplies and control relays.

Use of cables that do not require a raceway as stated hereinbefore are permitted; install them in accordance with NFPA 70. Protect any exposed (as defined in NFPA 70) cables against physical damage by the use of magnetic raceways which shall also be red colored. Utilize shielded wiring where recommended by the manufacturer. For shielded wiring, ground the shield at only one point, that is in or adjacent to the FMCP. Pigtail or T-tap connections to signal line circuits, initiating device circuits, supervisory alarm circuits, and notification appliance circuits are prohibited. Color coding is required for circuits and shall be maintained throughout the circuit. Conductors used for the same functions shall be similarly color coded. Conform wiring to NFPA 70.

3.2.4 Conductor Terminations

Labeling of conductors at terminal blocks in terminal cabinets, FMCP, and remote FMCP and the LOC shall be provided at each conductor connection. Each conductor or cable shall have a shrink-wrap label to provide a unique and specific designation. Each terminal cabinet, FMCP, and remote FMCP shall contain a laminated drawing that indicates each conductor, its label, circuit, and terminal. The laminated drawing shall be neat, using 12 point lettering minimum size, and mounted within each cabinet, panel, or unit so that it does not interfere with the wiring or terminals. Maintain existing color code scheme where connecting to existing equipment.

3.3 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.

3.4 PAINTING

Paint exposed electrical, fire alarm conduit, and surface metal raceway to match adjacent finishes in exposed areas. Paint junction boxes red in unfinished areas and conduits and surface metal raceways shall be painted with a 1-inch wide red band every 10 feet in unfinished areas.. Painting shall comply with Section 09 90 00 PAINTS AND COATINGS.

3.5 FIELD QUALITY CONTROL

3.5.1 Testing Procedures

Submit detailed test procedures, prepared and signed by a Registered Professional Engineer or a NICET Level 4 Fire Alarm Technician, and signed by representative of the installing company, for the fire detection and alarm system 60 days prior to performing system tests. Detailed test procedures shall 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, Guard's Tour equipment, and transient (surge) suppressors. Test procedures shall include sequence of testing, time estimate for each test, and sample test data forms. The test data forms shall be in a check-off format (pass/fail with space to add applicable test data; similar to the forma in NFPA 72) and shall be used for the preliminary testing and the acceptance testing. The test data forms shall record the test results and shall:

a. Identify the NFPA Class of all Initiating Device Circuits (IDC), 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 this test shall 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 testing smoke detectors using real smoke).

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.

3.5.2 Tests Stages

3.5.2.1 Preliminary Testing

Conduct preliminary tests to ensure that devices and circuits are functioning properly. Tests shall meet the requirements of paragraph entitled "Minimum System Tests." After preliminary testing is complete, provide a letter certifying that the installation is complete and fully operable. The letter shall state that each initiating and indicating device was tested in place and functioned properly. The letter shall also state that panel functions were tested and operated properly. The letter shall include the names and titles of the witnesses to the preliminary tests. The Contractor and an authorized representative from each supplier of equipment shall be in attendance at the preliminary testing to make necessary adjustments.

3.5.2.2 Request for Formal Inspection and Tests

When tests have been completed and corrections made, submit a signed, dated certificate with a request for formal inspection and tests to the Contracting Offices Designated Representative (COR).

3.5.2.3 Final Testing

Notify the Contracting Officer in writing when the system is ready for final acceptance testing. Submit request for test at least 15 calendar days prior to the test date. The tests shall be performed in accordance with the approved test procedures in the presence of the Contracting Officer. Furnish instruments and personnel required for the tests. A final acceptance test will not be scheduled until the following are provided at the job site:

a. The systems manufacturer's technical representative

b. Marked-up red line drawings of the system as actually installed

c. Megger test results

d. Loop resistance test results

e. Complete program printout including input/output addresses

The final tests will be witnessed by the Contracting Offices Designated Representative (COR). At this time, any and all required tests shall be repeated at their discretion.

3.5.2.4 System Acceptance

Following acceptance of the system, as-built drawings and O&M manuals

shall be delivered to the Contracting Officer for review and acceptance. Submit six sets of detailed as-built drawings. The drawings shall show the system as installed, including deviations from both the project drawings and the approved shop drawings. These drawings shall be submitted within two weeks after the final acceptance test of the system. At least one set of as-built (marked-up) drawings shall be provided at the time of, or prior to the final acceptance test.

a. Furnish one set of full size paper as-built drawings and schematics. The drawings shall be prepared on uniform sized mylar sheets not less than 22 by 34 inches similar to contract drawings. Furnish one set of CD or DVD discs containing software back-up and CAD based drawings in latest version of AutoCAD and DXF format of as-built drawings and schematics.

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.

3.5.3 Minimum System Tests

Test the system in accordance with the procedures outlined in NFPA 72, ISO 7240-16, IEC 60268-16. The required tests are as follows:

a. Megger Tests: After wiring has been installed, and prior to making any connections to panels or devices, wiring shall be megger tested for insulation resistance, grounds, and/or shorts. Conductors with 300 volt rated insulation shall be tested at a minimum of 250 VDC. Conductors with 600 volt rated insulation shall be tested at a minimum of 500 VDC. The tests shall be witnessed by the Contracting Officer and test results recorded for use at the final acceptance test.

b. 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 shall be witnessed by the Contracting Officer and test results recorded for use at the final acceptance test.

c. Verify the absence of unwanted voltages between circuit conductors and ground. The tests shall be accomplished at the preliminary test with results available at the final system test.

d. Verify that the control unit is in the normal condition as detailed in the manufacturer's O&M manual.

e. Test each initiating device and notification appliance and circuit for proper operation and response at the control unit. Smoke sensors shall be tested in accordance with manufacturer's recommended calibrated test method. Use of magnets is prohibited. Testing of duct smoke detectors shall comply with the requirements of NFPA 72 except that, for item 12(e) (Supervision) in Table 14.4.2.2, disconnect at least 20 percent of devices. If there is a failure at these devices, then supervision shall be tested at each device.

f. Test the system for specified functions in accordance with the contract drawings and specifications and the manufacturer's O&M manual.

g. 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.

h. Determine that the system is operable under trouble conditions as specified.

i. Visually inspect wiring.

j. Test the battery charger and batteries.

k. Verify that software control and data files have been entered or programmed into the FACP. Hard copy records of the software shall be provided to the Contracting Officer.

l. Verify that red-line drawings are accurate.

m. Measure the current in circuits to ensure there is the calculated spare capacity for the circuits.

n. Measure voltage readings for circuits to ensure that voltage drop is not excessive.

o. Disconnect the verification feature for smoke sensors during tests to minimize the amount of smoke needed to activate the sensor. Testing of smoke sensors shall be conducted using real smoke or the use of canned smoke which is permitted.

p. Measure the voltage drop at the most remote appliance (based on wire length) on each notification appliance circuit.

3.5.3.1 Intelligibility Tests

Intelligibility testing of the System shall be accomplished in accordance with NFPA 72 for Voice Evacuation Systems, IEC 60268-16, 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.

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 DOD installation, 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, as appropriate).

f. The distance the occupant must walk to the location meeting the minimum required CIS value shall 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 ISO 7240-19 and ISO 7240-16 as applicable. Use the mean value of at least three readings to compute the intelligibility score at each test location.

3.6 INSTRUCTION OF GOVERNMENT EMPLOYEES

3.6.1 Instructor

Include in the project the services of an instructor, who has received specific training from the manufacturer for the training of other persons regarding the inspection, testing, and maintenance of the system provided. The instructor shall train the Government employees designated by the Contracting Officer, in the care, adjustment, maintenance, and operation of the fire alarm and fire detection system. Each instructor shall be thoroughly familiar with all parts of this installation. The instructor shall be trained in operating theory as well as in practical O&M work. Submit the instructors information and qualifications including the training history.

3.6.2 Required Instruction Time

Provide 8 hours of instruction after final acceptance of the system. The instruction shall be given during regular working hours on such dates and times as are selected by the Contracting Officer. The instruction may be divided into two or more periods at the discretion of the Contracting Officer. The training shall allow for rescheduling for unforeseen maintenance and/or fire department responses.

3.6.2.1 Technical Training

Equipment manufacturer or a factory representative shall provide 1 days of on site. Training shall allow for classroom instruction as well as individual hands on programming, troubleshooting and diagnostics exercises. Training shall occur within 6 months of system acceptance.

3.7 Technical Data and Computer Software

Provide, in manual format, lesson plans, operating instructions, maintenance procedures, and training data for the training courses. The operations training shall familiarize designated government personnel with proper operation of the installed system. The maintenance training course

shall provide the designated government personnel adequate knowledge required to diagnose, repair, maintain, and expand functions inherent to the system.

3.8 OPERATION AND MAINTENANCE (O&M) INSTRUCTIONS

Submit 6 copies of the Operation and Maintenance Instructions, indexed and in booklet form. The Operation and Maintenance Instructions shall be a single volume or in separate volumes, and may be submitted as a Technical Data Package. Manuals shall be approved prior to training. The Interior Fire Alarm And Mass Notification System Operation and Maintenance Instructions shall include:

a. "Manufacturer Data Package 5" 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 shall include the manufacturer's name, model number, service manual, parts list, and complete description of equipment and their basic operating features.

c. Maintenance manual listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guide. The manuals shall include conduit layout, equipment layout and simplified wiring, and control diagrams of the system as installed.

d. The manuals shall include complete procedures for system revision and expansion, detailing both equipment and software requirements.

e. Software delivered for this project shall be provided, on each type of CD/DVD media utilized.

f. Printouts of configuration settings for all devices.

g. Routine maintenance checklist. The routine maintenance checklist shall be arranged in a columnar format. The first column shall list all installed devices, the second column shall state the maintenance activity or state no maintenance required, the third column shall state the frequency of the maintenance activity, and the fourth column for additional comments or reference. All data (devices, testing frequencies, etc.) shall comply with UFC 3-601-02.

3.9 EXTRA MATERIALS

3.9.1 Repair Service/Replacement Parts

Repair services and replacement parts for the system shall be available for a period of 10 years after the date of final acceptance of this work by the Contracting Officer. During guarantee period, the service technician shall be on-site within 24 hours after notification. All repairs shall be completed within 24 hours of arrival on-site.

3.9.2 Interchangeable Parts

Spare parts furnished shall be directly interchangeable with the corresponding components of the installed system. Spare parts shall be suitably packaged and identified by nameplate, tagging, or stamping. Spare parts shall be delivered to the Contracting Officer at the time of the final acceptance testing.

3.9.3 Spare Parts

Furnish the following spare parts and accessories:

a. Two fuses for each fused circuit

b. Two of each type of notification appliance in the system (e.g. speaker, FA strobe, MNS strobe, etc.)

c. Two of each type of initiating device included in the system (e.g. smoke detector, thermal detector, manual station, etc.)

3.9.4 Special Tools

Software, connecting cables and proprietary equipment, necessary for the maintenance, testing, and reprogramming of the equipment shall be furnished to the Contracting Officer.

-- End of Section --

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DIVISION 31 - EARTHWORK

SECTION 31 00 00

EARTHWORK

08/08

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SECTION 31 00 00

EARTHWORK
08/08

PART 1 GENERAL

1.1 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.

e. Material character is indicated by the boring logs.

f. Hard materials and rock is not expected to be encountered.

1.2 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
AASHTO T 224	(2010) Standard Method of Test for Correction for Coarse Particles in the Soil Compaction Test

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C600	(2017) Installation of Ductile-Iron Mains and Their Appurtenances

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2015; Errata 1 2015; Errata 2 2016) Structural Welding Code - Steel

ASTM INTERNATIONAL (ASTM)

ASTM A139/A139M	(2016) Standard Specification for

	Electric-Fusion (ARC)-Welded Steel Pipe (NPS 4 and over)
ASTM A252	(2010) Standard Specification for Welded and Seamless Steel Pipe Piles
ASTM C136/C136M	(2014) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C33/C33M	(2018) Standard Specification for Concrete Aggregates
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 D1883	(2016) Standard Test Method for California Bearing Ratio (CBR) of Laboratory-Compacted Soils
ASTM D2434	(1968; R 2006) Permeability of Granular Soils (Constant Head)
ASTM D2487	(2017) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D4318	(2017; E 2018) Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D6938	(2017a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM D698	(2012; E 2014; E 2015) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft. (600 kN-m/cu. m.))

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

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-203 (Rev C; Notice 3) Paper, Kraft, Untreated

1.3 DEFINITIONS

1.3.1 Satisfactory Materials

Satisfactory materials comprise any materials classified by ASTM D2487 as GW, GP, GM, GP-GM, GW-GM, GC, GP-GC, GM-GC, SW, SP, SM, SC, SP-SM, SP-SC, ML. Satisfactory materials for grading comprise stones less than 8 inches, except for fill material for pavements and railroads which comprise stones less than 3 inches in any dimension.

1.3.2 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; and material classified as satisfactory which contains root and other organic matter or frozen material. Notify the Contracting Officer when encountering any contaminated materials.

1.3.3 Cohesionless and Cohesive Materials

Cohesionless materials include materials classified in ASTM D2487 as GW, GP, SW, and SP. Cohesive materials include materials classified as GC, SC, ML, CL, MH, and CH. 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 C136/C136M and ASTM D1140.

1.3.4 Degree of Compaction

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 and corrected with AASHTO T 224. To maintain the same percentage of coarse material, use the "remove and replace" procedure as described in NOTE 8 of Paragraph 7.2 in AASHTO T 180.

1.3.5 Topsoil

Material suitable for topsoils obtained from offsite areas or 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. Amend topsoil pH range to obtain a pH of 5.5 to 7.

1.3.6 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.

1.3.7 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.

1.3.8 Unstable Material

Unstable materials are too wet to properly support the utility pipe, conduit, or appurtenant structure.

1.3.9 Select Granular Material

1.3.9.1 General Requirements

Select granular material consist of materials classified as GW, GP, SW, or SP by ASTM D2487 where indicated. The liquid limit of such material must not exceed 35 percent when tested in accordance with ASTM D4318. The plasticity index must not be greater than 10 percent when tested in accordance with ASTM D4318, and not more than 35 percent by weight may be finer than No. 200 sieve when tested in accordance with ASTM D1140. Provide a minimum coefficient of permeability of 0.002 feet per minute when tested in accordance with ASTM D2434.

1.3.9.2 California Bearing Ratio Values

Bearing Ratio: At 0.1 inch penetration, provide a CBR of 8 at 95 percent ASTM D1557 maximum density as determined in accordance with ASTM D1883 for a laboratory soaking period of not less than 4 days.

1.3.10 Initial Backfill Material

Initial backfill consists of select granular material or satisfactory materials free from rocks 3 inches or larger in any dimension or free from rocks of such size as recommended by the pipe manufacturer, whichever is smaller. When the pipe is coated or wrapped for corrosion protection, free the initial backfill material of stones larger than 1-1/2 inches in any dimension or as recommended by the pipe manufacturer, whichever is smaller.

1.3.11 Expansive Soils

Expansive soils are defined as soils that have a plasticity index equal to or greater than 30 when tested in accordance with ASTM D4318.

1.3.12 Nonfrost Susceptible (NFS) Material

Nonfrost susceptible material are a uniformly graded washed sand with a maximum particle size of 1 inch and less than 5 percent passing the No. 200 size sieve, and with not more than 3 percent by weight finer than 0.02 mm grain size.

1.3.13 Pile Supported Structure

As used herein, a structure where both the foundation and floor slab are pile supported.

1.4 SYSTEM DESCRIPTION

Subsurface soil boring logs are shown on the drawings. The subsoil investigation report and samples of materials taken from subsurface investigations may be obtained upon request through the Contracting Officer. These data represent the best subsurface information available; however, variations may exist in the subsurface between boring locations.

1.4.1 Classification of Excavation

No consideration will be given to the nature of the materials, and all excavation will be designated as unclassified excavation.

1.4.1.1 Common Excavation

Include common excavation with the satisfactory removal and disposal of all materials not classified as rock excavation.

1.4.1.2 Rock Excavation

Submit notification of encountering rock in the project. Include rock excavation with blasting, excavating, grading, disposing of material classified as rock, and the satisfactory removal and disposal of boulders 1/2 cubic yard or more in volume; solid rock; rock material that is in ledges, bedded deposits, and unstratified masses, which cannot be removed without systematic drilling and blasting; firmly cemented conglomerate deposits possessing the characteristics of solid rock impossible to remove without systematic drilling and blasting; and hard materials (see Definitions). Include the removal of any concrete or masonry structures, except pavements, exceeding 1/2 cubic yard in volume that may be encountered in the work in this classification. If at any time during excavation, the Contractor encounters material that may be classified as rock excavation, 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 and has taken cross sections as required. Failure on the part of the Contractor to uncover such material, notify the Contracting Officer, and allow ample time for classification and cross sectioning 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.

1.4.2 Blasting

Blasting will not be permitted.

1.4.3 Dewatering Work Plan

Submit procedures for accomplishing dewatering work.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Shoring; G
Dewatering Work Plan; G

SD-03 Product Data

Utilization of Excavated Materials; G
Rock Excavation
Opening of any Excavation or Borrow Pit
Shoulder Construction

SD-06 Test Reports

Testing

Borrow Site Testing

Within 24 hours of conclusion of physical tests, submit 2 copies of test results, including calibration curves and results of calibration tests.

SD-07 Certificates

Testing

PART 2 PRODUCTS

2.1 REQUIREMENTS FOR OFFSITE SOILS

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 shall contain a maximum of 100 parts per million (ppm) of total petroleum hydrocarbons (TPH) and a maximum of 10 ppm of the sum of Benzene, Toluene, Ethyl Benzene, and Xylene (BTEX) and shall pass the TCPL test. 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. Perform TCLP in accordance with EPA SW-846.3-3 Method 1311. Provide Borrow Site Testing for TPH, BTEX and TCLP from a composite sample of material from the borrow site, with at least one test from each borrow site. Do not bring material onsite until tests have been approved by the Contracting Officer.

2.2 BURIED WARNING AND IDENTIFICATION TAPE

Provide 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

2.2.1 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.

2.2.2 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 DETECTION WIRE FOR NON-METALLIC PIPING

Insulate a single strand, solid copper detection wire with a minimum of 12 AWG.

2.4 MATERIAL FOR RIP-RAP

Provide Bedding material, Grout, Filter fabric and rock conforming to NCDOT Standards for construction indicated.

2.4.1 Bedding Material

Provide bedding material consisting of sand, gravel, or crushed rock, well graded, with a maximum particle size of 2 inches. Compose material of tough, durable particles. Allow fines passing the No. 200 standard sieve with a plasticity index less than six.

2.4.2 Grout

Provide durable grout composed of cement, water, an air-entraining admixture, and sand mixed in proportions of one part portland cement to two parts of sand, sufficient water to produce a workable mixture, and an amount of admixture which will entrain sufficient air, as determined by the Contracting Officer. Mix grout in a concrete mixer. Allow a sufficient mixing time to produce a mixture having a consistency permitting gravity flow into the interstices of the rip-rap with limited spading and brooming.

2.4.3 Rock

Provide rock fragments sufficiently durable to ensure permanence in the structure and the environment in which it is to be used. Use rock fragments free from cracks, seams, and other defects that would increase the risk of deterioration from natural causes. Provide fragments sized so that no individual fragment exceeds a weight of 150 pounds and that no more than 10 percent of the mixture, by weight, consists of fragments weighing 2 pounds or less each. Provide rock with a minimum specific gravity of 2.50. Do not permit the inclusion of more than trace 1 percent quantities of dirt, sand, clay, and rock fines.

2.5 CAPILLARY WATER BARRIER

Provide capillary water barrier of clean, poorly graded crushed rock, crushed gravel, or uncrushed gravel placed beneath a building slab with or without a vapor barrier to cut off the capillary flow of pore water to the area immediately below. Conform to ASTM C33/C33M for fine aggregate grading with a maximum of 3 percent by weight passing ASTM D1140, No. 200 sieve, or 1-1/2 inch and no more than 2 percent by weight passing the No. 4 size sieve or coarse aggregate Size 57, 67, or 77.

2.6 PIPE CASING

2.6.1 Casing Pipe

ASTM A139/A139M, Grade B, or ASTM A252, Grade 2, smooth wall pipe. Match casing size to the outside diameter and wall thickness as indicated. Protective coating is not required on casing pipe.

PART 3 EXECUTION

3.1 STRIPPING OF TOPSOIL

Where indicated or directed, strip topsoil in its entirety. Spread topsoil on areas already graded and prepared for topsoil, or transported and deposited in stockpiles convenient to areas that are to receive application of the topsoil later, or at locations indicated or specified. 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.

3.2 GENERAL EXCAVATION

Perform excavation of every type of material encountered within the limits of the project to the lines, grades, and elevations indicated and as specified. Perform the grading in accordance with the typical sections shown and the tolerances specified in paragraph FINISHING. Transport satisfactory excavated materials and place in fill or embankment within the limits of the work. Excavate unsatisfactory materials encountered within the limits of the work below grade and replace with satisfactory materials as directed. Include such excavated material and the satisfactory material ordered as replacement in excavation. Dispose surplus satisfactory excavated material not required for fill or embankment in areas approved for surplus material storage or designated waste areas. Dispose unsatisfactory excavated material in designated waste or spoil areas. During construction, perform excavation and fill in a manner and sequence that will provide proper drainage at all times. Excavate material required for fill or embankment in excess of that produced by excavation within the grading limits or from other approved areas selected by the Contractor as specified.

3.2.1 Ditches, Gutters, and Channel Changes

Finish excavation of ditches, gutters, and channel changes by cutting accurately to the cross sections, grades, and elevations shown on Contract Drawings. Do not excavate ditches and gutters below grades shown. Backfill the excessive open ditch or gutter excavation with satisfactory, thoroughly compacted, material or with suitable stone or cobble to grades shown. Dispose excavated material as shown or as directed, except in no case allow material be deposited a maximum 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.

3.2.2 Drainage Structures

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. Do not disturb the bottom of the excavation when concrete or masonry is to be placed in an excavated area. Do not excavate to the final grade level until just before the concrete or masonry is to be placed. Where pile foundations are to be used, stop the excavation of each pit at an elevation 1 foot above the base of the footing, as specified, before piles are driven. After the pile driving has been completed, remove loose and displaced material and complete excavation, leaving a smooth, solid, undisturbed surface to receive the concrete or masonry.

3.2.3 Drainage

Provide for the collection and disposal of surface and subsurface water encountered during construction. Completely drain construction site during periods of construction to keep soil materials sufficiently dry. Construct storm drainage features (ponds/basins) at the earliest stages of site development, and throughout construction grade the construction area

to provide positive surface water runoff away from the construction activity and / or provide temporary ditches, swales, and other drainage features and equipment as required to maintain dry soils. When unsuitable working platforms for equipment operation and unsuitable soil support for subsequent construction features develop, remove unsuitable material and provide new soil material as specified herein. It is the responsibility of the Contractor to assess the soil and ground water conditions presented by the plans and specifications and to employ necessary measures to permit construction to proceed.

3.2.4 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. Do not permit French drains, sumps, ditches or trenches 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. Take 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. Operate dewatering system continuously until construction work below existing water levels is complete. Submit performance records weekly.

3.2.5 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 in the manufacturer's printed installation manual. Provide vertical trench walls where no manufacturer's printed installation manual is available. Shore trench walls more than 4 feet high, cut back to a stable slope, or provide with equivalent means of protection for employees who may be exposed to moving ground or cave in. Shore vertical trench walls more than 4 feet high. Excavate trench walls which are cut back to at least the angle of repose of the soil. Give special attention to slopes which may be adversely affected by weather or moisture content. Do not exceed the trench width below the pipe top of 24 inches 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 sizes larger than 24 inches inside diameter. Where recommended trench widths are exceeded, provide redesign, stronger pipe, or special installation procedures by the Contractor. The Contractor is responsible for the cost of redesign, stronger pipe, or special installation procedures without any additional cost to the Government.

3.2.5.1 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.

3.2.5.2 Removal of Unyielding Material

Where unyielding material is encountered in the bottom of the trench, remove such material 4 inches below the required grade and replaced with suitable materials as provided in paragraph BACKFILLING AND COMPACTION.

3.2.5.3 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 select granular material as provided in paragraph BACKFILLING 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.

3.2.5.4 Excavation for Appurtenances

Provide excavation for manholes, catch-basins, inlets, or similar structures sufficient to leave at least 12 inches clear between the outer structure surfaces and the face of the excavation or support members. Clean rock or loose debris and cut to a firm surface either level, stepped, or serrated, as shown or as directed. Remove loose disintegrated rock and thin strata. Specify removal of unstable material. When concrete or masonry is to be placed in an excavated area, take special care not to disturb the bottom of the excavation. Do not excavate to the final grade level until just before the concrete or masonry is to be placed.

3.2.5.5 Jacking, Boring, and Tunneling

Unless otherwise indicated, provide excavation by open cut except that sections of a trench may be jacked, bored, or tunneled if, in the opinion of the Contracting Officer, the pipe, cable, or duct can be safely and properly installed and backfill can be properly compacted in such sections.

3.2.6 Underground Utilities

The Contractor is responsible for movement of construction machinery and equipment over pipes and utilities during construction. Perform work adjacent to non-Government utilities as indicated in accordance with procedures outlined by utility company. Excavation made with power-driven equipment is not permitted within 2 feet of known Government-owned 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.

3.2.7 Structural Excavation

Ensure that footing subgrades have been inspected and approved by the Contracting Officer prior to concrete placement. Excavate to bottom of pile cap prior to placing or driving piles, unless authorized otherwise by the Contracting Officer. Backfill and compact over excavations and changes in grade due to pile driving operations to 95 percent of ASTM D698

maximum density.

3.3 SELECTION OF BORROW MATERIAL

Select borrow material to meet the requirements and conditions of the particular fill or embankment for which it is to be used. Obtain borrow material within the limits of the project site, selected by the Contractor or from approved private sources. Unless otherwise provided in the contract, the Contractor is responsible for obtaining the right to procure material, pay royalties and other charges involved, and bear the expense of developing the sources, including rights-of-way for hauling from the owners. Borrow material from approved sources on Government-controlled land may be obtained without payment of royalties. Unless specifically provided, do not obtain borrow within the limits of the project site without prior written approval. Consider necessary clearing, grubbing, and satisfactory drainage of borrow pits and the disposal of debris thereon related operations to the borrow excavation.

3.4 OPENING AND DRAINAGE OF EXCAVATION AND BORROW PITS

Notify the Contracting Officer sufficiently in advance of the opening of any excavation or borrow pit or borrow areas to permit elevations and measurements of the undisturbed ground surface to be taken. Except as otherwise permitted, excavate borrow pits and other excavation areas providing adequate drainage. Transport overburden and other spoil material to designated spoil areas or otherwise dispose of as directed. Provide neatly trimmed and drained borrow pits after the excavation is completed. Ensure that excavation of any area, operation of borrow pits, or dumping of spoil material results in minimum detrimental effects on natural environmental conditions.

3.5 SHORING

3.5.1 General Requirements

Submit a Shoring and Sheeting plan for approval 15 days prior to starting work. Submit drawings and calculations, certified by a registered professional engineer, describing the methods for shoring and sheeting of excavations. Finish shoring, including sheet piling, and install as necessary to protect workmen, banks, adjacent paving, structures, and utilities. Remove shoring, bracing, and sheeting as excavations are backfilled, in a manner to prevent caving.

3.5.2 Geotechnical Engineer

Hire a Professional Geotechnical Engineer to provide inspection of excavations and soil/groundwater conditions throughout construction. The Geotechnical Engineer is responsible for performing pre-construction and periodic site visits throughout construction to assess site conditions. The Geotechnical Engineer is responsible for updating the excavation, sheeting and dewatering plans as construction progresses to reflect changing conditions and submit an updated plan if necessary. Submit a monthly written report, informing the Contractor and Contracting Officer of the status of the plan and an accounting of the Contractor's adherence to the plan addressing any present or potential problems. The Contracting Officer is responsible for arranging meetings with the Geotechnical Engineer at any time throughout the contract duration.

3.6 GRADING AREAS

Where indicated, divide work into grading areas within which satisfactory excavated material will be placed in embankments, fills, and required backfills. Do not haul satisfactory material excavated in one grading area to another grading area except when so directed in writing. Place and grade stockpiles of satisfactory and unsatisfactory and wasted materials 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. If the Contractor fails to protect the stockpiles, and any material becomes unsatisfactory, remove and replace such material with satisfactory material from approved sources.

3.7 FINAL GRADE OF SURFACES TO SUPPORT CONCRETE

Do not excavate to final grade until just before concrete is to be placed. For pile foundations, stop the excavation at an elevation of from 6 to 12 inches above the bottom of the footing before driving piles. After pile driving has been completed, complete the remainder of the excavation to the elevations shown. Only use excavation methods that will leave the foundation rock in a solid and unshattered condition. Roughen the level surfaces, and cut the sloped surfaces, as indicated, into rough steps or benches to provide a satisfactory bond. Protect shales from slaking and all surfaces from erosion resulting from ponding or water flow.

3.8 GROUND SURFACE PREPARATION

3.8.1 General Requirements

Remove and replace unsatisfactory material with satisfactory materials, as directed by the Contracting Officer, in surfaces to receive fill or in excavated areas. Scarify the surface to a depth of 6 inches before the fill is started. Plow, step, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so that the fill material will bond with the existing material. When subgrades are less than the specified density, break up the ground surface to a minimum depth of 6 inches, pulverizing, and compacting to the specified density. When the subgrade is part fill and part excavation or natural ground, scarify the excavated or natural ground portion to a depth of 12 inches and compact it as specified for the adjacent fill.

3.8.2 Frozen Material

Do not place material on surfaces that are muddy, frozen, or contain frost.

3.9 UTILIZATION OF EXCAVATED MATERIALS

Dispose unsatisfactory materials removing from excavations into designated waste disposal or spoil areas. Use satisfactory material removed from excavations, insofar as practicable, in the construction of fills, embankments, subgrades, shoulders, bedding (as backfill), and for similar purposes. Submit procedure and location for disposal of unused satisfactory material. Submit proposed source of borrow material. Do not waste any satisfactory excavated material without specific written

authorization. Dispose of satisfactory material, authorized to be wasted, in designated areas approved for surplus material storage or designated waste areas as directed. Clear and grub newly designated waste areas on Government-controlled land before disposal of waste material thereon. Stockpile and use coarse rock from excavations for constructing slopes or embankments adjacent to streams, or sides and bottoms of channels and for protecting against erosion. Do not dispose excavated material to 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.

3.10 BURIED TAPE AND DETECTION WIRE

3.10.1 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.

3.10.2 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 it's 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.

3.11 BACKFILLING AND COMPACTION

Place backfill adjacent to any and all types of structures, in successive horizontal layers of loose materia not more than 8 inches in depth. Compact to at least 90 percent laboratory maximum density for cohesive materials or 95 percent laboratory maximum density for cohesionless materials, to prevent wedging action or eccentric loading upon or against the structure. Backfill material must be within the range of -2 to +2 percent of optimum moisture content at the time of 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 GROUND SURFACE PREPARATION. Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment.

3.11.1 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. Do not backfill the trench until all specified tests are performed.

3.11.1.1 Replacement of Unyielding Material

Replace unyielding material removed from the bottom of the trench with select granular material or initial backfill material.

3.11.1.2 Replacement of Unstable Material

Replace unstable material removed from the bottom of the trench or excavation with select granular material placed in layers not exceeding 6 inches loose thickness.

3.11.1.3 Bedding and Initial Backfill

Provide bedding of the type and thickness shown. 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 as specified otherwise in the individual piping section, provide bedding for buried piping in accordance with AWWA C600, Type 4, except as specified herein. Compact backfill to top of pipe to 95 percent of ASTM D698 maximum density. Provide plastic piping with bedding to spring line of pipe. Provide materials as follows:

3.11.1.3.1 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.

3.11.1.3.2 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.

3.11.1.3.3 Sand

Clean, coarse-grained sand in accordance with NCDOT Standard Section 1012-3.

3.11.1.3.4 Gravel and Crushed Stone

Clean, coarsely graded natural gravel, crushed stone or a combination thereof in accordance with NCDOT Standard Section 1005.

3.11.1.4 Final Backfill

Fill the remainder of the trench, except for special materials for roadways, railroads and airfields, with satisfactory material. Place backfill material and compact as follows:

3.11.1.4.1 Roadways, Railroads, and Airfields

Place backfill up to the required elevation as specified. Do not permit water flooding or jetting methods of compaction.

3.11.1.4.2 Sidewalks, 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.

3.11.2 Backfill for Appurtenances

After the manhole, catchbasin, inlet, or similar structure has been constructed, 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.

3.12 SPECIAL REQUIREMENTS

Special requirements for both excavation and backfill relating to the specific utilities are as follows:

3.12.1 Gas Distribution

Excavate trenches to a depth that will provide a minimum 18 inches of cover in rock excavation and a minimum 24 inch of cover in other excavation.

3.12.2 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.

3.12.3 Heat Distribution System

Free initial backfill material of stones larger than 1/4 inch in any dimension.

3.12.4 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.

3.12.5 Sewage Absorption Trenches or Pits

3.12.5.1 Porous Fill

Provide backfill material consisting of clean crushed rock as specified in the Contract Drawings.

3.12.5.2 Cover

Filter fabric, Concrete, Kraft paper conforming to CID A-A-203, Grade B, No. 2, 50 pound weight or a layer of straw at least 2 inches thick as indicated.

3.12.6 Pipeline Casing

Provide new smooth wall steel pipeline casing under new or existing pavement. Provide each new pipeline casing, where indicated and to the lengths and dimensions shown, complete and suitable for use with the new piped utility as indicated.

3.12.6.1 Bore Holes

Mechanically bore holes and case through the soil with a cutting head on a continuous auger mounted inside the casing pipe. Weld lengths of pipe together in accordance with AWS D1.1/D1.1M. Do not use water or other fluids in connection with the boring operation.

3.12.6.2 Cleaning

Clean inside of the pipeline casing of dirt, weld splatters, and other foreign matter which would interfere with insertion of the piped utilities by attaching a pipe cleaning plug to the boring rig and passing it through the pipe.

3.12.6.3 End Seals

After installation of piped utilities in pipeline casing, provide watertight end seals at each end of pipeline casing between pipeline casing and piping utilities. Provide watertight end seals as indicated.

3.12.7 Rip-Rap Construction

Construct rip-rap on bedding material, or on filter fabric with grout as indicated. Trim and dress indicated areas to conform to cross sections, lines and grades shown within a tolerance of 0.1 foot.

3.12.7.1 Bedding Placement

Spread filter fabric and bedding material uniformly to a thickness of at least 3 inches on prepared subgrade as indicated. Compaction of bedding is not required. Finish bedding to present even surface free from mounds and windrows.

3.12.7.2 Stone Placement

Place rock for rip-rap on prepared bedding material to produce a well graded mass with the minimum practicable percentage of voids in conformance with lines and grades indicated. Distribute larger rock fragments, with dimensions extending the full depth of the rip-rap throughout the entire mass and eliminate "pockets" of small rock fragments. Rearrange individual pieces by mechanical equipment or by hand as necessary to obtain the distribution of fragment sizes specified above. For grouted rip-rap, hand-place surface rock with open joints to facilitate grouting and do not fill smaller spaces between surface rock with finer material. Provide at least one "weep hole" through grouted rip-rap for every 50 square feet of finished surface. Provide weep holes with columns of bedding material, 4 inches in diameter, extending up to the rip-rap surface without grout.

3.12.7.3 Grouting

Prior to grouting, wet rip-rap surfaces. Grout rip-rap in successive longitudinal strips, approximately 10 feet in width, commencing at the lowest strip and working up the slope. Distribute grout to place of final deposit and work into place between stones with brooms, spades, trowels, or vibrating equipment. Take precautions to prevent grout from penetrating bedding layer. Protect and cure surface for a minimum of 7 days.

3.13 EMBANKMENTS

3.13.1 Earth Embankments

Construct earth embankments from satisfactory materials free of organic or frozen material and rocks with any dimension greater than 3 inches. Place the material in successive horizontal layers of loose material not more than 8 inches in depth. Spread each layer uniformly on a soil surface that has been moistened or aerated as necessary, and scarified or otherwise broken up so that the fill will bond with the surface on which it is placed. After spreading, plow, disk, or otherwise break up each layer; moisten or aerate as necessary; thoroughly mix; and compact to at least 90 percent laboratory maximum density for cohesive materials or 95 percent laboratory maximum density for cohesionless materials. Backfill material must be within the range of -2 to +2 percent of optimum moisture content at the time of compaction.

Compaction requirements for the upper portion of earth embankments forming subgrade for pavements are identical with those requirements specified in paragraph SUBGRADE PREPARATION. Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment.

3.14 SUBGRADE PREPARATION

3.14.1 Proof Rolling

Finish proof rolling on an exposed subgrade free of surface water (wet conditions resulting from rainfall) which would promote degradation of an otherwise acceptable subgrade. After stripping, proof roll the existing subgrade of all areas with six passes of a dump truck loaded with 4 cubic yards of soil or 15 ton, pneumatic-tired roller. Operate the roller or truck in a systematic manner to ensure the number of passes over all areas, and at speeds between 2-1/2 to 3-1/2 mph. When proof rolling, provide one-half of the passes made with the roller in a direction perpendicular to the other passes. Notify the Contracting Officer a minimum of 3 days prior to proof rolling. Perform proof rolling in the presence of the Contracting Officer and Geotechnical Engineer. Undercut rutting or pumping of material as directed by the Contracting Officer and replace with select material.

3.14.2 Construction

Shape subgrade to line, grade, and cross section, and compact as specified. Include plowing, disking, and any moistening or aerating required to obtain specified compaction for this operation. Remove soft or otherwise unsatisfactory material and replace with satisfactory excavated material or other approved material as directed. Excavate rock encountered in the cut section to a depth of 6 inches below finished grade for the subgrade. Bring up low areas resulting from removal of unsatisfactory material or excavation of rock to required grade with satisfactory materials, and shape the entire subgrade to line, grade, and cross section and compact as specified. After rolling, the surface of the subgrade for roadways shall not show deviations greater than 1/2 inch when tested with a 12-foot straightedge applied both parallel and at right angles to the centerline of the area. Do not vary the elevation of the finish subgrade more than 0.05 foot from the established grade and cross section.

3.14.3 Compaction

Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment. Except for paved areas, compact each layer of the embankment to at least 90 percent of laboratory maximum density.

3.14.3.1 Subgrade for Pavements

Compact subgrade for pavements to at least 100 percentage laboratory maximum density for the depth below the surface of the pavement shown. When more than one soil classification is present in the subgrade, thoroughly blend, reshape, and compact the top 12 inches of subgrade.

3.14.3.2 Subgrade for Shoulders

Compact subgrade for shoulders to at least 90 percentage laboratory maximum density for the full depth of the shoulder.

3.15 SHOULDER CONSTRUCTION

Construct shoulders of satisfactory excavated or borrow material or as otherwise shown or specified.. Submit advanced notice on shoulder construction for rigid pavements. Construct shoulders immediately after adjacent paving is complete. In the case of rigid pavements, do not construct shoulders until permission of the Contracting Officer has been obtained. Compact the entire shoulder area to at least the percentage of maximum density as specified in paragraph SUBGRADE PREPARATION above, for specific ranges of depth below the surface of the shoulder. Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment. Finish shoulder construction in proper sequence in such a manner that adjacent ditches will be drained effectively and that no damage of any kind is done to the adjacent completed pavement. Align the completed shoulders true to grade and shaped to drain in conformity with the cross section shown.

3.16 FINISHING

Finish the surface of excavations, embankments, and subgrades to a smooth and compact surface in accordance with the lines, grades, and cross sections or elevations shown. Provide the degree of finish for graded areas within 0.1 foot of the grades and elevations indicated except that the degree of finish 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 from settlement or washing 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.

3.16.1 Subgrade and Embankments

During construction, keep embankments and 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 the 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, or frozen subgrade.

3.16.2 Capillary Water Barrier

Place a capillary water barrier under concrete floor and area-way slabs grade directly on the subgrade and compact with a minimum of two passes of a hand-operated plate-type vibratory compactor.

3.16.3 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.

3.17 PLACING TOPSOIL

On areas to receive topsoil, prepare the compacted subgrade soil to a 2 inches depth for bonding of topsoil with subsoil. Spread topsoil evenly to a thickness of 6 inch and grade to the elevations and slopes shown. Do not spread topsoil when frozen or excessively wet or dry. Obtain material required for topsoil in excess of that produced by excavation within the grading limits from offsite areas.

3.18 TESTING

Perform testing by a Corps validated commercial testing laboratory or the Contractor's validated testing facility. Submit qualifications of the Corps validated commercial testing laboratory or the Contractor's validated testing facilities. If the Contractor elects to establish testing facilities, do not permit work requiring testing until the Contractor's facilities have been inspected, Corps validated and approved by the Contracting Officer.

a. Determine field in-place density in accordance with ASTM D1556/D1556M.

b. When test results indicate, as determined by the Contracting Officer, that compaction is not as specified, remove the material, replace and recompact to meet specification requirements.

c. Perform tests on recompacted areas to determine conformance with specification requirements. Appoint a registered professional civil engineer to certify inspections and test results. These certifications shall state that the tests and observations were performed by or under the direct supervision of the engineer and that the results are representative of the materials or conditions being certified by the tests. The following number of tests, if performed at the appropriate time, will be the minimum acceptable for each type operation.

3.18.1 Fill and Backfill Material Gradation

One test per 1,000 cubic yards stockpiled or in-place source material. Determine gradation of fill and backfill material in accordance with ASTM C136/C136M.

3.18.2 In-Place Densities

a. One test per 10,000 square feet, or fraction thereof, of each lift of

fill or backfill areas compacted by other than hand-operated machines.

b. One test per 3,500 square feet, or fraction thereof, of each lift of fill or backfill areas compacted by hand-operated machines.

c. One test per 100 linear feet, or fraction thereof, of each lift of embankment or backfill for roads.

3.18.3 Check Tests on In-Place Densities

If ASTM D6938 is used, check in-place densities by ASTM D1556/D1556M as follows:

a. One check test per lift for each 10,000 square feet, or fraction thereof, of each lift of fill or backfill compacted by other than hand-operated machines.

b. One check test per lift for each 3,500 square feet, of fill or backfill areas compacted by hand-operated machines.

c. One check test per lift for each 100 linear feet, or fraction thereof, of embankment or backfill for roads.

3.18.4 Moisture Contents

In the stockpile, excavation, or borrow areas, perform a minimum of two tests per day per type of material or source of material being placed during stable weather conditions. During unstable weather, perform tests as dictated by local conditions and approved by the Contracting Officer.

3.18.5 Optimum Moisture and Laboratory Maximum Density

Perform tests for each type material or source of material including borrow material to determine the optimum moisture and laboratory maximum density values. One representative test per 500 cubic yards of fill and backfill, or when any change in material occurs which may affect the optimum moisture content or laboratory maximum density.

3.18.6 Tolerance Tests for Subgrades

Perform continuous checks on the degree of finish specified in paragraph SUBGRADE PREPARATION during construction of the subgrades.

3.18.7 Displacement of Sewers

After other required tests have been performed and the trench backfill compacted to 2, feet above the top of the pipe, inspect the pipe to determine whether significant displacement has occurred. Conduct this inspection in the presence of the Contracting Officer. Inspect pipe sizes larger than 36 inches, while inspecting smaller diameter pipe by shining a light or laser between manholes or manhole locations, or by the use of television cameras passed through the pipe. If, in the judgment of the Contracting Officer, the interior of the pipe shows poor alignment or any other defects that would cause improper functioning of the system, replace or repair the defects as directed at no additional cost to the Government.

3.19 DISPOSITION OF SURPLUS MATERIAL

Remove surplus material or other soil material not required or suitable

for filling or backfilling, and brush, refuse, stumps, roots, and timber from Government property and delivered to a licensed/permitted facility or to a location approved by the Contracting Officer..

-- End of Section --

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DIVISION 31 - EARTHWORK

SECTION 31 05 22

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08/08

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SECTION 31 05 22

GEOTEXTILES USED AS FILTERS
08/08

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 D123	(2015b; R 2017) Standard Terminology Relating to Textiles
ASTM D4354	(2012) Sampling of Geosynthetics for Testing
ASTM D4355/D4355M	(2014) Deterioration of Geotextiles from Exposure to Light, Moisture and Heat in a Xenon-Arc Type Apparatus
ASTM D4491/D4491M	(2015) Standard Test Methods for Water Permeability of Geotextiles by Permittivity
ASTM D4533/D4533M	(2015) Standard Test Method for Trapezoid Tearing Strength of Geotextiles
ASTM D4632/D4632M	(2015a) Grab Breaking Load and Elongation of Geotextiles
ASTM D4751	(2016) Standard Test Method for Determining Apparent Opening Size of a Geotextile
ASTM D4833/D4833M	(2007; E 2013; R 2013) Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products
ASTM D4873/D4873M	(2017) Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
ASTM D4884/D4884M	(2014a) Strength of Sewn or Thermally Bonded Seams of Geotextiles

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 1110-2-1601	(1991; 1994 Change 1) Engineering and Design -- Hydraulic Design of Flood Control Channels

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-04 Samples

Geotextiles

Minimum of 60 days prior to the beginning of installation of the same textile

SD-06 Test Reports

Geotextiles
Site Verification

SD-07 Certificates

Geotextiles
Needle Punched Geotextile

1.3 DELIVERY, STORAGE, AND HANDLING

Deliver only approved geotextile rolls to the project site. All geotextile shall be labeled, shipped, stored, and handled in accordance with ASTM D4873/D4873M. No hooks, tongs, or other sharp instruments shall be used for handling geotextile.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 General

Provide geotextile that is a non-woven pervious sheet of plastic yarn as defined by ASTM D123 matching or exceeding the minimum average roll values listed in TABLE 1. Strength values indicated in the table are for the weaker principal direction.

TABLE 1
MINIMUM PHYSICAL REQUIREMENTS FOR DRAINAGE GEOTEXTILE

PROPERTY	UNITS	ACCEPTABLE VALUES	TEST METHOD
GRAB STRENGTH	lb	200	ASTM D4632/D4632M
SEAM STRENGTH	lb	160	ASTM D4632/D4632M
PUNCTURE	lb	125	ASTM D4833/D4833M

TRAPEZOID TEAR	lb	75	ASTM D4533/D4533M
PERMEABILITY	cm/sec	.004	ASTM D4491/D4491M
APPARENT OPENING SIZE	U.S. SIEVE	20	ASTM D4751
ULTRAVIOLET DEGRADATION	Percent	50 at 500 Hrs	ASTM D4355/D4355M

2.1.2 Geotextile Fiber

Fibers used in the manufacturing of the geotextile shall consist of a long-chain synthetic polymer composed of at least 85 percent by weight of polyolefins, polyesters, or polyamides. Add stabilizers and/or inhibitors to the base polymer, if necessary to make the filaments resistant to deterioration caused by ultraviolet light and heat exposure. Reclaimed or recycled fibers or polymer shall not be added to the formulation. Geotextile shall be formed into a network such that the filaments or yarns retain dimensional stability relative to each other, including the edges. Finish the edges of the geotextile to prevent the outer fiber from pulling away from the geotextile.

2.1.3 Seams

Sew the seams of the geotextile with thread of a material meeting the chemical requirements given above for geotextile yarn or bond the seams by cementing or by heat. Attach the sheets of geotextile at the factory or another approved location, if necessary, to form sections not less than 6 feet wide. Test seams in accordance with method ASTM D4884/D4884M. The strength of the seam shall be not less than 90 percent of the required grab tensile strength of the unaged geotextile in any principal direction.

2.1.4 Securing Pins

Secure the geotextile to the embankment or foundation soil by pins to prevent movement prior to placement of revetment materials. Other appropriate means to prevent movement such as staples, sand bags, and stone could also be used. Insert securing pins through both strips of overlapped geotextile along the line passing through midpoints of the overlap. Remove securing pins as placement of revetment materials are placed to prevent tearing of geotextile or enlarging holes. Maximum spacing between securing pins depends on the steepness of the embankment slope. The maximum pins spacing shall be equal to or less than the values listed in TABLE 2. When windy conditions prevail at the construction site, increase the number of pins upon the demand of the Contracting Officer. Anchor terminal ends of the geotextile with key trench or apron at crest, toe of the slope and upstream and downstream limits of installation.

TABLE 2
MAXIMUM SPACING FOR SECURING PINS

EMBANKMENT	SPACING, feet

TABLE 2 MAXIMUM SPACING FOR SECURING PINS	
STEEPER THAN 1V ON 3H	2
1V ON 3H TO 1V ON 4H	3
FLATTER THAN 1V ON 4H	5

2.2 INSPECTIONS, VERIFICATIONS, AND TESTING

2.2.1 Manufacturing and Sampling

Geotextiles and factory seams shall meet the requirements specified in TABLE 1.

2.2.1.1 Conformance Testing

Perform conformance testing in accordance with the manufacturers approved quality control manual. Submit manufacturer's quality control conformance test results.

2.2.1.2 Factory Sampling

Randomly sample geotextiles in accordance with ASTM D4354 (Procedure Method A). Sample factory seams at the frequency specified in ASTM D4884/D4884M. Provide all samples from the same production lot as will be supplied for the contract, of the full manufactured width of the geotextile by at least 10 feet long, except that samples for seam strength may be a full width sample folded over and the edges stitched for a length of at least 5 feet. Samples submitted for testing shall be identified by manufacturers lot designation.

2.2.1.3 Needle Punched Geotextile

For needle punched geotextile, provide manufacturer certification that the geotextile has been inspected using permanent on-line metal detectors and does not contain any needles.

2.2.1.4 Manufacturer Certification

Upon delivery of the geotextile, submit duplicate copies of the written certificate of compliance signed by a legally authorized official of the manufacturer. The certificate shall state that the geotextile shipped to the site meets the chemical requirements and exceeds the minimum average roll value listed in TABLE 1.

2.2.2 Site Verification and Testing

Collect samples at approved locations upon delivery to the site at the request of the Contracting Officerin accordance with ASTM D4354 (Procedure Method B). Test samples to verify that the geotextile meets the requirements specified in TABLE 1. Identify samples by manufacturers name, type of geotextile, lot number, roll number, and machine direction. Perform testing at an approved laboratory. Submit test results from the lot under review for approval prior to deployment of that lot of geotextile. Rolls which are sampled shall be immediately rewrapped in their protective covering.

PART 3 EXECUTION

3.1 SURFACE PREPARATION

Prepare surface, on which the geotextile will be placed, to a relatively smooth surface condition in accordance with the applicable portion of this specification and shall be free from obstruction, debris, depressions, erosion feature, or vegetation. Remove any irregularities so as to ensure continuous, intimate contact of the geotextile with all the surface. Any loose material, soft or low density pockets of material, shall be removed; erosion features such as rills, gullies etc. shall be graded out of the surface before geotextile placement.

3.2 INSTALLATION OF THE GEOTEXTILE

3.2.1 General

Place the geotextile in the manner and at the locations shown. At the time of installation, reject the geotextile if it has defects, rips, holes, flaws, deterioration or damage incurred during manufacture, transportation or storage.

3.2.2 Placement

Place the geotextile with the long dimension parallel to the trench and laid smooth and free of tension, stress, folds, wrinkles, or creases. Place the strips to provide a minimum width of 18 inches of overlap for each joint. Adjust the actual length of the geotextile used based on initial installation experience. Temporary pinning of the geotextile to help hold it in place until the bedding layer or riprap is placed will be allowed. Remove the temporary pins as the bedding or riprap is placed to relieve high tensile stress which may occur during placement of material on the geotextile. Design protection of riprap in compliance with EM 1110-2-1601. Perform trimming in such a manner that the geotextile is not damaged in any way.

3.3 PROTECTION

Protect the geotextile at all times during construction from contamination by surface runoff; remove any geotextile so contaminated and replaced with uncontaminated geotextile. Replace any geotextile damaged during its installation or during placement of bedding materials or riprap at no cost to the Government. Schedule the work so that the covering of the geotextile with a layer of the specified material is accomplished within 7 calendar days after placement of the geotextile. Failure to comply shall require replacement of geotextile. Protect the geotextile from damage prior to and during the placement of riprap or other materials. This may be accomplished by limiting the height of drop to less than 1 foot, by placing a cushioning layer of sand or gravel on top of the geotextile before placing the material, or other methods deemed necessary. Care should be taken to ensure that the utilized cushioning materials will not impede the flow of water. Before placement of riprap or other materials, demonstrate that the placement technique will not cause damage to the geotextile. In no case shall any type of equipment be allowed on the unprotected geotextile.

3.4 PLACEMENT OF CUSHIONING MATERIAL

Perform placing of cushioning material in a manner to ensure intimate contact of the geotextile with the prepared surface and with the cushioning material. The placement shall also be performed in a manner that will not damage the geotextile including tear, puncture, or abrasion. On sloping surfaces place the cushioning material from the bottom of the slopes upward. During placement, the height of the drop of riprap material shall not be greater than 12 inches. Uncover any geotextile damaged beneath the cushioning material, as necessary, and replaced at no cost to the Government.

3.5 OVERLAPPING AND SEAMING

3.5.1 Overlapping

The minimum overlap of geotextile rolls shall be 18 inches. Appropriate measures will be taken to ensure required overlap exists after cushion placement.

3.5.2 Sewn Seams

High strength thread should be used so that seam test conforms to ASTM D4884/D4884M. The thread shall meet the chemical, ultraviolet, and physical requirements of the geotextile, and the color shall be different from that of the geotextile. The seam strength shall be equal to the strength required for the geotextile in the direction across the seam. Overlapping J-type seams are preferable over prayer-type seams as the overlapping geotextile reduces the chance of openings to occur at the seam. Use double sewing, specially for field seams, to provide a safety factor against undetected missed stitches.

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CLEARING AND GRUBBING
08/08

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.

U.S. DEPARTMENT OF DEFENSE (DOD)

DODI 4150.07	(2008; Change 1-2017) DOD Pest Management Program

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Herbicide Application Plan

SD-03 Product Data

Nonsaleable Materials; G

Herbicides; G

SD-04 Samples

Tree Wound Paint

SD-07 Certificates

Qualifications; G

SD-11 Closeout Submittals

Pest Management Report

1.3 QUALITY CONTROL

1.3.1 Regulatory Requirements

Comply with DODI 4150.07 for requirements on Contractor's licensing, certification, and record keeping. Maintain daily records using the Pest

Management Maintenance Record, DD Form 1532-1, or a computer generated equivalent. These forms may be obtained from the main web site: http://www.dtic.mil/whs/directives/forms/eforms/dd1532-1.pdf

1.3.2 Qualifications

For the application of herbicides, use the services of an applicator who is commercially certified in the state where the work is to be performed as required by DODI 4150.07. Submit a copy of the pesticide applicator certificates.

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver materials to the site, and handle in a manner which will maintain the materials in their original manufactured or fabricated condition until ready for use.

1.4.1 Storage

Storage of herbicides on the installation will not be permitted unless it is written into the contract.

1.4.2 Handling

Handle herbicides in accordance with the manufacturer's label and Safety Data Sheet (SDS), preventing contamination by dirt, water, and organic material. Protect herbicides from weather elements as recommended by the manufacturer's label and SDS. Spill kits must be maintained on herbicide control vehicles. Mixing of herbicides on the installation will not be permited unless it is written into the contract.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Tree Wound Paint

Submit samples in cans with manufacturer's label of bituminous based paint of standard manufacture specially formulated for tree wounds.

2.1.2 Herbicide

Provide herbicides currently registered by the EPA or approved for such use by the appropriate agency of the host county and approved by the Contracting Officer. Select a herbicide that is suitable for the climatic conditions at the project site. Submit manufacturer's label and SDS for herbicides proposed for use.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Herbicide Application Plan

Prior to commencing application of herbicide, submit a herbicide application plan with proposed sequence of treatment work including dates and times of application. Include the herbicide trade name, EPA

registration number, chemical composition, formulation, application rate of active ingredients, method of application, area or volume treated, and amount applied. Include a copy of the pesticide applicator certificates.

3.1.2 Protection

3.1.2.1 Roads and Walks

Keep roads and walks free of dirt and debris at all times.

3.1.2.2 Trees, Shrubs, and Existing Facilities

Provide protection in accordance with Section 01 57 19 TEMPORARY ENVIRONMENTAL CONTROLS. Protect trees and vegetation to be left standing from damage incident to clearing, grubbing, and construction operations by the erection of barriers or by such other means as the circumstances require.

3.1.2.3 Utility Lines

Protect existing utility lines that are indicated to remain from damage. Notify the Contracting Officer immediately of damage to or an encounter with an unknown existing utility line. The Contractor is responsible for the repair of damage to existing utility lines that are indicated or made known to the Contractor prior to start of clearing and grubbing operations. When utility lines which are to be removed are encountered within the area of operations, notify the Contracting Officer in ample time to minimize interruption of the service. Refer to Section 01 57 19 TEMPORARY ENVIRONMENTAL CONTROLS for additional utility protection.

3.2 Application

3.2.1 Herbicide Application

Adhere to safety precautions as recommended by the manufacturer concerning handling and application of the herbicide.

3.2.1.1 Clean Up, Disposal, And Protection

Once application has been completed, proceed with clean up and protection of the site without delay. Clean the site of all material associated with the treatment measures, according to label instructions, and as indicated. Remove and dispose of excess and waste material off Government property.

3.2.1.1.1 Disposal of Herbicide

Dispose of residual herbicides and containers off Government property, and in accordance with the approved disposal plan, label instructions and EPA requirements.

3.3 CLEARING

Clearing shall consist of the felling, trimming, and cutting of trees into sections and the satisfactory disposal of the trees and other vegetation designated for removal, including downed timber, snags, brush, and rubbish occurring within the areas to be cleared. Clearing shall also include the removal and disposal of structures that obtrude, encroach upon, or otherwise obstruct the work. Trees, stumps, roots, brush, and other

vegetation in areas to be cleared shall be cut off flush with or below the original ground surface, except such trees and vegetation as may be indicated or directed to be left standing. Trees designated to be left standing within the cleared areas shall be trimmed of dead branches 1-1/2 inches or more in diameter and shall be trimmed of all branches the heights indicated or directed. Limbs and branches to be trimmed shall be neatly cut close to the bole of the tree or main branches. Cuts more than 1-1/2 inches in diameter shall be painted with an approved tree-wound paint. Apply herbicide in accordance with the manufacturer's label to the top surface of stumps designated not to be removed.

3.3.1 Tree Removal

Where indicated or directed, trees and stumps that are designated as trees shall be removed from areas outside those areas designated for clearing and grubbing. This work shall include the felling of such trees and the removal of their stumps and roots as specified in paragraph GRUBBING. Trees shall be disposed of as specified in paragraph DISPOSAL OF MATERIALS.

3.3.2 Pruning

Prune trees designated to be left standing within the cleared areas of dead branches 1-1/2 inches or more in diameter; and trim branches to heights and in a manner as indicated. Neatly cut limbs and branches to be trimmed close to the bole of the tree or main branches. Paint cuts more than 1-1/4 inches in diameter with an approved tree wound paint.

3.3.3 Grubbing

Grubbing consists of the removal and disposal of stumps, roots larger than 3 inches in diameter, and matted roots from the designated grubbing areas. Remove material to be grubbed, together with logs and other organic or metallic debris not suitable for foundation purposes, to a depth of not less than 18 inches below the original surface level of the ground in areas indicated to be grubbed and in areas indicated as construction areas under this contract, such as areas for buildings, and areas to be paved. Fill depressions made by grubbing with suitable material and compact to make the surface conform with the original adjacent surface of the ground.

3.4 DISPOSAL OF MATERIALS

3.4.1 Saleable Timber

The Government will, by separate contract, harvest all saleable timber from the project site. All remaining timber, limbs, tops, stumps, and debris shall be cleared and disposed of by the Contractor as specified.

3.4.2 Nonsaleable Materials

Written permission to dispose of such products on private property shall be filed with the Contracting Officer. Logs, stumps, roots, brush, rotten wood, and other refuse from the clearing and grubbing operations, except for salable timber, shall be disposed of outside the limits of Government-controlled land at the Contractor's responsibility, except when otherwise directed in writing. Such directive will state the conditions covering the disposal of such products and will also state the areas in which they may be placed. Burning shall not be permitted.

3.5 CLOSEOUT ACTIVITIES

3.5.1 Herbicides

Upon completion of this work, submit the Pest Management Report DD Form 1532, or an equivalent computer product, to the Integrated Pest Management Coordinator. This form identifies the type of operation, brand name and manufacturer of herbicide, formulation, concentration or rate of application used.

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CHEMICAL TERMITE CONTROL
11/14

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.

U.S. DEPARTMENT OF DEFENSE (DOD)

DODI 4150.07 DOD Pest Management Program

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Termiticide Application Plan; G,RO
Termiticides
Foundation Exterior
Utilities and Vents
Crawl and Plenum Air Spaces
Verification of Measurement
Application Equipment
Warranty

SD-04 Samples

Termiticides

SD-06 Test Reports

Equipment Calibration and Tank Measurement
Soil Moisture
Quality Assurance

SD-07 Certificates

Qualifications

1.3 QUALITY ASSURANCE

Comply with DODI 4150.07 for requirements on Contractor's licensing, certification, and record keeping. Maintain daily records using the Pest

Management Maintenance Record, DD Form 1532-1, or a computer generated equivalent, and submit copies of records when requested by the Contracting Officer. These forms may be obtained from the following web link or by searching the main web site:

http://www.dtic.mil/whs/directives/forms/eforms/dd1532-1.pdf

Upon completion of this work, submit the Pest Management Report DD Form 1532, or an equivalent computer product, to the Integrated Pest Management Coordinator. This form identifies the target pest, type of operation, brand name and manufacturer of pesticide, formulation, concentration or rate of application used.

1.3.1 Qualifications

For the application of pesticides, use the services of a applicator whose principal business is pest control. The applicator shall be licensed and certified in the state where the work is to be performed. Termiticide applicators shall also be certified in the U.S. Environmental Protection Agency (EPA) pesticide applicator category which includes structural pest control. Submit a copy of the pest control business license and pesticide applicator certificate(s).

The contractor shall:

a. Have personnel with a commercial state of North Carolina certification as required by DODI 4150.07.

b. Provide a submittal with the following information to the Contracting Officer and installation Integrated Pest Management Coordinator:

(1) Quantity of pesticide used.
(2) Rate of dispersion.
(3) Percent of use.
(4) Total amount used.

1.3.2 Safety Requirements

Formulate, treat, and dispose of termiticides and their containers in accordance with label directions. Draw water for formulating only from sites designated by the Contracting Officer, and fit the filling hose with a backflow preventer meeting local plumbing codes or standards. The filling operation shall be under the direct and continuous observation of a contractor's representative to prevent overflow. Secure pesticides and related materials under lock and key when unattended. Ensure that proper protective clothing and equipment are worn and used during all phases of termiticide application. Dispose of used pesticide containers off Government property.

1.4 DELIVERY, STORAGE, AND HANDLING

1.4.1 Delivery

Deliver termiticide material to the site in the original unopened containers bearing legible labels indicating the EPA registration number and manufacturer's registered uses. All other materials, to be used on

site for the purpose of termite control, shall be delivered in new or otherwise good condition as supplied by the manufacturer or formulator.

1.4.2 Inspection

Inspect termiticides upon arrival at the job site for conformity to type and quality in accordance with paragraph TERMITICIDES. Each label shall bear evidence of registration under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as amended or under appropriate regulations of the host county. Other materials shall be inspected for conformance with specified requirements. Remove unacceptable materials from the job site.

1.4.3 Storage

Contractors shall not store pesticides on the installation unless it is written into the contract.

1.4.4 Handling

Termiticides shall be handled and mixed in accordance with the manufacturer's label and SDS, preventing contamination by dirt, water, and organic material. Protect termiticides from weather elements as recommended by the manufacturer's label and SDS. Spill kits must be maintained on pest control vehicles and must be available at the mixing site. Termiticide mixing must be conducted in an area with adequate spill containment.

1.5 SITE CONDITIONS

The following conditions will determine the time of application.

1.5.1 Soil Moisture

Soils to be treated shall be tested immediately before application. Test soil moisture content to a minimum depth of 3 inches. The soil moisture shall be as recommended by the termiticide manufacturer. The termiticide will not be applied when soil moisture exceeds manufacturer's recommendations because termiticides do not adhere to the soil particles in saturated soils.

1.5.2 Runoff and Wind Drift

Do not apply termiticide during or immediately following heavy rains. Applications shall not be performed when conditions may cause runoff or create an environmental hazard. Applications shall not be performed when average wind speed exceeds 10 miles per hour. The termiticide shall not be allowed to enter water systems, aquifers, or endanger humans or animals.

1.5.2.1 Vapor Barriers and Waterproof Membranes

Termiticide shall be applied prior to placement of a vapor barrier or waterproof membrane.

1.5.2.2 Utilities and Vents

Prior to application, HVAC ducts and vents located in treatment area shall be turned off and blocked to protect people and animals from termiticide. Submit written verification that utilities and vents have been located and

treated as specified.

1.5.3 Placement of Concrete

Place concrete covering treated soils as soon as the termiticide has reached maximum penetration into the soil. Time for maximum penetration shall be as recommended by the manufacturer.

1.6 WARRANTY

The Contractor shall provide a 5 -year written warranty against infestations or reinfestations by subterranean termites of the buildings or building additions constructed under this contract. Warranty shall include annual inspections of the buildings or building additions. If live subterranean termite infestation or subterranean termite damage is discovered during the warranty period, and the soil and building conditions have not been altered in the interim:

a. Retreat the soil and perform other treatment as may be necessary for elimination of subterranean termite infestation;

b. Repair damage caused by termite infestation; and

c. Reinspect the building approximately 180 days after the retreatment.

PART 2 PRODUCTS

2.1 TERMITICIDES

Submit manufacturer's label and Material Safety Data Sheet (MSDS) for termiticides proposed for use. Provide termiticides currently registered by the EPA or approved for such use by the appropriate agency of the host county. Non-repellant termiticides shall be selected for maximum effectiveness and duration after application. The selected termiticide shall be suitable for the soil and climatic conditions at the project site and applied at the highest labeled rate. Submit samples of the pesticides used in this work. The Contracting Officer may draw, at any time and without prior notice, from stocks at the job site; should analysis, performed by the Government, indicate such samples to contain less than the amount of active ingredient specified on the label, work performed with such products shall be repeated, with pesticides conforming to this specification, at no additional cost to the Government.

PART 3 EXECUTION

3.1 VERIFICATION OF MEASUREMENT

Once termiticide application has been completed, measure tank contents to determine the remaining volume. The total volume measurement of used contents for the application shall equal the established application rate for the project site conditions. Provide written verification that the volume of termiticide used meets the application rate.

3.2 TECHNICAL REPRESENTATIVE

A DOD certified pesticide applicator or Pest Management Quality Assurance Evaluator (QAE)/Performance Assessment Representative (PAR) shall be the technical representative, shall be present at all meetings concerning treatment measures for subterranean termites, and shall be present during

treatment application. The command Integrated Pest Management Coordinator shall be contacted prior to starting work.

3.3 SITE PREPARATION

Work related to final grades, landscape plantings, foundations, or any other alterations to finished construction which might alter the condition of treated soils, must be coordinated with this specification.

3.3.1 Ground Preparation

Eliminate food sources by removing debris from clearing and grubbing and post construction wood scraps such as ground stakes, form boards, and scrap lumber from the site, before termiticide application begins.

3.3.2 Verification

Before work starts, verify that final grades are as indicated and smooth grading has been completed in accordance with Section 31 00 00 EARTHWORK. Soil particles shall be finely graded with particles no larger than 1 inch and compacted to eliminate soil movement to the greatest degree.

3.3.3 Foundation Exterior

Provide written verification that final grading and landscape planting operations will not disturb treatment of the soil on the exterior sides of foundation walls, grade beams, and similar structures.

3.3.4 Utilities and Vents

Provide written verification that the location and identity of HVAC ducts and vents, water and sewer lines, and plumbing have been accomplished prior to the termiticide application.

3.3.5 Crawl and Plenum Air Spaces

Provide written verification that the location and identity of crawl and plenum air spaces have been accomplished prior to the termiticide application.

3.3.6 Application Plan

Submit a Termiticide Application Plan with proposed sequence of treatment work with dates and times for approval before starting the specified treatment. Include the termiticide trade name, EPA registration number, chemical composition, formulation, concentration of original and diluted material, application rate of active ingredients, method of application, area/volume treated, and amount applied. Also include a copy of the pest control business license and pesticide applicator certificate(s).

3.4 TERMITICIDE TREATMENT

3.4.1 Equipment Calibration and Tank Measurement

Submit a listing of equipment to be used. Immediately prior to commencement of termiticide application, calibration tests shall be conducted on the application equipment to be used and the application tank shall be measured to determine the volume and contents. These tests shall confirm that the application equipment is operating within the

manufacturer's specifications and will meet the specified requirements. Submit written certification of the equipment calibration test results within 1 week of testing.

3.4.2 Mixing and Application

Formulating, mixing, and application shall be performed in the presence of a DOD certified pesticide applicator, Pest Management QAE/PAR, or Integrated Pest Management Coordinator. A closed system is recommended as it prevents the termiticide from coming into contact with the applicator or other persons. Water for formulating shall only come from designated locations. Filling hoses shall be fitted with a backflow preventer meeting local plumbing codes or standards. Overflow shall be prevented during the filling operation. Spill kits must be maintained on pest control vehicles and must be available at the mixing site. Termiticide mixing must be conducted in an area that has been designated by the government representative and that has adequate spill containment. Prior to each day of use, the equipment used for applying termiticides shall be inspected for leaks, clogging, wear, or damage. Any repairs are to be performed immediately.

3.4.3 Treatment Method

For areas to be treated, establish complete and unbroken vertical and/or horizontal soil poison barriers between the soil and all portions of the intended structure which may allow termite access to wood and wood related products. Applications to crawl spaces shall be made in accordance with (IAW) label directions. Applications shall not be made to crawl space areas that are used as plenum air spaces.

3.4.3.1 Surface Application

Use surface application for establishing horizontal barriers. Surface applicants shall be applied as a coarse spray and provide uniform distribution over the soil surface. Termiticide shall penetrate a minimum of 1 inch into the soil, or as recommended by the manufacturer.

3.4.3.2 Rodding and Trenching

Use rodding and trenching for establishing vertical soil barriers. Trenching shall be to the depth of the foundation footing. Width of trench shall be as recommended by the manufacturer, or as indicated. Rodding or other approved method may be implemented for saturating the base of the trench with termiticide. Immediately after termiticide has reached maximum penetration as recommended by the manufacturer, backfilling of the trench shall commence. Backfilling shall be in 6 inch rises or layers. Each rise shall be treated with termiticide.

3.4.4 Sampling

The Contracting Officer may draw from stocks at the job site, at any time and without prior notice, take samples of the termiticides used to determine if the amount of active ingredient specified on the label is being applied.

3.5 CLEAN UP, DISPOSAL, AND PROTECTION

Once application has been completed, proceed with clean up and protection of the site without delay.

3.5.1 Clean Up

The site shall be cleaned of all material associated with the treatment measures, according to label instructions, and as indicated. Excess and waste material shall be removed and disposed off site.

3.5.2 Disposal of Termiticide

Dispose of residual termiticides and containers off Government property, and in accordance with label instructions and EPA criteria.

3.5.3 Protection of Treated Area

Immediately after the application, the area shall be protected from other use by erecting barricades and providing signage as required or directed. Signage shall be in accordance with Section 10 14 00.10 EXTERIOR SIGNAGE. Signage shall be placed inside the entrances to crawl spaces and shall identify the space as treated with termiticide and not safe for children and animals. Treated areas should be covered with plastic if slab is not to be poured immediately following termiticide application.

3.6 CONDITIONS FOR SATISFACTORY TREATMENT

3.6.1 Equipment Calibrations and Measurements

Where results from the equipment calibration and tank measurements tests are unsatisfactory, re-treatment will be required.

3.6.2 Testing

Should an analysis, performed by a third party, indicate that the samples of the applied termiticide contain less than the amount of active ingredient specified on the label, and/or if soils are treated to a depth less than specified or approved, re-treatment will be required.

3.6.3 Disturbance of Treated Soils

Soil and fill material disturbed after treatment shall be re-treated before placement of slabs or other covering structures.

3.6.4 Termites Found Within the Warranty Period

If live subterranean termite infestation or termite damage is discovered during the warranty period, re-treat the site.

3.7 RE-TREATMENT

Where re-treatment is required, comply with the requirements specified in paragraph WARRANTY.

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SECTION 32 01 19

FIELD MOLDED SEALANTS FOR SEALING JOINTS IN RIGID PAVEMENTS
08/08

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 C1016	(2014) Standard Test Method for Determination of Water Absorption of Sealant Backing (Joint Filler) Material
ASTM D5893/D5893M	(2016) Standard Specification for Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements
ASTM D6690	(2015) Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements
ASTM D789	(2015) Determination of Relative Viscosity and Moisture Content of Polyamide (PA)

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS SS-S-200	(Rev E; Am 1; Notice 1) Sealant, Joint, Two-Component, Jet-Blast-Resistant, Cold-Applied, for Portland Cement Concrete Pavement

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Manufacturer's Recommendations; G.
Equipment.

SD-04 Samples

Materials; G.

SD-06 Test Reports

Certified Copies of the Test Reports; G.

1.3 QUALITY ASSURANCE

1.3.1 Test Requirements

Test the joint sealant and backup or separating material for conformance with the referenced applicable material specification. Perform testing of the materials in an approved independent laboratory and submit certified copies of the test reports for approval 14 days prior to the use of the materials at the job site. Samples will be retained by the Government for possible future testing should the materials appear defective during or after application. Conformance with the requirements of the laboratory tests specified will not constitute final acceptance of the materials. Final acceptance will be based on the performance of the in-place materials. Submit samples of the materials (sealant, primer if required, and backup material), in sufficient quantity for testing and approval 28 days prior to the beginning of work. No material will be allowed to be used until it has been approved.

1.3.2 Trial Joint Sealant Installation

Prior to the cleaning and sealing of the joints for the entire project, prepare a test section at least 50 feet long using the specified materials and approved equipment, so as to demonstrate the proposed joint preparation and sealing of all types of joints in the project. Following the completion of the test section and before any other joint is sealed, inspect the test section to determine that the materials and installation meet the requirements specified. If it is determined that the materials or installation do not meet the requirements, remove the materials, and reclean and reseal the joints at no cost to the Government. When the test section meets the requirements, it may be incorporated into the permanent work. Prepare and seal all other joints in the manner approved for sealing the test section.

1.4 DELIVERY, STORAGE, AND HANDLING

Inspect materials delivered to the job site for defects, unload, and store them with a minimum of handling to avoid damage. Provide storage facilities at the job site for maintaining materials at the temperatures and conditions recommended by the manufacturer.

1.5 ENVIRONMENTAL REQUIREMENTS

The ambient air temperature and the pavement temperature within the joint wall shall be a minimum of 50 degrees F and rising at the time of application of the materials. Do not apply sealant if moisture is observed in the joint.

PART 2 PRODUCTS

2.1 SEALANTS

Materials for sealing cracks in the various paved areas indicated on the drawings shall be as follows: ASTM D6690, Type III and COE CRD-C 525.

2.2 PRIMERS

When primers are recommended by the manufacturer of the sealant, use them in accordance with the recommendation of the manufacturer.

2.3 BACKUP MATERIALS

Provide backup material that is a compressible, nonshrinking, nonstaining, nonabsorbing material, nonreactive with the joint sealant. The material shall have a melting point at least 5 degrees F greater than the pouring temperature of the sealant being used when tested in accordance with ASTM D789. The material shall have a water absorption of not more than 5 percent of the sample weight when tested in accordance with ASTM C1016. Use backup material that is 25 plus or minus 5 percent larger in diameter than the nominal width of the crack.

2.4 BOND BREAKING TAPES

Provide a bond breaking tape or separating material that is a flexible, nonshrinkable, nonabsorbing, nonstaining, and nonreacting adhesive-backed tape. The material shall have a melting point at least 5 degrees F greater than the pouring temperature of the sealant being used when tested in accordance with ASTM D789. The bond breaker tape shall be approximately 1/8 inch wider than the nominal width of the joint and shall not bond to the joint sealant.

PART 3 EXECUTION

3.1 EXECUTING EQUIPMENT

Machines, tools, and equipment used in the performance of the work required by this section shall be approved before the work is started maintained in satisfactory condition at all times. Submit a list of proposed equipment to be used in performance of construction work including descriptive data, 21 days prior to use on the project.

3.1.1 Joint Cleaning Equipment

3.1.1.1 Tractor-Mounted Routing Tool

Provide a routing tool, used for removing old sealant from the joints, of such shape and dimensions and so mounted on the tractor that it will not damage the sides of the joints. The tool shall be designed so that it can be adjusted to remove the old material to varying depths as required. The use of V-shaped tools or rotary impact routing devices will not be permitted. Hand-operated spindle routing devices may be used to clean and enlarge random cracks.

3.1.1.2 Concrete Saw

Provide a self-propelled power saw, with water-cooled diamond or abrasive saw blades, for cutting joints to the depths and widths specified or for refacing joints or cleaning sawed joints where sandblasting does not provide a clean joint.

3.1.1.3 Sandblasting Equipment

Include with the sandblasting equipment an air compressor, hose, and long-wearing venturi-type nozzle of proper size, shape and opening. The

maximum nozzle opening should not exceed 1/4 inch. The air compressor shall be portable and capable of furnishing not less than 150 cfm and maintaining a line pressure of not less than 90 psi at the nozzle while in use. Demonstrate compressor capability, under job conditions, before approval. The compressor shall be equipped with traps that will maintain the compressed air free of oil and water. The nozzle shall have an adjustable guide that will hold the nozzle aligned with the joint approximately 1 inch above the pavement surface. Adjust the height, angle of inclination and the size of the nozzle as necessary to secure satisfactory results.

3.1.1.4 Waterblasting Equipment

Include with the waterblasting equipment a trailer-mounted water tank, pumps, high-pressure hose, wand with safety release cutoff control, nozzle, and auxiliary water resupply equipment. Provide water tank and auxiliary resupply equipment of sufficient capacity to permit continuous operations. The nozzle shall have an adjustable guide that will hold the nozzle aligned with the joint approximately 1 inch above the pavement surface. Adjust the height, angle of inclination and the size of the nozzle as necessary to obtain satisfactory results. A pressure gauge mounted at the pump shall show at all times the pressure in psi at which the equipment is operating.

3.1.1.5 Hand Tools

Hand tools may be used, when approved, for removing defective sealant from a crack and repairing or cleaning the crack faces.

3.1.2 Sealing Equipment

3.1.2.1 Hot-Poured Sealing Equipment

The unit applicators used for heating and installing ASTM D6690 joint sealant materials shall be mobile and shall be equipped with a double-boiler, agitator-type kettle with an oil medium in the outer space for heat transfer; a direct-connected pressure-type extruding device with a nozzle shaped for inserting in the joint to be filled; positive temperature devices for controlling the temperature of the transfer oil and sealant; and a recording type thermometer for indicating the temperature of the sealant. The applicator unit shall be designed so that the sealant will circulate through the delivery hose and return to the inner kettle when not in use.

3.1.2.2 Two-Component, Cold-Applied, Machine Mix Sealing Equipment

Provide equipment used for proportioning, mixing, and installing FS SS-S-200 Type M joint sealants designed to deliver two semifluid components through hoses to a portable mixer at a preset ratio of 1 to 1 by volume using pumps with an accuracy of plus or minus 5 percent for the quantity of each component. The reservoir for each component shall be equipped with mechanical agitation devices that will maintain the components in a uniform condition without entrapping air. Incorporate provisions to permit thermostatically controlled indirect heating of the components, when required. However, immediately prior to proportioning and mixing, the temperature of either component shall not exceed 90 degrees F. Provide screens near the top of each reservoir to remove any foreign particles or partially polymerized material that could clog fluid lines or otherwise cause misproportioning or improper mixing of the two

components. Provide equipment capable of thoroughly mixing the two components through a range of application rates of 10 to 60 gallons per hour and through a range of application pressures from 50 to 1500 psi as required by material, climatic, or operating conditions. Design the mixer for the easy removal of the supply lines for cleaning and proportioning of the components. The mixing head shall accommodate nozzles of different types and sizes as may be required by various operations. The dimensions of the nozzle shall be such that the nozzle tip will extend into the joint to allow sealing from the bottom of the joint to the top. Maintain the initially approved equipment in good working condition, serviced in accordance with the supplier's instructions, and unaltered in any way without obtaining prior approval.

3.1.2.3 Two-Component, Cold-Applied, Hand-Mix Sealing Equipment

Mixing equipment for FS SS-S-200 Type H sealants shall consist of a slow-speed electric drill or air-driven mixer with a stirrer in accordance with the manufacturer's recommendations. Submit printed copies of manufacturer's recommendations, 21 days prior to use on the project, where installation procedures, or any part thereof, are required to be in accordance with those recommendations. Installation of the material will not be allowed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material.

3.1.2.4 Cold-Applied, Single-Component Sealing Equipment

The equipment for installing ASTM D5893/D5893M single component joint sealants shall consist of an extrusion pump, air compressor, following plate, hoses, and nozzle for transferring the sealant from the storage container into the joint opening. The dimension of the nozzle shall be such that the tip of the nozzle will extend into the joint to allow sealing from the bottom of the joint to the top. Maintain the initially approved equipment in good working condition, serviced in accordance with the supplier's instructions, and unaltered in any way without obtaining prior approval. Small hand-held air-powered equipment (i.e., caulking guns) may be used for small applications.

3.2 SAFETY

Do not place joint sealant within 25 feet of any liquid oxygen (LOX) equipment, LOX storage, or LOX piping. Thoroughly clean joints in this area and leave them unsealed.

3.3 PREPARATION OF JOINTS

Immediately before the installation of the sealant, thoroughly clean the joints to remove all laitance, curing compound, filler, protrusions of hardened concrete, and old sealant from the sides and upper edges of the joint space to be sealed.

3.3.1 Existing Sealant Removal

Cut loose the in-place sealant from both joint faces and to the depth shown on the drawings, using the concrete saw as specified in paragraph EQUIPMENT. Depth shall be sufficient to accommodate any separating or backup material that is required to maintain the depth of new sealant to be installed. Prior to further cleaning operations, remove all loose old sealant remaining in the joint opening by blowing with compressed air. Hand tools may be required to remove sealant from random cracks.

Chipping, spalling, or otherwise damaging the concrete will not be allowed.

3.3.2 Sawing

3.3.2.1 Facing of Joints

Accomplish facing of joints using a concrete saw as specified in paragraph EQUIPMENT to saw through sawed and filler-type joints to loosen and remove material until the joint is clean and open to the full specified width and depth. Stiffen the blade with a sufficient number of suitable dummy (used) blades or washers. Thoroughly clean, immediately following the sawing operation, the joint opening using a water jet to remove all saw cuttings and debris.

3.3.2.2 Refacing of Random Cracks

Accomplish sawing of the cracks using a power-driven concrete saw as specified in paragraph EQUIPMENT. The saw blade shall be 6 inches or less in diameter to enable the saw to follow the trace of the crack. Stiffen the blade, as necessary, with suitable dummy (or used) blades or washers. Immediately following the sawing operation, thoroughly clean the crack opening using a water jet to remove all saw cuttings and debris.

3.3.3 Sandblasting

The newly exposed concrete joint faces and the pavement surfaces extending a minimum of 1/2 inch from the joint edges shall be waterblasted clean. use a multiple-pass technique until the surfaces are free of dust, dirt, curing compound, filler, old sealant residue, or any foreign debris that might prevent the bonding of the sealant to the concrete. After final cleaning and immediately prior to sealing, blow out the joints with compressed air and leave them completely free of debris and water.

3.3.4 Back-Up Material

When the joint opening is of a greater depth than indicated for the sealant depth, plug or seal off the lower portion of the joint opening using a back-up material to prevent the entrance of the sealant below the specified depth. Take care to ensure that the backup material is placed at the specified depth and is not stretched or twisted during installation.

3.3.5 Bond Breaking Tape

Where inserts or filler materials contain bitumen, or the depth of the joint opening does not allow for the use of a backup material, insert a bond breaker separating tape to prevent incompatibility with the filler materials and three-sided adhesion of the sealant. Securely bond the tape to the bottom of the joint opening so it will not float up into the new sealant.

3.3.6 Rate of Progress of Joint Preparation

Limit the stages of joint preparation, which include sandblasting, air pressure cleaning and placing of the back-up material to only that lineal footage that can be sealed during the same day.

3.4 PREPARATION OF SEALANT

3.4.1 Hot-Poured Sealants

Do not heat sealants conforming to ASTM D6690 in excess of the safe heating temperature recommended by the manufacturer as shown on the sealant containers. Withdraw and waste sealant that has been overheated or subjected to application temperatures for over 4 hours or that has remained in the applicator at the end of the day's operation.

3.4.2 Type M Sealants

Inspect the FS SS-S-200 Type M sealant components and containers prior to use. Reject any materials that contain water, hard caking of any separated constituents, nonreversible jell, or materials that are otherwise unsatisfactory. Settlement of constituents in a soft mass that can be readily and uniformly remixed in the field with simple tools will not be cause for rejection. Prior to transfer of the components from the shipping containers to the appropriate reservoir of the application equipment, thoroughly mix the materials to ensure homogeneity of the components and incorporation of all constituents at the time of transfer. When necessary for remixing prior to transfer to the application equipment reservoirs, warm the components to a temperature not to exceed 90 degrees F by placing the components in heated storage or by other approved methods but in no case shall the components be heated by direct flame, or in a single walled kettle, or a kettle without an oil bath.

3.4.3 Type H Sealants

Mix the FS SS-S-200 Type H sealant components either in the container furnished by the manufacturer or a cylindrical metal container of volume approximately 50 percent greater than the package volume. Thoroughly mix the base material in accordance with the manufacturer's instructions. The cure component shall then be slowly added during continued mixing until a uniform consistency is obtained.

3.4.4 Single-Component, Cold-Applied Sealants

Inspect the ASTM D5893/D5893M sealant and containers prior to use. Reject any materials that contain water, hard caking of any separated constituents, nonreversible jell, or materials that are otherwise unsatisfactory. Settlement of constituents in a soft mass that can be readily and uniformly remixed in the field with simple tools will not be cause for rejection.

3.5 INSTALLATION OF SEALANT

3.5.1 Time of Application

Seal joints immediately following final cleaning of the joint walls and following the placement of the separating or backup material. Open joints, that cannot be sealed under the conditions specified, or when rain interrupts sealing operations shall be recleaned and allowed to dry prior to installing the sealant.

3.5.2 Sealing Joints

Immediately preceding, but not more than 50 feet ahead of the joint sealing operations, perform a final cleaning with compressed air. Fill

the joints from the bottom up to 1/4 inch plus or minus 1/16 inch below the pavement surface. Remove and discard excess or spilled sealant from the pavement by approved methods. Install the sealant in such a manner as to prevent the formation of voids and entrapped air. In no case shall gravity methods or pouring pots be used to install the sealant material. Traffic shall not be permitted over newly sealed pavement until authorized by the Contracting Officer. When a primer is recommended by the manufacturer, apply it evenly to the joint faces in accordance with the manufacturer's instructions. Check the joints frequently to ensure that the newly installed sealant is cured to a tack-free condition within the time specified.

3.6 INSPECTION

3.6.1 Joint Cleaning

Inspect joints during the cleaning process to correct improper equipment and cleaning techniques that damage the concrete pavement in any manner. Cleaned joints will be approved prior to installation of the separating or back-up material and joint sealant.

3.6.2 Joint Sealant Application Equipment

Inspect the application equipment to ensure conformance to temperature requirements, proper proportioning and mixing (if two-component sealant) and proper installation. Evidences of bubbling, improper installation, failure to cure or set will be cause to suspend operations until causes of the deficiencies are determined and corrected.

3.6.3 Joint Sealant

Inspect the joint sealant for proper rate of cure and set, bonding to the joint walls, cohesive separation within the sealant, reversion to liquid, entrapped air and voids. Sealants exhibiting any of these deficiencies at any time prior to the final acceptance of the project shall be removed from the joint, wasted, and replaced as specified herein at no additional cost to the Government.

3.7 CLEAN-UP

Upon completion of the project, remove all unused materials from the site and leave the pavement in a clean condition.

-- End of Section --

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08/17

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-- End of Section Table of Contents --

SECTION 32 05 33

LANDSCAPE ESTABLISHMENT
08/17

PART 1 GENERAL

1.1 REFERENCES

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

ASTM INTERNATIONAL (ASTM)

ASTM D5851	(1995; R 2015) Planning and Implementing a Water Monitoring Program

TREE CARE INDUSTRY ASSOCIATION (TCIA)

TCIA Z133	(2017) American National Standard for Arboricultural Operations - Pruning, Repairing, Maintaining, and Removing Trees, and Cutting Brush - Safety Requirements

1.2 DEFINITIONS

1.2.1 Pesticide

Any substance or mixture of substances, including biological control agents, that may prevent, destroy, repel, or mitigate pests and are specifically labeled for use by the U.S. Environmental Protection Agency (EPA). Also, any substance used as a plant regulator, defoliant, disinfectant, or biocide. Examples of pesticides include fumigants, herbicides, insecticides, fungicides, nematicides, molluscicides and rodenticides.

1.2.2 Stand of Turf

100 percent ground cover of the established species.

1.2.3 Planter Beds

A planter bed is defined as an area containing one or a combination of the following plant types: shrubs, vines, wildflowers, annuals, perennials, ground cover, and a mulch topdressing excluding turf. Trees may also be found in planter beds.

1.3 RELATED REQUIREMENTS

Section 32 92 19 SEEDINGSection 32 92 23 SODDING applies to this section for installation of seed or sod requirements, with additions and modifications herein.

Section 32 93 00 EXTERIOR PLANTS applies to this section for installation of trees, shrubs, ground cover, vines, and wildflower, with additions and

modifications herein.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance with Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Integrated Pest Management Plan; G

SD-03 Product Data

Fertilizer; G

Mulches Topdressing

Organic Mulch Materials

SD-07 Certificates

Maintenance Inspection Report

Plant Quantities; G

SD-10 Operation and Maintenance Data

Maintenance

SD-11 Closeout Submittals

Tree Staking and Guying Removal

1.5 DELIVERY, STORAGE AND HANDLING

1.5.1 Delivery

Deliver fertilizer, gypsum, iron to the site in original containers bearing manufacturer's chemical analysis, name, trade name, or trademark, and indication of conformance to state and federal laws. Instead of containers, fertilizer, and gypsum may be furnished in bulk with a certificate indicating the above information.

1.5.2 Storage

1.5.2.1 Fertilizer, Lime, Iron, Mulch Storage

Store material in designated areas. Store lime and fertilizer in cool, dry locations away from contaminants.

1.5.2.2 Antidesiccant's Storage

Do not store with fertilizers or other landscape maintenance materials.

1.5.3 Handling

Do not drop or dump materials from vehicles.

1.6 MAINTENANCE

Submit Operation and Maintenance (O&M) Manuals for planting materials. Include instructions indicating procedures during one typical year including variations of maintenance for climatic conditions throughout the year. Provide instructions and procedures for watering; promotion of growth, including fertilizing, pruning, and mowing; and integrated pest management. O&M Manuals must include pictures of planting materials cross referenced to botanical and common names, with a description of the normal appearance in each season.

Develop a water monitoring program for surface and ground water on the project site in accordance with ASTM D5851 and consistent with the water management program utilized during construction operations.

1.7 Fort Bragg Installation Design Guide

Refer to Fort Bragg Installation Design Guide for more information on Landscaping requirements.

PART 2 PRODUCTS

2.1 POST-PLANT FERTILIZER

Fertilizer for groundcover, wildflowers, and grasses is not permitted. Provide fertilizer for trees, plants, and shrubs as recommended by plant supplier, except synthetic chemical fertilizers are not permitted. Fertilizers containing petrochemical additives or that have been treated with pesticides or herbicides are not permitted.

2.1.1 Granular Fertilizer

Organic, granular controlled release fertilizer containing the following minimum percentages, by weight, of plant food nutrients:

20 percent available nitrogen
20 percent available phosphorus
20 percent available potassium
5 percent sulfur
5 percent iron

2.2 WATER

Source of water must be approved by the Contracting Officer, and be of suitable quality for irrigation. Use collected storm water or graywater when available.

2.3 MULCHES TOPDRESSING

Free from noxious weeds, mold, pesticides, or other deleterious materials.

2.3.1 Organic Mulch Materials

Provide shredded hardwood, or recycled shredded hardwood from site when available. Wood cellulose fiber must be processed to contain no growth or

germination-inhibiting factors, dyed with non-toxic, biodegradable dye to an appropriate color to facilitate visual metering of materials application. Paper-based hydraulic mulch must contain a minimum of 100 percent post-consumer recycled content. Wood-based hydraulic mulch must contain a minimum of 100 percent total recovered materials content.

2.3.2 Recycled Organic Mulch

Recycled mulch may include compost, tree trimmings, or pine needles with a gradation that passes through a 2-1/2 by 2-1/2 inch screen. Clean recycled mulch of all sticks a minimum one inch in diameter and plastic materials a minimum 3 inch length. The material must be treated to retard the growth of mold and fungi.

2.4 PESTICIDES

Pesticides and herbicides are not permitted. Submit an Integrated Pest Management Plan, including weed and pest management strategies. Use biological pest controls as approved in the Plan.

PART 3 EXECUTION

3.1 EXTENT OF WORK

Provide landscape construction maintenance to include temporary irrigation equipment cleaning and adjustments, mowing, edging, overseeding, aeration, fertilizing, watering, weeding, pruning, stake and guy adjusting, for all newly installed landscape areas and existing plant material, unless indicated otherwise, and at all areas inside or outside the limits of the construction that are disturbed by the Contractor's operations.

3.1.1 Policing

Police all landscaped areas. Policing includes removal of leaves, branches and limbs regardless of length or diameter, dead vegetation, paper, trash, cigarette butts, garbage, rocks or other debris. Collected debris must be promptly removed and disposed of at an approved disposal site.

3.1.2 Drainage System Maintenance

Remove all obstructions from surface and subsurface drain lines to allow water to flow unrestricted in swales, gutters, catch basins, storm drain curb inlets, and yard drains. Remove grates and clear debris in catch basins. Open drainage channels are to be maintained free of all debris and vegetation at all times. Edges of these channels must be clear of any encroachment by vegetation.

3.2 IRRIGATION ESTABLISHMENT PERIOD

The irrigation establishment period will commence on the date that inspection by the Contracting Officer shows that the new irrigation equipment furnished under this contract have been satisfactorily installed and is functional and must continue for a period of 365 days.

3.2.1 Maintenance During the Irrigation Establishment Period

Begin maintenance immediately after irrigation equipment has been installed and is functional. Inspect irrigation equipment at least once a

week during the installation and establishment period and perform needed maintenance promptly. Automatic controllers not equipped with rain shut-off sensors must be turned off during periods of rain that exceed twelve hours of continuous rainfall in one day or during rain storms of one day or more. Once the rain has subsided timers must be reactivated. Irrigation controllers must be inspected and reprogrammed after power outages. Contractor must be responsible for winterization and startup. Sprinkler heads must direct water away from buildings and hard surfaced areas.

3.2.2 Water Restrictions

aabide by state, local or other water conservation regulations in force during the establishment period. Automatic controller must be adjusted to comply with the water conservation regulations schedule.

3.2.3 Fire Hydrants

To use a fire hydrant for irrigation, obtain prior clearance from the Contracting Officer and provide the tools and connections approved for use on fire hydrants. If a fire hydrant is used, Provide a reduced pressure backflow preventer for each connection between hose and fire hydrant. Backflow preventer used must be tested once per month by a certified backflow preventer tester.

3.2.4 Final Acceptance

Upon completion of the irrigation establishment period and final acceptance of groundcover and exterior plants, irrigation equipment must be removed.

3.2.5 Controller Charts

Provide one chart for each controller supplied. Indicate in chart area controlled by the automatic controller. The chart is a reduction of the actual plans that will fit the maximum dimensions inside the controller housing. Use a black line print for the chart and a different pastel or transparent color to indicate each station zone of coverage. After chart is completed and approved for final acceptance, seal chart between two 20 mil pieces of clear plastic.

3.3 GROUNDCOVER ESTABLISHMENT PERIOD

Groundcover establishment period will commence on the date that inspection by the Contracting Officer shows that the new turf furnished under this contract has been satisfactorily installed to a 100 percent stand of coverage. The establishment period must continue for a period of 365 days.

3.3.1 Frequency of Maintenance

Begin maintenance immediately after turf has been installed. Inspect areas once a week during the installation and establishment period and perform needed maintenance promptly.

3.3.2 Promotion of Growth

Maintain groundcover in a manner that promotes proper health, growth, natural color. Turf must have a neat uniform manicured appearance, free of bare areas, ruts, holes, weeds, pests, dead vegetation, debris, and

unwanted vegetation that present an unsightly appearance. Mow, remove excess clippings, eradicate weeds, water, fertilize, overseed, aerate, topdress and perform other operations necessary to promote growth, as approved by Contracting Officer and consistent with approved Integrated Pest Management Plan. Remove noxious weeds common to the area from planting areas by mechanical means.

3.3.3 Mowing

3.3.3.1 Turf

Mow turf at a uniform finished height. Mow turfed areas to a minimum average height of 4 inches when average height of grass becomes 6 inches for spring/summer maintenance and to a minimum average height of 4 inches when the average height of grass reaches 6 inches for fall maintenance. The height of turf is measured from the soil. Perform mowing of turf in a manner that prevents scalping, rutting, bruising, uneven and rough cutting. Prior to mowing, all rubbish, debris, trash, leaves, rocks, paper, and limbs or branches on a turf area must be picked up and disposed. Adjacent paved areas must be swept/vacuumed clean.

3.3.3.2 Native Grasses

Mow above height of native grass seedlings (approximately 3.5 to 4 inches). Mow during spring or early summer. Do not mow after early summer during the second growing season.

3.3.3.3 Wildflowers

Mow three times per season above height of the wildflowers (approximately 12 to 15 inches).

3.3.4 Turf Edging and Trimming

Perimeter of planter bed edges, sidewalks, driveways, curbs, and other paved surfaces must be edged. Uniformly edge these areas to prevent encroachment of vegetation onto paved surfaces and to provide a clear cut division line between planter beds, turf, and ground cover. Edging is to be accomplished in a manner that prevents scalping, rutting, bruising, uneven and rough cutting. Perform edging on the same day that turf is mowed. Use of string line trimmers is permitted in "soft" areas such as an edge between turfgrass and a planter bed. Exercise care to avoid damage to any plant materials, structures, and other landscape features.

Trimming around trees, fences, poles, walls, irrigation valve boxes and other similar objects is to be accomplished to match the height and appearance of surrounding mowed turf growth. Trimming must be performed on the same day the turf's mowed. Care must be exercised to avoid "Girdling" trees located in turf areas. The use of protective tree collars on trees in turf areas may be utilized as a temporary means to avoid injury to tree trunks. At the end of the plant establishment period Contractor will be responsible for removing all protective tree collars.

3.3.5 Post-Fertilizer Application

Do not fertilize wildflowers, groundcover, and grasses. Apply turf fertilizer in a manner that promotes health, growth, vigor, color and appearance of cultivated turf areas. The method of application, fertilizer type and frequencies must be determined by the laboratory soil

analysis results the requirements of the particular turf species. Apply fertilizer by approved methods in accordance with the manufacturer's recommendations.

3.3.6 Turf Watering

Perform irrigation in a manner that promotes the health, growth, color and appearance of cultivated vegetation and that complies with all Federal, State, and local water agencies and authorities directives. The Contractor must be responsible to prevent over watering, water run-off, erosion, and ponding due to excessive quantities or rate of application. Abide by state, local or other water conservation regulations or restrictions in force during the establishment period. Adjust irrigation controllers to comply with the water conservation regulations schedule.

3.3.7 Turf Aeration

Upon completion of weed eradication operations and Contracting Officer's approval to proceed, aerate turf areas by approved device. Core, by pulling soil plugs, to a minimum depth of 2 inches. Leave all soil plugs that are produced in the turf area. After aeration operations are complete, topdress entire area 1/2 inch depth with the following mixture:

2 percent sand
20 percent humus
10 percent gypsum
20 percent lime

Blend all parts of topdressing mixture to a uniform consistency throughout. Keep clean at all times at least one paved pedestrian access route and one paved vehicular access route to each building. Clean all soil plugs off of other paving when work is complete. This work must commence 24 days prior final acceptance of the maintenance establishment period.

3.3.8 Turf Clearance Area

Trees located in turf areas must be maintained with a growth free clearance of 18 inches from the tree trunk base. The use of mechanical weed whips to accomplish the turf growth free bed area is prohibited.

3.3.9 Replanting

Replant in accordance with Section 32 92 19 SEEDING, Section 32 92 23 SODDING and within specified planting dates areas which do not have a satisfactory stand of turf. Replant areas which do not have a satisfactory stand of other groundcover and grasses.

3.3.10 Final Inspection and Acceptance

Final inspection will be make upon written request from the Contractor at least 10 days prior to the last day of the turf establishment period. Final turf acceptance will be based upon a satisfactory stand of turf. Final acceptance of wildflower and grass areas will be based upon a stand of 95 percent groundcover of established species.

3.3.11 Unsatisfactory Work

When work is found to not meet design intent and specifications, maintenance period will be extended at no additional cost to the

Government until work has been completed, inspected and accepted by Contracting Officer.

3.4 EXTERIOR PLANT ESTABLISHMENT PERIOD

The exterior plant establishment period will commence on the date that inspection by the Contracting Officer shows that the new plants furnished under this contract has been satisfactorily installed and must continue for a period of 365 days.

3.4.1 Frequency of Maintenance

Begin maintenance immediately after plants have been installed. Inspect exterior plants at least once a week during the installation and establishment period and perform needed maintenance promptly.

3.4.2 Promotion of Plant Growth and Vigor

Water, prune, fertilize, mulch, adjust stakes, guys and turnbuckles, eradicate weeds and perform other operations necessary to promote plant growth, and vigor.

3.4.3 Planter Bed Maintenance

Planter beds must be weeded, fertilized, irrigated, kept pest free, turf free, pruned, and mulch levels maintained. Planter beds will not be allowed to encroach into turf areas. A definite break must be maintained between turf areas and planter beds. Fertilize exterior planting materials to promote healthy plant growth without encouraging excessive top foliar growth. Remove noxious weeds common to the area from planting areas by mechanical means.

3.4.3.1 Shrub Selective Maintenance

In addition to the above requirements, shrubs must be selectively pruned, and shaped for health and safety when the following conditions exist: Remove growth in front of windows, over entrance ways or walks, and any growth which will obstruct vision at street intersections or of security personnel; Remove dead, damaged or diseased branches or limbs; where shrub growth obstructs pedestrian walkways; where shrub growth is found growing against or over structures; where shrub growth permits concealment of unauthorized persons. Dispose of all pruning debris in a proper manner.

3.4.3.2 Tree Maintenance

Tree maintenance must include adjustment of stakes, ties, guy supports, watering, fertilizing, pest control, mulching, pruning for health and safety and fall leaf cleanup. Fertilize exterior trees to promote healthy plant growth without encouraging excessive top foliar growth. Inspect and adjust stakes, ties, guy supports to avoid girdling and promote natural development. All trees within the project boundaries, regardless of caliper, must be selectively pruned for safety and health reasons. These include but are not limited to removal of dead and broken branches and correction of structural defects. Prune trees according to their natural growth characteristics leaving trees well shaped and balanced. Pruning of all trees including palm trees must be accomplished by or in the presence of a certified member of the International Society of Arboriculture and in accordance with TCIA Z133. All pruning debris generated must be disposed of in a proper manner.

3.4.4 Slope Erosion Control Maintenance

Provide slope erosion control maintenance to prevent undermining of all slopes in newly landscaped and natural growth areas. Maintenance tasks include immediate repairs to weak spots in sloped areas, and maintaining clean, clear culverts, and graded berms, and terraces to intercept and direct water flow to prevent development of large gullies and slope erosion and during periods of extended rainfall, irrigation systems must be secured. Eroded areas must be filled with amended topsoil and replanted with the same plant species. Erosion control netting or blankets damaged due to slope erosion must be reinstalled.

3.4.5 Removal of Dying or Dead Plants

Remove dead and dying plants and provide new plants immediately upon commencement of the specified planting season, and replace stakes, mulch and eroded earth mound water basins. Provide an additional 90 day establishment period for replacement plants beyond the original warranty period. A tree must be considered dying or dead when the main leader has died back, or a minimum of 20 percent of the crown has died. A shrub or ground cover must be considered dying or dead when a minimum of 20 percent of the plant has died. This condition must be determined by scraping on a branch an area 1/16 inch square, maximum, to determine the cause for dying plant material and must provide recommendations for replacement. The Contractor must determine the cause for dying plant material and provide recommendations for replacement.

3.4.6 Tracking of Unhealthy Plants

Note plants not in healthy growing condition, as determined by the Contracting Officer, and as soon as seasonal conditions permit, remove and replace with plants of the same species and sizes as originally specified. Install replacement plantings in accordance with Section 32 93 00 EXTERIOR PLANTS.

3.4.7 Final Inspection

Final inspection will be made upon written request from the Contractor at least 10 days prior to the last day of the establishment period. Final inspection will be based upon satisfactory health and growth of plants and on the following:

3.4.7.1 Total Plants on Site

Plants have been accepted and required number of replacements have been installed.

3.4.7.2 Mulching and Weeding

Planter beds and earth mound water basins are properly mulched and free of weeds.

3.4.7.3 Tree Supports

Stakes guys and turnbuckles are in good condition.

3.4.7.4 Remedial Work

Remedial measures directed by the Contracting Officer to ensure plant material survival and promote healthy growth have been completed.

3.4.8 Unsatisfactory Work

When work is found to not meet design intent and specifications, maintenance period will be extended at no additional cost to the Government until work has been completed, inspected and accepted by Contracting Officer.

3.5 FIELD QUALITY CONTROL

3.5.1 Maintenance Inspection Report

Provide maintenance inspection report to assure that landscape maintenance is being performed in accordance with the specifications and in the best interest of plant growth and survivability. Site observations must be documented at the start of the establishment period, then quarterly following the start, and at the end of establishment period. Submit results of site observation visits to the Contracting Officer within 7 calendar days of each site observation visit.

3.5.2 Plant Quantities

Provide Contracting Officer with the number of plant quantities. In addition, provide total exterior area of hardscape and landscaping such as turf and total number of shrubs.

3.5.3 Tree Staking and Guying Removal

Provide a certified letter that all stakes and guys are removed from all project trees at the end of the establishment period.

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SECTION 32 11 23

AGGREGATE BASE COURSES
08/17

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by 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
AASHTO T 224	(2010) Standard Method of Test for Correction for Coarse Particles in the Soil Compaction Test
AASHTO T 88	(2013) Standard Method of Test for Particle Size Analysis of Soils

ASTM INTERNATIONAL (ASTM)

ASTM C117	(2017) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C127	(2015) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
ASTM C128	(2015) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate
ASTM C131/C131M	(2014) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136/C136M	(2014) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C29/C29M	(2017a) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C88	(2013) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or

	Magnesium Sulfate
ASTM D1556/D1556M	(2015; E 2016) Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
ASTM D1557	(2012; E 2015) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D2167	(2015) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D2487	(2017) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D4318	(2017; E 2018) Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D5821	(2013; R 2017) Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate
ASTM D6938	(2017a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM D75/D75M	(2014) Standard Practice for Sampling Aggregates
ASTM E11	(2016) Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves

1.2 DEFINITIONS

For the purposes of this specification, the following definitions apply.

1.2.1 Aggregate Base Course

Aggregate base course (ABC) is well graded, durable aggregate uniformly moistened and mechanically stabilized by compaction.

1.2.2 Graded-Crushed Aggregate Base Course

Graded-crushed aggregate (GCA) base course is well graded, crushed, durable aggregate uniformly moistened and mechanically stabilized by compaction.

1.2.3 Degree of Compaction

Degree of compaction required, except as noted in the second sentence, is expressed as a percentage of the maximum laboratory dry density obtained by the test procedure presented in ASTM D1557 abbreviated as a percent of laboratory maximum dry density. Since ASTM D1557 applies only to soils

that have 30 percent or less by weight of their particles retained on the 3/4 inch sieve, the degree of compaction for material having more than 30 percent by weight of their particles retained on the 3/4 inch sieve will be expressed as a percentage of the laboratory maximum dry density in accordance with AASHTO T 180 Method D and corrected with AASHTO T 224.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Plant, Equipment, and Tools; G

SD-06 Test Reports

Initial Tests; G
In-Place Tests; G

1.4 EQUIPMENT, TOOLS, AND MACHINES

All plant, equipment, and tools used in the performance of the work will be subject to approval by the Contracting Officer before the work is started. Maintain all plant, equipment, and tools in satisfactory working condition at all times. Submit a list of proposed equipment, including descriptive data. Use equipment capable of minimizing segregation, producing the required compaction, meeting grade controls, thickness control, and smoothness requirements as set forth herein.

1.5 QUALITY ASSURANCE

Sampling and testing are the responsibility of the Contractor. Perform sampling and testing using a laboratory approved in accordance with Section 01 45 00.00 10 QUALITY CONTROL. Work requiring testing will not be permitted until the testing laboratory has been inspected and approved. Test the materials to establish compliance with the specified requirements and perform testing at the specified frequency. The Contracting Officer may specify the time and location of the tests. Furnish copies of test results to the Contracting Officer within 24 hours of completion of the tests.

1.5.1 Sampling

Take samples for laboratory testing in conformance with ASTM D75/D75M. When deemed necessary, the sampling will be observed by the Contracting Officer.

1.5.2 Tests

1.5.2.1 Sieve Analysis

Perform sieve analysis in conformance with ASTM C117 and ASTM C136/C136M using sieves conforming to ASTM E11. .

1.5.2.2 Liquid Limit and Plasticity Index

Determine liquid limit and plasticity index in accordance with ASTM D4318.

1.5.2.3 Moisture-Density Determinations

Determine the laboratory maximum dry density and optimum moisture content in accordance with paragraph DEGREE OF COMPACTION.

1.5.2.4 Field Density Tests

Measure field density in accordance with ASTM D1556/D1556M, ASTM D2167 or ASTM D6938. For the method presented in ASTM D1556/D1556M use the base plate as shown in the drawing. For the method presented in ASTM D6938 check the calibration curves and adjust them, if necessary, using only the sand cone method as described in paragraph Calibration, of the ASTM publication. Tests performed in accordance with ASTM D6938 result in a wet unit weight of soil and ASTM D6938 will be used to determine the moisture content of the soil. Also check the calibration curves furnished with the moisture gauges along with density calibration checks as described in ASTM D6938. Make the calibration checks of both the density and moisture gauges using the prepared containers of material method, as described in paragraph Calibration of ASTM D6938, on each different type of material being tested at the beginning of a job and at intervals as directed. Submit calibration curves and related test results prior to using the device or equipment being calibrated.

1.5.2.5 Wear Test

Perform wear tests on ABC and GCA course material in conformance with ASTM C131/C131M.

1.5.2.6 Soundness

Perform soundness tests on GCA in accordance with ASTM C88.

1.5.2.7 Weight of Slag

Determine weight per cubic foot of slag in accordance with ASTM C29/C29M on the ABC and GCA course material.

1.6 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.

PART 2 PRODUCTS

2.1 AGGREGATES

Provide ABC and GCA consisting of clean, sound, durable particles of crushed stone, crushed slag, crushed gravel, crushed recycled concrete, angular sand, or other approved material. Provide ABC that is free of lumps of clay, organic matter, and other objectionable materials or coatings. Provide GCA that is free of silt and clay as defined by

ASTM D2487, organic matter, and other objectionable materials or coatings. The portion retained on the No. 4 sieve is known as coarse aggregate; that portion passing the No. 4 sieve is known as fine aggregate. When the coarse and fine aggregate is supplied form more than one source, provide aggregate from each source that meets the specified requirements.

2.1.1 Coarse Aggregate

Provide coarse aggregates with angular particles of uniform density. Separately stockpile coarse aggregate supplied from more than one source.

a. Crushed Gravel: Provide crushed gravel that has been manufactured by crushing gravels and that meets all the requirements specified below.

b. Crushed Stone: Provide crushed stone consisting of freshly mined quarry rock, meeting all the requirements specified below.

c. Crushed Recycled Concrete: Provide crushed recycled concrete consisting of previously hardened portland cement concrete or other concrete containing pozzolanic binder material. Provide recycled concrete that is free of all reinforcing steel, bituminous concrete surfacing, and any other foreign material and that has been crushed and processed to meet the required gradations for coarse aggregate. Reject recycled concrete aggregate exceeding this value. Provide crushed recycled concrete that meets all other applicable requirements specified below.

d. Crushed Slag: Provide crushed slag that is an air-cooled blast-furnace product having an air dry unit weight of not less than 70 pcf as determined by ASTM C29/C29M, and meets all the requirements specified below.

2.1.1.1 Aggregate Base Course

The percentage of loss of ABC coarse aggregate must not exceed 50 percent when tested in accordance with ASTM C131/C131M. Provide aggregate that contains no more than 30 percent flat and elongated particles. A flat particle is 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. In the portion retained on each sieve specified, the crushed aggregates must contain at least 50 percent by weight of crushed pieces having two or more freshly fractured faces determined in accordance with ASTM D5821. When two fractures are contiguous, the angle between planes of the fractures must be at least 30 degrees in order to count as two fractured faces. Manufacture crushed gravel from gravel particles 50 percent of which, by weight, are retained on the maximum size sieve listed in TABLE 1.

2.1.1.2 Graded-Crushed Aggregate Base Course

The percentage of loss of GCA coarse aggregate must not exceed 50 percent loss when tested in accordance with ASTM C131/C131M. Provide GCA coarse aggregate that does not exhibit a loss greater than 18 percent weighted average, at five cycles, when tested for soundness in magnesium sulfate, or 12 percent weighted average, at five cycles, when tested in sodium sulfate in accordance with ASTM C88. Provide aggregate that contains no more than 20 percent flat and elongated particles for the fraction retained on the 1/2 inch sieve nor 20 percent for the fraction passing the 1/2 inch sieve. A flat particle is 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. In the portion retained on each sieve specified, the crushed aggregate must contain at least 90 percent by weight of crushed pieces having two or more freshly fractured faces determined in accordance with ASTM D5821. When two fractures are contiguous, the angle between planes of the fractures must be at least 30 degrees in order to count as two fractured faces. Manufacture crushed gravel from gravel particles 90 percent of which by weight are retained on the maximum size sieve listed in TABLE 1.

2.1.2 Fine Aggregate

Provide fine aggregates consisting of angular particles of uniform density.

2.1.2.1 Aggregate Base Course

Provide ABC fine aggregate that consists of screenings, angular sand, crushed recycled concrete fines, or other finely divided mineral matter processed or naturally combined with the coarse aggregate.

2.1.2.2 Graded-Crushed Aggregate Base Course

Provide GCA fine aggregate consisting of angular particles produced by crushing stone, slag, recycled concrete, or gravel that meets the requirements for wear and soundness specified for GCA coarse aggregate. Produce fine aggregate by crushing only particles larger than No. 4 sieve in size. Provide fine aggregate that contains at least 90 percent by weight of particles having two or more freshly fractured faces in the portion passing the No. 4 sieve and retained on the No. 10 sieve, and in the portion passing the No. 10 sieve and retained on the No. 40 sieve.

2.1.3 Gradation Requirements

Apply the specified gradation requirements to the completed base course. Provide aggregates that are continuously well graded within the limits specified in TABLE 1. Use sieves that conform to ASTM E11.

TABLE 1. GRADATION OF AGGREGATES

Percentage by Weight Passing Square-Mesh Sieve

Sieve Designation	ABC
2 inch	----
1-1/2 inch	100
1 inch	75-97
1/2 inch	55-80
No. 4	35-55
No. 10	25-45
No. 40	14-30
No. 200	4-12

NOTE 1: Particles having diameters less than 0.02 mm must not be in excess of 3 percent by weight of the total sample tested as determined in accordance with AASHTO T 88.

NOTE 2: The values are based on aggregates of uniform specific gravity. If materials from different sources are used for the coarse and fine aggregates, test the materials in accordance with ASTM C127 and ASTM C128 to determine their specific gravities. Correct the percentages passing the various sieves as directed by the Contracting Officer if the specific gravities vary by more than 10 percent.

2.2 LIQUID LIMIT AND PLASTICITY INDEX

Apply liquid limit and plasticity index requirements to the completed course and to any component that is blended to meet the required gradation. The portion of any component or of the completed course passing the No. 40 sieve must be either nonplastic or have a liquid limit not greater than 25 and a plasticity index not greater than 5.

2.3 TESTS, INSPECTIONS, AND VERIFICATIONS

2.3.1 Initial Tests

Perform one of each of the following tests, on the proposed material prior to commencing construction, to demonstrate that the proposed material meets all specified requirements when furnished. Complete this testing for each source if materials from more than one source are proposed.

a. Sieve Analysis.

b. Liquid limit and plasticity index.

c. Moisture-density relationship.

d. Wear.

e. Soundness.

f. Weight per cubic foot of Slag.

Submit certified copies of test results for approval not less than 30 days before material is required for the work.

2.3.2 Approval of Material

Tentative approval of material will be based on initial test results.

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

When the ABC or GCA is constructed in more than one layer, clean the previously constructed layer of loose and foreign matter by sweeping with power sweepers or power brooms, except that hand brooms may be used in areas where power cleaning is not practicable. 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 or 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 by the Contracting Officer 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 base course(s). Do not construct base course(s) 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 base course(s). Stabilize by mixing ABC or GCA 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 base course is placed.

3.5 GRADE CONTROL

Provide a finished and completed 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 the coarse and fine aggregates in a stationary plant, or in a traveling plant or bucket loader on an approved paved working area. Make adjustments in mixing procedures or in equipment, as directed, to obtain true grades, to minimize segregation or degradation, to obtain the required water content, and to insure a satisfactory base course meeting all requirements of this specification. Place the mixed material on the prepared subgrade or subbase in layers of uniform thickness with an approved spreader. Place the layers so that when compacted they will be true to the grades or levels required with the least possible surface disturbance. Where the base course is placed in more than one layer, clean the previously constructed layers of loose and foreign matter by sweeping with power sweepers, power brooms, or hand brooms, as directed. Make adjustments in placing procedures or equipment as may be directed by the Contracting Officer to obtain true grades, to minimize segregation and degradation, to adjust the water content, and to insure an acceptable base course.

3.7 LAYER THICKNESS

Compact the completed base course to the thickness indicated. No individual layer may be thicker than 6 inches nor be thinner than 3 inches in compacted thickness. Compact the base course(s) to a total thickness

that is within 1/2 inch of the thickness indicated. Where the measured thickness is more than 1/2 inch deficient, correct such areas by scarifying, adding new material of proper gradation, reblading, and recompacting as directed. Where the measured thickness is more than 1/2 inch thicker than indicated, the course will be considered as conforming to the specified thickness requirements. The average job thickness will be the average of all thickness measurements taken for the job and must be within 1/4 inch of the thickness indicated. Measure the total thickness of the base course at intervals of one measurement for each 500 square yards of base course. Measure total thickness using 3 inch diameter test holes penetrating the base course.

3.8 COMPACTION

Compact each layer of the base course, as specified, with approved compaction equipment. Maintain water content during the compaction procedure to within plus or minus 2 percent of the optimum water content determined from laboratory tests as specified in this Section. 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 until each layer is compacted through the full depth to at least 100 percent of laboratory maximum density. Make such adjustments in compacting or finishing procedures as may be directed by the Contracting Officer to obtain true grades, to minimize segregation and degradation, to reduce or increase water content, and to ensure a satisfactory base course. Remove any materials found to be unsatisfactory and replace with satisfactory material or rework, as directed, to meet the requirements of this specification.

3.9 EDGES OF BASE COURSE

Place the base course(s) so that the completed section will be a minimum of 2 feet wider, on all sides, than the next layer that will be placed above it. Place approved material along the outer edges of the 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 layers, simultaneously roll and compact at least a 2 foot width of this shoulder material with the rolling and compacting of each layer of the base course, as directed.

3.10 FINISHING

Finish the surface of the top layer of base course after final compaction by cutting any overbuild to grade and rolling with a steel-wheeled roller. Do not add thin layers of material to the top layer of base course to meet grade. If the elevation of the top layer of base course is 1/2 inch or more below grade, scarify the top layer 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 as directed by the Contracting Officer to minimize segregation and degradation, obtain grades, maintain moisture content, and insure an acceptable base course. Should the surface become rough, corrugated, uneven in texture, or traffic marked prior to completion, scarify the unsatisfactory portion and rework and recompact it or replace as directed.

3.11 SMOOTHNESS TEST

Construct the top layer so that the surface shows no deviations in excess of 3/8 inch when tested with a 12 foot straightedge. Take measurements in successive positions parallel to the centerline of the area to be paved. Also take measurements perpendicular to the centerline at 50 foot intervals. Correct deviations exceeding this amount 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 each of the following tests on samples taken from the placed and compacted ABC and GCA. Take samples and test at the rates indicated. Perform sampling and testing of recycled concrete aggregate at twice the specified frequency until the material uniformity is established.

a. Perform density tests on every lift of material placed and at a frequency of one set of tests for every 250 square yards, or portion thereof, of completed area.

b. Perform sieve analysis on every lift of material placed and at a frequency of one sieve analysis for every 500 square yards, or portion thereof, of material placed.

c. Perform liquid limit and plasticity index tests at the same frequency as the sieve analysis.

d. Measure the thickness of the base course at intervals providing at least one measurement for each 500 square yards of base course or part thereof. Measure the thickness using test holes, at least 3 inch in diameter through the base 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 base course may 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 base course except when necessary for construction. When it is necessary for heavy equipment to travel on the completed base course, protect the area against marring or damage to the completed work.

3.14 MAINTENANCE

Maintain the base 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 base 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 of base course 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.

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SECTION 32 12 13

BITUMINOUS TACK AND PRIME COATS
05/17

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO T 102	(2009; R 2013) Standard Method of Test for Spot Test of Asphaltic Materials

ASTM INTERNATIONAL (ASTM)

ASTM D140/D140M	(2016) Standard Practice for Sampling Asphalt Materials
ASTM D2027/D2027M	(2013) Cutback Asphalt (Medium-Curing Type)
ASTM D2028/D2028M	(2015) Cutback Asphalt (Rapid-Curing Type)
ASTM D2995	(1999; R 2009) Determining Application Rate of Bituminous Distributors
ASTM D977	(2017) Standard Specification for Emulsified Asphalt

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Local/Regional Materials

SD-06 Test Reports

Sampling and Testing

1.3 QUALITY ASSURANCE

Certificates of compliance for asphalt materials delivered will be obtained and checked to ensure that specification requirements are met.

Quantities of applied material will be determined. Payment will be for amount of residual asphalt applied. Tack coat materials will not be diluted. Prime coat materials when emulsions are used can be diluted on site with potable water up to 1 part emulsion to 1 part water.

1.4 DELIVERY, STORAGE, AND HANDLING

Inspect the materials delivered to the site for contamination and damage. Unload and store the materials with a minimum of handling.

1.5 EQUIPMENT, TOOLS AND MACHINES

1.5.1 General Requirements

Equipment, tools and machines used in the work are subject to approval. Maintain in a satisfactory working condition at all times. Calibrate equipment such as asphalt distributors, scales, batching equipment, spreaders and similar equipment within 12 months of there use. If the calibration expires during project, recalibrate the equipment before work can continue.

1.5.2 Bituminous Distributor

Provide a self propelled distributor with pneumatic tires of such size and number to prevent rutting, shoving or otherwise damaging the surface being sprayed. Calibrate the distributer in accordance with ASTM D2995. Design and equip the distributor to spray the bituminous material in a uniform coverage at the specified temperature, at readily determined and controlled total liquid rates from 0.03 to 1.0 gallons per square yard, with a pressure range of 25 to 75 psi and with an allowable variation from the specified rate of not more than plus or minus 5 percent, and at variable widths. Include with the distributor equipment a separate power unit for the bitumen pump, full-circulation spray bars, tachometer, pressure gauges, volume-measuring devices, adequate heaters for heating of materials to the proper application temperature, a thermometer for reading the temperature of tank contents, and a hand hose attachment suitable for applying bituminous material manually to areas inaccessible to the distributor. The distributor will be capable of circulating and agitating the bituminous material during the heating process.

1.5.3 Heating Equipment for Storage Tanks

Use steam, electric, or hot oil heaters for heating the bituminous material. Provide steam heaters consisting of steam coils and equipment for producing steam, so designed that the steam cannot come in contact with the bituminous material. Fix an armored thermometer to the tank with a temperature range from 40 to 400 degrees F so that the temperature of the bituminous material may be determined at all times.

1.5.4 Power Brooms and Power Blowers

Use power brooms and power blowers suitable for cleaning the surfaces to which the bituminous coat is to be applied.

1.6 ENVIRONMENTAL REQUIREMENTS

Apply bituminous coat only when the surface to receive the bituminous coat is dry. A limited amount of moisture (approximately 0.03 gallon/square yard) can be sprayed on the surface of unbound material when prime coat is

used to improve coverage and penetration of asphalt material. Apply bituminous coat only when the atmospheric temperature in the shade is 50 degrees F or above and when the temperature has not been below 35 degrees F for the 12 hours prior to application, unless otherwise directed.

PART 2 PRODUCTS

2.1 PRIME COAT

Provide asphalt conforming to one of the following grades:

2.1.1 Cutback Asphalt

Provide cutback asphalt conforming to ASTM D2027/D2027M, Grade MC-70.

2.1.2 Emulsified Asphalt

Provide emulsified asphalt conforming to ASTM D977, Type SS-1 or SS1h. Asphalt emulsion can be diluted up to 1 part water to 1 part emulsion for prime coat use. Do not dilute asphalt emulsion for tack coat use.

2.2 TACK COAT

2.2.1 Cutback Asphalt

Provide cutback asphalt conforming to ASTM D2028/D2028M, RC-250.

2.2.2 Emulsified Asphalt

Provide emulsified asphalt conforming to ASTM D977, Type SS-1 or SS1h. For prime coats the emulsified asphalt can be diluted with up to 1 part emulsion to 1 part water. No dilution is allowed for tack coat applications. The base asphalt used to manufacture the emulsion is required to show a negative spot when tested in accordance with AASHTO T 102 using standard naphtha.

2.2.3 Local/Regional Materials

Use Local/Regional Materials or products extracted, harvested, or recovered, as well as manufactured, within a 500 mile radius from the project site, if available from a minimum of three sources.

PART 3 EXECUTION

3.1 PREPARATION OF SURFACE

Immediately before applying the bituminous coat, remove all loose material, dirt, clay, or other objectionable material from the surface to be treated by means of a power broom or blower supplemented with hand brooms. Apply treatment only when the surface is dry and clean.

3.2 APPLICATION RATE

The exact quantities within the range specified, which may be varied to suit field conditions, will be determined by the Contracting Officer.

3.2.1 Tack Coat

Apply bituminous material for the tack coat in quantities of not less than

0.03 gallons nor more than 0.10 gallons per square yard of residual asphalt onto the pavement surface as approved by the Contracting Officer. Do not dilute asphalt emulsion when used as a tack coat.

3.2.2 Prime Coat

Apply bituminous material for the prime coat in quantities of not less than 0.05 gallons nor more than 0.12 gallons per square yard of residual asphalt for asphalt emulsion up to a 1 to 1 dilution rate or for residual asphalt for cutback asphalt.

3.3 APPLICATION TEMPERATURE

3.3.1 Viscosity Relationship

Apply asphalt at a temperature that will provide a viscosity between 10 and 60 seconds, Saybolt Furol, or between 20 and 120 centistokes, kinematic. Furnish the temperature viscosity relation to the Contracting Officer.

3.3.2 Temperature Ranges

The viscosity requirements determine the application temperature to be used. The following is a normal range of application temperatures:

Cutback Asphalts	
MC-30	85-190 degrees F
SC-70, MC-70, RC-70	120-225 degrees F
SC-250, MC-250, RC-250	165-270 degrees F
Asphalt Emulsion	
All Grades	70-160 degrees F
Asphalt Cement	
All Grades	275-350 degrees F

Some of these temperatures for rapid cure cutbacks are above the flash point of the material and care should be taken in their heating.

3.4 APPLICATION

3.4.1 General

Following preparation and subsequent inspection of the surface, apply the bituminous prime or tack coat with the bituminous distributor at the specified rate with uniform distribution over the surface to be treated. Properly treat all areas and spots, not capable of being sprayed with the distributor, with the hand spray. Until the succeeding layer of pavement is placed, maintain the surface by protecting the surface against damage and by repairing deficient areas at no additional cost to the Government. If required, spread clean dry sand to effectively blot up any excess bituminous material. No smoking, fires, or flames other than those from

the heaters that are a part of the equipment are permitted within 25 feet of heating, distributing, and transferring operations of cutback materials. Prevent all traffic, except for paving equipment used in constructing the surfacing, from using the underlying material, whether primed or not, until the surfacing is completed. The bituminous coat requirements are described herein.

3.4.2 Prime Coat

The prime coat is required if it will be at least 7 days before the asphalt mixture is constructed on the underlying (base course, etc.) compacted material. The type of liquid asphalt and application rate will be as specified herein. Protect the underlying layer from any damage (water, traffic, etc.) until the surfacing is placed. If the Contractor places the surfacing within seven days, the choice of protection measures or actions to be taken is at the Contractor's option. Repair (recompact or replace) damage to the underlying material caused by lack of, or inadequate, protection by approved methods at no additional cost to the Government. If the Contractor opts to use the prime coat, apply as soon as possible after consolidation of the underlying material. Apply the bituminous material uniformly over the surface to be treated at a pressure range of 25 to 75 psi; the rate will be as specified above in paragraph APPLICATION RATE. To obtain uniform application of the prime coat on the surface treated at the junction of previous and subsequent applications, spread building paper on the surface for a sufficient distance back from the ends of each application to start and stop the prime coat on the paper and to ensure that all sprayers will operate at full force on the surface to be treated. Immediately after application remove and destroy the building paper.

3.4.3 Tack Coat

Apply tack coat at the locations shown on the drawings. A tack coat should be applied to every bound surface (asphalt or concrete pavement) that is being overlaid with asphalt mixture and at transverse and longitudinal joints. Apply the tack coat when the surface to be treated is clean and dry. Immediately following the preparation of the surface for treatment, apply the bituminous material by means of the bituminous distributor, within the limits of temperature specified herein and at a rate as specified above in paragraph APPLICATION RATE. Apply the bituminous material so that uniform distribution is obtained over the entire surface to be treated. Treat lightly coated areas and spots missed by the distributor by spraying with a hand wand or using other approved method. Following the application of bituminous material, allow the surface to cure without being disturbed for period of time necessary to permit setting of the tack coat. Apply the bituminous tack coat only as far in advance of the placing of the overlying layer as required for that day's operation. Maintain and protect the treated surface from damage until the succeeding course of pavement is placed.

3.5 CURING PERIOD

Following application of the bituminous material and prior to application of the succeeding layer of asphalt mixture allow the bituminous coat to cure and water or volatiles to evaporate prior to overlaying. Maintain the tacked surface in good condition until the succeeding layer of pavement is placed, by protecting the surface against damage and by repairing and recoating deficient areas. Allow the prime coat to cure without being disturbed for a period of at least 48 hours or longer, as

may be necessary to attain penetration into the treated course. Furnish and spread enough sand to effectively blot up excess bituminous material.

3.6 FIELD QUALITY CONTROL

Obtain certificates of compliance for all asphalt material delivered to the project. Obtain samples of the bituminous material under the supervision of the Contracting Officer. The sample may be retained and tested by the Government at no cost to the Contractor.

3.7 SAMPLING AND TESTING

Furnish certified copies of the manufacturer's test reports indicating temperature viscosity relationship for cutback asphalt or asphalt cement, compliance with applicable specified requirements, not less than 5 days before the material is required in the work.

3.7.1 Sampling

Unless otherwise specified, sample bituminous material in accordance with ASTM D140/D140M.

3.7.2 Calibration Test

Furnish all equipment, materials, and labor necessary to calibrate the bituminous distributor. Calibrate using the approved job material and prior to applying the bituminous coat material to the prepared surface. Calibrate the bituminous distributor in accordance with ASTM D2995.

3.7.3 Trial Applications

Before applying the spray application of tack or prime coat, apply three lengths of at least 100 feet for the full width of the distributor bar to evaluate the amount of bituminous material that can be satisfactorily applied.

3.7.3.1 Tack Coat Trial Application Rate

Unless otherwise authorized, apply the trial application rate of bituminous tack coat materials in the amount of 0.05 gallons per square yard. Make other trial applications using various amounts of material as may be deemed necessary.

3.7.3.2 Prime Coat Trial Application Rate

Unless otherwise authorized, apply the trial application rate of bituminous materials in the amount of 0.15 gallon per square yard. Make other trial applications using various amounts of material as may be deemed necessary.

3.7.4 Sampling and Testing During Construction

Perform quality control sampling and testing as required in paragraph FIELD QUALITY CONTROL.

3.8 TRAFFIC CONTROLS

Keep traffic off surfaces freshly treated with bituminous material. Provide sufficient warning signs and barricades so that traffic will not

travel over freshly treated surfaces.

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HOT-MIX ASPHALT (HMA) FOR ROADS

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HOT-MIX ASPHALT (HMA) FOR ROADS
08/09

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 156	(2013; R 2017) Standard Specification for Requirements for Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures
AASHTO M 320	(2017) Standard Specification for Performance-Graded Asphalt Binder
AASHTO T 304	(2011; R 2015) Standard Method of Test for Uncompacted Void Content of Fine Aggregate

ASPHALT INSTITUTE (AI)

AI MS-2	(2015) Asphalt Mix Design Methods
AI MS-22	(2001; 2nd Ed) Construction of Hot-Mix Asphalt Pavements
AI SP-2	(2001; 3rd Ed) Superpave Mix Design

ASTM INTERNATIONAL (ASTM)

ASTM C117	(2017) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C127	(2015) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
ASTM C128	(2015) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate
ASTM C131/C131M	(2014) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136/C136M	(2014) Standard Test Method for Sieve

	Analysis of Fine and Coarse Aggregates
ASTM C142/C142M	(2017) Standard Test Method for Clay Lumps and Friable Particles in Aggregates
ASTM C29/C29M	(2017a) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C566	(2013) Standard Test Method for Total Evaporable Moisture Content of Aggregate by Drying
ASTM C88	(2013) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM D140/D140M	(2016) Standard Practice for Sampling Asphalt Materials
ASTM D1461	(2017) Standard Test Method for Moisture or Volatile Distillates in Asphalt Mixtures
ASTM D2172/D2172M	(2017; E 2018) Standard Test Methods for Quantitative Extraction of Asphalt Binder from Asphalt Mixtures
ASTM D2419	(2014) Sand Equivalent Value of Soils and Fine Aggregate
ASTM D242/D242M	(2009; R 2014) Mineral Filler for Bituminous Paving Mixtures
ASTM D2489/D2489M	(2016) Standard Test Method for Estimating Degree of Particle Coating of Asphalt Mixtures
ASTM D2950/D2950M	(2014) Density of Bituminous Concrete in Place by Nuclear Methods
ASTM D3665	(2012; R 2017) Standard Practice for Random Sampling of Construction Materials
ASTM D3666	(2016) Standard Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials
ASTM D4125/D4125M	(2010) Asphalt Content of Bituminous Mixtures by the Nuclear Method
ASTM D4791	(2010) Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D4867/D4867M	(2009; R 2014) Effect of Moisture on Asphalt Concrete Paving Mixtures
ASTM D5444	(2015) Mechanical Size Analysis of Extracted Aggregate

ASTM D6307	(2016) Standard Test Method for Asphalt Content of Hot Mix Asphalt by Ignition Method
ASTM D6925	(2014) Standard Test Method for Preparation and Determination of the Relative Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
ASTM D6926	(2016) Standard Practice for Preparation of Asphalt Mixture Specimens Using Marshall Apparatus
ASTM D6927	(2015) Standard Test Method for Marshall Stability and Flow of Bituminous Mixtures

STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION (CALTRANS)

CTM 526	(2012) Methof of Test for Operation of California Profilograph and Evaluation of Profiles

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 171	(1995) Standard Test Method for Determining Percentage of Crushed Particles in Aggregate

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Mix Design; G

Quality Control; G

Material Acceptance; G

SD-04 Samples

Asphalt Cement Binder

Aggregates

SD-06 Test Reports

Aggregates; G

QC Monitoring

SD-07 Certificates

Asphalt Cement Binder; G

Testing Laboratory

1.3 ENVIRONMENTAL REQUIREMENTS

Do not place the hot-mix asphalt upon a wet surface or when the surface temperature of the underlying course is less than specified in Table 3. The temperature requirements may be waived by the Contracting Officer, if requested; however, meet all other requirements, including compaction.

Table 3. Surface Temperature Limitations of Underlying Course

Mat Thickness, inches	Degrees F
3 or greater	40
Less than 3	45

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Perform the work consisting of pavement courses composed of mineral aggregate and asphalt material heated and mixed in a central mixing plant and placed on a prepared course. HMA designed and constructed in accordance with this section shall conform to the lines, grades, thicknesses, and typical cross sections indicated. Construct each course to the depth, section, or elevation required by the drawings and roll, finish, and approve it before the placement of the next course.

2.1.1 Asphalt Mixing Plant

Plants used for the preparation of hot-mix asphalt shall conform to the requirements of AASHTO M 156 with the following changes:

2.1.1.1 Truck Scales

Weigh the asphalt mixture on approved, certified scales at the Contractor's expense. Inspect and seal scales at least annually by an approved calibration laboratory.

2.1.1.2 Testing Facilities

Provide laboratory facilities at the plant for the use of the Government's acceptance testing and the Contractor's quality control testing.

2.1.1.3 Inspection of Plant

Provide the Contracting Officer with access at all times, to all areas of the plant for checking adequacy of equipment; inspecting operation of the plant; verifying weights, proportions, and material properties; checking the temperatures maintained in the preparation of the mixtures and for taking samples. Provide assistance as requested, for the Government to

procure any desired samples.

2.1.1.4 Storage bins

Use of storage bins for temporary storage of hot-mix asphalt will be permitted as follows:

a. The asphalt mixture may be stored in non-insulated storage bins for a period of time not exceeding 3 hours.

b. The asphalt mixture may be stored in insulated storage bins for a period of time not exceeding 8 hours. The mix drawn from bins shall meet the same requirements as mix loaded directly into trucks.

2.1.2 Hauling Equipment

Provide trucks for hauling hot-mix asphalt having tight, clean, and smooth metal beds. To prevent the mixture from adhering to them, the truck beds shall be lightly coated with a minimum amount of paraffin oil, lime solution, or other approved material. Petroleum based products shall not be used as a release agent. Each truck shall have a suitable cover to protect the mixture from adverse weather. When necessary to ensure that the mixture will be delivered to the site at the specified temperature, truck beds shall be insulated or heated and covers (tarps) shall be securely fastened.

2.1.3 Asphalt Pavers

Provide asphalt pavers which are self-propelled, with an activated screed, heated as necessary, and capable of spreading and finishing courses of hot-mix asphalt which will meet the specified thickness, smoothness, and grade. The paver shall have sufficient power to propel itself and the hauling equipment without adversely affecting the finished surface.

2.1.3.1 Receiving Hopper

Provide paver with a receiving hopper of sufficient capacity to permit a uniform spreading operation and equipped with a distribution system to place the mixture uniformly in front of the screed without segregation. The screed shall effectively produce a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture.

2.1.4 Rollers

Rollers shall be in good condition and shall be operated at slow speeds to avoid displacement of the asphalt mixture. The number, type, and weight of rollers shall be sufficient to compact the mixture to the required density while it is still in a workable condition. Do not use equipment which causes excessive crushing of the aggregate.

2.2 AGGREGATES

Provide aggregates consisting of crushed stone, crushed gravel, crushed slag, screenings, natural sand and mineral filler, as required. Submit sufficient materials to produce 200 lb of blended mixture for mix design verification. The portion of material retained on the No. 4 sieve is coarse aggregate. The portion of material passing the No. 4 sieve and retained on the No. 200 sieve is fine aggregate. The portion passing the No. 200 sieve is defined as mineral filler. Submit all aggregate test

results and samples to the Contracting Officer at least 14 days prior to start of construction.

2.2.1 Coarse Aggregate

Provide coarse aggregate consisting of sound, tough, durable particles, free from films of material that would prevent thorough coating and bonding with the asphalt material and free from organic matter and other deleterious substances. All individual coarse aggregate sources shall meet the following requirements:

a. The percentage of loss shall not be greater than 40 percent after 500 revolutions when tested in accordance with ASTM C131/C131M.

b. The percentage of loss shall not be greater than 18 percent after five cycles when tested in accordance with ASTM C88 using magnesium sulfate or 12 percent when using sodium sulfate.

c. At least 75 percent by weight of coarse aggregate shall have at least two or more fractured faces when tested in accordance with COE CRD-C 171. Fractured faces shall be produced by crushing.

d. The particle shape shall be essentially cubical and the aggregate shall not contain more than 20 percent percent, by weight, of flat and elongated particles (3:1 ratio of maximum to minimum) when tested in accordance with ASTM D4791.

e. Slag shall be air-cooled, blast furnace slag, with a compacted weight of not less than 75 lb/cu ft when tested in accordance with ASTM C29/C29M.

f. Clay lumps and friable particles shall not exceed 0.3 percent, by weight, when tested in accordance with ASTM C142/C142M.

2.2.2 Fine Aggregate

Fine aggregate shall consist of clean, sound, tough, durable particles free from coatings of clay, silt, or any objectionable material and containing no clay balls.

a. All individual fine aggregate sources shall have a sand equivalent value not less than 45 when tested in accordance with ASTM D2419.

b. The fine aggregate portion of the blended aggregate shall have an uncompacted void content not less than 45.0 percent when tested in accordance with AASHTO T 304 Method A.

c. The quantity of natural sand (noncrushed material) added to the aggregate blend shall not exceed 25 percent by weight of total aggregate.

d. Clay lumps and friable particles shall not exceed 0.3 percent, by weight, when tested in accordance with ASTM C142/C142M

2.2.3 Mineral Filler

Mineral filler shall be nonplastic material meeting the requirements of ASTM D242/D242M.

2.2.4 Aggregate Gradation

The combined aggregate gradation shall conform to NCDOT Standard Specification for Roads and Structures Table 1005-1 std size #4 when tested in accordance with ASTM C136/C136M and ASTM C117, and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve or vice versa, but grade uniformly from coarse to fine.

2.3 ASPHALT CEMENT BINDER

Submit a 5 gallon sample for mix design verification. Asphalt cement binder shall conform to AASHTO M 320 Performance Grade (PG) 64-22. Test data indicating grade certification shall be provided by the supplier at the time of delivery of each load to the mix plant. Submit copies of these certifications to the Contracting Officer. The supplier is defined as the last source of any modification to the binder. The Contracting Officer may sample and test the binder at the mix plant at any time before or during mix production. Obtain samples for this verification testing in accordance with ASTM D140/D140M and in the presence of the Contracting Officer. Furnish these samples to the Contracting Officer for the verification testing, which shall be at no cost to the Contractor. Submit samples of the asphalt cement specified for approval not less than 14 days before start of the test section. Submit copies of certified test data, amount, type and description of any modifiers blended into the asphalt cement binder.

2.4 MIX DESIGN

a. Develop the mix design. The asphalt mix shall be composed of a mixture of well-graded aggregate, mineral filler if required, and asphalt material. The aggregate fractions shall be sized, handled in separate size groups, and combined in such proportions that the resulting mixture meets the grading requirements of the job mix formula (JMF). Submit proposed JMF; do not produce hot-mix asphalt for payment until a JMF has been approved. The hot-mix asphalt shall be designed in accordance with Marshall (MS-02), Superpave (SP-2), or Hveem (MS-02) procedures and the criteria shown in Table 5. Use the hand-held hammer to compact the specimens for Marshall mix design. If the Tensile Strength Ratio (TSR) of the composite mixture, as determined by ASTM D4867/D4867M is less than 75, the aggregates shall be rejected or the asphalt mixture treated with an approved anti-stripping agent. The amount of anti-stripping agent added shall be sufficient to produce a TSR of not less than 75. Provide an antistrip agent, if required, at no additional cost. Sufficient materials to produce 200 pound of blended mixture shall be provided to the Contracting Officer for verification of mix design at least 14 days prior to construction of test section.

b. At the option of the Contractor, a currently used DOT Superpave hot mix may be used in lieu of developing a Marshall hot mix design as described herein. Design the Superpave volumetric mix in accordance with AI SP-2 and ASTM D6925. The nominal maximum aggregate size (NMAS) shall be 1/2 inch. Other DOT hot mix design methods (Hveem, etc.) may be suitable, as determined by the Contracting Officer. The number of compaction gyrations, Ndes, shall be based on a design traffic of 0.3 to 3 equivalent single axle loads (million EASLs).

c. Design Superpave mixes with the number of gyrations specified in Table 5, unless the DOT option is chosen.

2.4.1 JMF Requirements

Submit in writing the job mix formula for approval at least 14 days prior to the start of the test section including as a minimum:

a. Percent passing each sieve size.

b. Percent of asphalt cement.

c. Percent of each aggregate and mineral filler to be used.

d. Asphalt viscosity grade, penetration grade, or performance grade.

e. Number of blows of hand-held hammer per side of molded specimen. (NA for Superpave)

f. Number of gyrations of Superpave gyratory compactor, (NA for Marshall mix design)

g. Laboratory mixing temperature.

h. Lab compaction temperature.

i. Temperature-viscosity relationship of the asphalt cement.

j. Plot of the combined gradation on the 0.45 power gradation chart, stating the nominal maximum size.

k. Graphical plots of stability (NA for Superpave), flow (NA for Superpave), air voids, voids in the mineral aggregate, and unit weight versus asphalt content as shown in AI MS-2.

l. Specific gravity and absorption of each aggregate.

m. Percent natural sand.

n. Percent particles with 2 or more fractured faces (in coarse aggregate).

o. Fine aggregate angularity.

p. Percent flat or elongated particles (in coarse aggregate).

q. Tensile Strength Ratio(TSR).

r. Antistrip agent (if required) and amount.

s. List of all modifiers and amount.

t. Correlation of hand-held hammer with mechanical hammer (NA for Superpave).

u. Percentage and properties (asphalt content, binder properties, and aggregate properties) of reclaimed asphalt pavement (RAP) in accordance with paragraph RECYCLED HOT-MIX ASPHALT, if RAP is used.

Table 5. Mix Design Criteria		
Test Property	50 Blows or Mix Gyrations	75 Blows or Mix Gyrations
Stability, pounds, minimum (NA for Superpave)	*1000	*1800
Flow, 0.01 inch, (NA for Superpave)	8-18	8-16
Air voids, percent	3-5	3-5
Percent Voids in mineral aggregate (VMA),(minimum)		
Gradation 1	13.0	13.0
Gradation 2	14.0	14.3
Gradation 3	15.0	15.0
TSR, minimum percent	75	75
* This is a minimum requirement. The average during construction shall be significantly higher than this number to ensure compliance with the specifications.		
** Calculate VMA in accordance with AI MS-2, based on ASTM C127 and ASTM C128 bulk specific gravity for the aggregate.		

2.4.2 Adjustments to Field JMF

Keep the Laboratory JMF for each mixture in effect until a new formula is approved in writing by the Contracting Officer. Should a change in sources of any materials be made, perform a new laboratory jmf design and a new JMF approved before the new material is used. The Contractor will be allowed to adjust the Laboratory JMF within the limits specified below to optimize mix volumetric properties with the approval of the Contracting Officer. Adjustments to the Laboratory JMF shall be applied to the field (plant) established JMF and limited to those values as shown. Adjustments shall be targeted to produce or nearly produce 4 percent voids total mix (VTM).

TABLE 6. Field (Plant) Established JMF Tolerances	
Sieves	Adjustments (plus or minus), percent
1/2 inch	3
No. 4	3
No. 8	3

TABLE 6. Field (Plant) Established JMF Tolerances	
Sieves	Adjustments (plus or minus), percent
No. 200	1
Binder Content	0.4

If adjustments are needed that exceed these limits, develop a new mix design. Tolerances given above may permit the aggregate grading to be outside the limits shown in Table 4; while not desirable, this is acceptable, except for the No. 200 sieve, which shall remain within the aggregate grading of Table 4.

2.5 RECYCLED HOT MIX ASPHALT

Recycled HMA shall consist of reclaimed asphalt pavement (RAP), coarse aggregate, fine aggregate, mineral filler, and asphalt cement to produce a consistent gradation and asphalt content and properties. When RAP is fed into the plant, the maximum RAP chunk size shall not exceed 2 inches. Design the recycled HMA mix using procedures contained in AI MS-2 and AI MS-22. The job mix shall meet the requirements of paragraph MIX DESIGN. The amount of RAP shall not exceed 30 percent.

2.5.1 RAP Aggregates and Asphalt Cement

The blend of aggregates used in the recycled mix shall meet the requirements of paragraph AGGREGATES. Establish the percentage of asphalt in the RAP for the mixture design according to ASTM D2172/D2172M or ASTM D6307 using the appropriate dust correction procedure.

2.5.2 RAP Mix

The blend of new asphalt cement and the RAP asphalt binder shall meet the requirements in paragraph ASPHALT CEMENT BINDER. The virgin asphalt cement shall not be more than two standard asphalt material grades different than that specified in paragraph ASPHALT CEMENT BINDER.

PART 3 EXECUTION

3.1 PREPARATION OF ASPHALT BINDER MATERIAL

Heat the asphalt cement material avoiding local overheating and providing a continuous supply of the asphalt material to the mixer at a uniform temperature. The temperature of unmodified asphalts shall be no more than 325 degrees F when added to the aggregates. Performance-Graded (PG) asphalts shall be within the temperature range of 265-320 degrees F when added to the aggregate.

3.2 PREPARATION OF MINERAL AGGREGATE

Heat and dry the aggregate for the mixture prior to mixing. No damage shall occur to the aggregates due to the maximum temperature and rate of heating used. The temperature of the aggregate and mineral filler shall not exceed 350 degrees F when the asphalt cement is added. The temperature shall not be lower than is required to obtain complete coating and uniform distribution on the aggregate particles and to provide a mixture of satisfactory workability.

3.3 PREPARATION OF HOT-MIX ASPHALT MIXTURE

The aggregates and the asphalt cement shall be weighed or metered and introduced into the mixer in the amount specified by the JMF. Mix the combined materials until the aggregate obtains a uniform coating of asphalt binder and is thoroughly distributed throughout the mixture. Wet mixing time shall be the shortest time that will produce a satisfactory mixture, but no less than 25 seconds for batch plants. Establish the wet mixing time for all plants based on the procedure for determining the percentage of coated particles described in ASTM D2489/D2489M, for each individual plant and for each type of aggregate used. The wet mixing time will be set to at least achieve 95 percent of coated particles. The moisture content of all hot-mix asphalt upon discharge from the plant shall not exceed 0.5 percent by total weight of mixture as measured by ASTM D1461.

3.4 PREPARATION OF THE UNDERLYING SURFACE

Immediately before placing the hot mix asphalt, clean the underlying course of dust and debris. Apply a prime coat and/or tack coat in accordance with the contract specifications.

3.5 TEST SECTION

Prior to full production, place a test section for each JMF used. Construct a test section 250 - 500 feet long and two paver passes wide placed for two lanes, with a longitudinal cold joint. The test section shall be of the same thickness as the course which it represents. The underlying grade or pavement structure upon which the test section is to be constructed shall be the same as the remainder of the course represented by the test section. The equipment and personnel used in construction of the test section shall be the same equipment to be used on the remainder of the course represented by the test section. Place the test section as part of the project pavement, as approved by the Contracting Officer.

3.5.1 Sampling and Testing for Test Section

Take one random sample at the plant, triplicate specimens compacted, and tested for stability, flow, and laboratory air voids. Test a portion of the same sample for theoretical maximum density (TMD), aggregate gradation and asphalt content. Take four randomly selected cores from the finished pavement mat, and four from the longitudinal joint, and tested for density. Random sampling shall be in accordance with procedures contained in ASTM D3665. The test results shall be within the tolerances shown in Table 7 for work to continue. If all test results meet the specified requirements, the test section shall remain as part of the project pavement. If test results exceed the tolerances shown, the test section shall be removed and replaced at no cost to the Government and another test section shall be constructed. The test section shall be paid for with the first lot of paving

Table 7. Test Section Requirements for Material and Mixture Properties	
Property	Specification Limit
Aggregate Gradation-Percent Passing (Individual Test Result)	
No. 4 and larger	JMF plus or minus 8
No. 8, No. 16, No. 30, and No. 50	JMF plus or minus 6
No. 100 and No. 200	JMF plus or minus 2.0
Asphalt Content, Percent (Individual Test Result)	JMF plus or minus 0.5
Laboratory Air Voids, Percent (Average of 3 specimens)	JMF plus or minus 1.0
VMA, Percent (Average of 3 specimens)	13 minimum
Stability, pounds (Average of 3 specimens) (NA for Superpave)	1800 minimum for 75 blows
Flow, 0.01 inch (Average of 3 specimens) (NA for Superpave)	8 - 18 for 50 blows
Mat Density, Percent of TMD (Average of 4 Random Cores)	92.0 - 96.0
Joint Density, Percent of TMD (Average of 4 Random Cores)	90.5 - 92.5

3.5.2 Additional Test Sections

If the initial test section should prove to be unacceptable, make the necessary adjustments to the JMF, plant operation, placing procedures, and/or rolling procedures and place a second test section. Additional test sections, as required, shall be constructed and evaluated for conformance to the specifications. Full production shall not begin until an acceptable section has been constructed and accepted.

3.6 TESTING LABORATORY

Submit certification of compliance and Plant Scale Calibration Certification. Use a laboratory to develop the JMF that meets the requirements of ASTM D3666. The Government will inspect the laboratory equipment and test procedures prior to the start of hot mix operations for conformance to ASTM D3666. The laboratory shall maintain the Corps certification for the duration of the project. A statement signed by the manager of the laboratory stating that it meets these requirements or clearly listing all deficiencies shall be submitted to the Contracting Officer prior to the start of construction. The statement shall contain as a minimum:

a. Qualifications of personnel; laboratory manager, supervising

technician, and testing technicians.

b. A listing of equipment to be used in developing the job mix.

c. A copy of the laboratory's quality control system.

d. Evidence of participation in the AASHTO Materials Reference Laboratory (AMRL) program.

3.7 TRANSPORTING AND PLACING

3.7.1 Transporting

Transport the hot-mix asphalt from the mixing plant to the site in clean, tight vehicles. Schedule deliveries so that placing and compacting of mixture is uniform with minimum stopping and starting of the paver. Provide adequate artificial lighting for night placements. Hauling over freshly placed material will not be permitted until the material has been compacted as specified, and allowed to cool to 140 degrees F. To deliver mix to the paver, use a material transfer vehicle operated to produce continuous forward motion of the paver.

3.7.2 Placing

Place and compact the mix at a temperature suitable for obtaining density, surface smoothness, and other specified requirements. Upon arrival, place the mixture to the full width by an asphalt paver; it shall be struck off in a uniform layer of such depth that, when the work is completed, it will have the required thickness and conform to the grade and contour indicated. Regulate the speed of the paver to eliminate pulling and tearing of the asphalt mat. Unless otherwise permitted, placement of the mixture shall begin along the centerline of a crowned section or on the high side of areas with a one-way slope. Place the mixture in consecutive adjacent strips having a minimum width of 10 feet. The longitudinal joint in one course shall offset the longitudinal joint in the course immediately below by at least 1 foot; however, the joint in the surface course shall be at the centerline of the pavement. Transverse joints in one course shall be offset by at least 10 feet from transverse joints in the previous course. Transverse joints in adjacent lanes shall be offset a minimum of 10 feet. On isolated areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the mixture may be spread and luted by hand tools.

3.8 COMPACTION OF MIXTURE

After placing, the mixture shall be thoroughly and uniformly compacted by rolling. Compact the surface as soon as possible without causing displacement, cracking or shoving. The sequence of rolling operations and the type of rollers used shall be at the discretion of the Contractor. The speed of the roller shall, at all times, be sufficiently slow to avoid displacement of the hot mixture and be effective in compaction. Any displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall be corrected at once. Furnish sufficient rollers to handle the output of the plant. Continue rolling until the surface is of uniform texture, true to grade and cross section, and the required field density is obtained. To prevent adhesion of the mixture to the roller, keep the wheels properly moistened but excessive water will not be permitted. In areas not accessible to the roller, the mixture shall be thoroughly compacted with hand tampers. Any mixture that

becomes loose and broken, mixed with dirt, contains check-cracking, or is in any way defective shall be removed full depth, replaced with fresh hot mixture and immediately compacted to conform to the surrounding area. This work shall be done at the Contractor's expense. Skin patching will not be allowed.

3.9 JOINTS

The formation of joints shall be performed ensuring a continuous bond between the courses and to obtain the required density. All joints shall have the same texture as other sections of the course and meet the requirements for smoothness and grade.

3.9.1 Transverse Joints

Do not pass the roller over the unprotected end of the freshly laid mixture, except when necessary to form a transverse joint. When necessary to form a transverse joint, it shall be made by means of placing a bulkhead or by tapering the course. The tapered edge shall be cut back to its full depth and width on a straight line to expose a vertical face prior to placing material at the joint. Remove the cutback material from the project. In both methods, all contact surfaces shall be given a light tack coat of asphalt material before placing any fresh mixture against the joint.

3.9.2 Longitudinal Joints

Longitudinal joints which are irregular, damaged, uncompacted, cold (less than 175 degrees F at the time of placing adjacent lanes), or otherwise defective, shall be cut back a maximum of 3 inches from the top of the course with a cutting wheel to expose a clean, sound vertical surface for the full depth of the course. All cutback material shall be removed from the project. All contact surfaces shall be given a light tack coat of asphalt material prior to placing any fresh mixture against the joint. The Contractor will be allowed to use an alternate method if it can be demonstrated that density, smoothness, and texture can be met.

3.10 QUALITY CONTROL

3.10.1 General Quality Control Requirements

Develop and submit an approved Quality Control Plan. Submit aggregate and QC test results. Do not produce hot-mix asphalt for payment until the quality control plan has been approved addressing all elements which affect the quality of the pavement including, but not limited to:

a. Mix Design

b. Aggregate Grading

c. Quality of Materials

d. Stockpile Management

e. Proportioning

f. Mixing and Transportation

g. Mixture Volumetrics

h. Moisture Content of Mixtures

i. Placing and Finishing

j. Joints

k. Compaction

l. Surface Smoothness

3.10.2 Testing Laboratory

Provide a fully equipped asphalt laboratory located at the plant or job site and meeting the pertinent requirements in ASTM D3666. Laboratory facilities shall be kept clean and all equipment maintained in proper working condition. The Contracting Officer shall be permitted unrestricted access to inspect the Contractor's laboratory facility, to witness quality control activities, and to perform any check testing desired. The Contracting Officer will advise the Contractor in writing of any noted deficiencies concerning the laboratory facility, equipment, supplies, or testing personnel and procedures. When the deficiencies are serious enough to adversely affect test results, the incorporation of the materials into the work shall be suspended immediately and will not be permitted to resume until the deficiencies are corrected.

3.10.3 Quality Control Testing

Perform all quality control tests applicable to these specifications and as set forth in the Quality Control Program. The testing program shall include, but shall not be limited to, tests for the control of asphalt content, aggregate gradation, temperatures, aggregate moisture, moisture in the asphalt mixture, laboratory air voids, stability (NA for Superpave), flow (NA for Superpave), in-place density, grade and smoothness. Develop a Quality Control Testing Plan as part of the Quality Control Program.

3.10.3.1 Asphalt Content

A minimum of two tests to determine asphalt content will be performed per lot (a lot is defined in paragraph MATERIAL ACCEPTANCE and PERCENT PAYMENT) by one of the following methods: the extraction method in accordance with ASTM D2172/D2172M, Method A or B, the ignition method in accordance with ASTM D6307, or the nuclear method in accordance with ASTM D4125/D4125M. Calibrate the ignition oven or the nuclear gauge for the specific mix being used. For the extraction method, determine the weight of ash, as described in ASTM D2172/D2172M, as part of the first extraction test performed at the beginning of plant production; and as part of every tenth extraction test performed thereafter, for the duration of plant production. The last weight of ash value obtained shall be used in the calculation of the asphalt content for the mixture.

3.10.3.2 Gradation

Determine aggregate gradations a minimum of twice per lot from mechanical analysis of recovered aggregate in accordance with ASTM D5444. When asphalt content is determined by the ignition oven or nuclear method, aggregate gradation shall be determined from hot bin samples on batch plants, or from the cold feed on drum mix plants. For batch plants, test

aggregates in accordance with ASTM C136/C136M using actual batch weights to determine the combined aggregate gradation of the mixture.

3.10.3.3 Temperatures

Check temperatures at least four times per lot, at necessary locations, to determine the temperature at the dryer, the asphalt cement in the storage tank, the asphalt mixture at the plant, and the asphalt mixture at the job site.

3.10.3.4 Aggregate Moisture

Determine the moisture content of aggregate used for production a minimum of once per lot in accordance with ASTM C566.

3.10.3.5 Moisture Content of Mixture

Determine the moisture content of the mixture at least once per lot in accordance with ASTM D1461 or an approved alternate procedure.

3.10.3.6 Laboratory Air Voids, Marshall Stability and Flow

Take mixture samples at least four times per lot compacted into specimens, using 50 blows per side with the hand-held Marshall hammer as described in ASTM D6926. When the Superpave gyratory compactor is used, mixes will be compacted to 50 gyrations in accordance with ASTM D6925. Hot-mix provided under the DOT Superpave option shall be compacted in accordance with the DOT requirements. After compaction, determine the laboratory air voids of each specimen. Stability and flow shall be determined for the Marshall-compacted specimens, in accordance with ASTM D6927.

3.10.3.7 In-Place Density

Conduct any necessary testing to ensure the specified density is achieved. A nuclear gauge may be used to monitor pavement density in accordance with ASTM D2950/D2950M.

3.10.3.8 Grade and Smoothness

Conduct the necessary checks to ensure the grade and smoothness requirements are met in accordance with paragraphs MATERIAL ACCEPTANCE and PERCENT PAYMENT.

3.10.3.9 Additional Testing

Any additional testing, which the Contractor deems necessary to control the process, may be performed at the Contractor's option.

3.10.3.10 QC Monitoring

Submit all QC test results to the Contracting Officer on a daily basis as the tests are performed. The Contracting Officer reserves the right to monitor any of the Contractor's quality control testing and to perform duplicate testing as a check to the Contractor's quality control testing.

3.10.4 Sampling

When directed by the Contracting Officer, sample and test any material which appears inconsistent with similar material being produced, unless

such material is voluntarily removed and replaced or deficiencies corrected by the Contractor. All sampling shall be in accordance with standard procedures specified.

3.10.5 Control Charts

For process control, establish and maintain linear control charts on both individual samples and the running average of last four samples for the parameters listed in Table 8, as a minimum. These control charts shall be posted as directed by the Contracting Officer and kept current at all times. The control charts shall identify the project number, the test parameter being plotted, the individual sample numbers, the Action and Suspension Limits listed in Table 8 applicable to the test parameter being plotted, and the Contractor's test results. Target values from the JMF shall also be shown on the control charts as indicators of central tendency for the cumulative percent passing, asphalt content, and laboratory air voids parameters. When the test results exceed either applicable Action Limit, take immediate steps to bring the process back in control. When the test results exceed either applicable Suspension Limit, halt production until the problem is solved. Use the control charts as part of the process control system for identifying trends so that potential problems can be corrected before they occur. Make decisions concerning mix modifications based on analysis of the results provided in the control charts. The Quality Control Plan shall indicate the appropriate action to be taken to bring the process into control when certain parameters exceed their Action Limits.

Table 8. Action and Suspension Limits for the Parameters to be Plotted on Individual and Running Average Control Charts

	Individual Samples		Running Average of Last Four Samples	
Parameter to be Plotted	Action Limit	Suspension Limit	Action Limit	Suspension Limit
No. 4 sieve, Cumulative percent passing, deviation for JMF target; plus or minus values	6	8	4	5
No. 30 sieve, Cumulative percent passing, deviation for JMF target; plus or minus values	4	6	3	4
No. 200 sieve, Cumulative percent passing, deviation for JMF target; plus or minus values	1.4	2.0	1.1	1.5
Stability, pounds (minimum) (NA for Superpave)				
75 Blow JMF	1800	1700	1900	1800
50 Blow JMF	1000	900	1100	1000
Flow, 0.01 inch (NA for Superpave)				
75 Blow JMF	8 min.	7 min.	9 min.	8 min.
	16 max.	17 max.	15 max.	16 max.

Table 8. Action and Suspension Limits for the Parameters to be Plotted on Individual and Running Average Control Charts				
	Individual Samples		Running Average of Last Four Samples	
Parameter to be Plotted	Action Limit	Suspension Limit	Action Limit	Suspension Limit
50 Blow JMF	8 min.	7 min.	9 min.	8 min.
	18 max.	19 max.	17 max.	18 max.
Asphalt content, percent deviation from JMF target; plus or minus value	0.4	0.5	0.2	0.3
Laboratory Air Voids, percent deviation from JMF target value	No specific action and suspension limits set since this parameter is used to determine percent payment			
In-place Mat Density, percent of TMD	No specific action and suspension limits set since this parameter is used to determine percent payment			
In-place Joint Density, percent of TMD	No specific action and suspension limits set since this parameter is used to determine percent payment			

3.11 MATERIAL ACCEPTANCE

Testing for acceptability of work will be performed by an independent laboratory hired by the Contractor. Forward test results and payment calculations daily to the Contracting Officer. Acceptance of the plant produced mix and in-place requirements will be on a lot to lot basis. A standard lot for all requirements will be equal to 8 hours of production.

3.11.1 Sublot Sampling

One random mixture sample for determining laboratory air voids, theoretical maximum density, and for any additional testing the Contracting Officer desires, will be taken from a loaded truck delivering mixture to each sublot, or other appropriate location for each sublot. All samples will be selected randomly, using commonly recognized methods of assuring randomness conforming to ASTM D3665 and employing tables of random numbers or computer programs. Laboratory air voids will be determined from three laboratory compacted specimens of each sublot sample in accordance with ASTM D6926. The specimens will be compacted within 2 hours of the time the mixture was loaded into trucks at the asphalt plant. Samples will not be reheated prior to compaction and insulated containers will be used as necessary to maintain the temperature.

3.11.2 Additional Sampling and Testing

The Contracting Officer reserves the right to direct additional samples and tests for any area which appears to deviate from the specification requirements. The cost of any additional testing will be paid for by the Government. Testing in these areas will be in addition to the lot testing, and the requirements for these areas will be the same as those for a lot.

3.11.3 Grade

The final wearing surface of pavement shall conform to the elevations and cross sections shown and shall vary not more than 0.05 foot from the plan grade established and approved at site of work. Finished surfaces at juncture with other pavements shall coincide with finished surfaces of abutting pavements. Deviation from the plan elevation will not be permitted in areas of pavements where closer conformance with planned elevation is required for the proper functioning of drainage and other appurtenant structures involved. The grade will be determined by running lines of levels at intervals of 25 feet, or less, longitudinally and transversely, to determine the elevation of the completed pavement surface. Within 5 working days, after the completion of a particular lot incorporating the final wearing surface, test the final wearing surface of the pavement for conformance with the specified plan grade. Diamond grinding may be used to remove high spots to meet grade requirements. Skin patching for correcting low areas or planing or milling for correcting high areas will not be permitted.

3.11.4 Surface Smoothness

Use one of the following methods to test and evaluate surface smoothness of the pavement. Perform all testing in the presence of the Contracting Officer. Keep detailed notes of the results of the testing and furnish a copy to the Government immediately after each day's testing. Use the profilograph method for all longitudinal testing, except where the runs would be less than 200 feet in length and the ends where the straightedge will be used. Where drawings show required deviations from a plane surface (crowns, drainage inlets, etc.), the surface shall be finished to meet the approval of the Contracting Officer.

3.11.4.1 Smoothness Requirements

3.11.4.1.1 Straightedge Testing

The finished surfaces of the pavements shall have no abrupt change of 1/4 inch or more, and all pavements shall be within the tolerances of 1/4 inch in both the longitudinal and transverse directions, when tested with an approved 12 feet straightedge.

3.11.4.1.2 Profilograph Testing

The finished surfaces of the pavements shall have no abrupt change of 1/8 inch or more, and each 0.1 mile segment of each pavement lot shall have a Profile Index not greater than 9 inches/mile when tested with an approved California-type profilograph. If the extent of the pavement in either direction is less than 200 feet, that direction shall be tested by the straightedge method and shall meet requirements specified above.

3.11.4.2 Testing Method

After the final rolling, but not later than 24 hours after placement, test the surface of the pavement in each entire lot in such a manner as to reveal all surface irregularities exceeding the tolerances specified above. Separate testing of individual sublots is not required. If any pavement areas are ground, these areas shall be retested immediately after grinding. Test each lot of the pavement in both a longitudinal and a transverse direction on parallel lines. Set the transverse lines 15 feet or less apart, as directed. The longitudinal lines shall be at the

centerline of each paving lane for lanes less than 20 feet wide and at the third points for lanes 20 feet or wider. Also test other areas having obvious deviations. Longitudinal testing lines shall be continuous across all joints.

3.11.4.2.1 Straightedge Testing

Hold the straightedge in contact with the surface and move it 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 allowing it to rest upon the two highest spots covered by its length, and measuring the maximum gap between the straightedge and the pavement surface in the area between these two high points.

3.11.4.2.2 Profilograph Testing

Perform profilograph testing using approved equipment and procedures described in CTM 526. The equipment shall utilize electronic recording and automatic computerized reduction of data to indicate "must-grind" bumps and the Profile Index for each 0.1 mile segment of each pavement lot. Grade breaks on parking lots shall be accommodated by breaking the profile segment into shorter sections and repositioning the blanking band on each segment. The "blanking band" shall be 0.2 inches wide and the "bump template" shall span 1 inch with an offset of 0.3 inch. Compute the Profile Index for each pass of the profilograph in each 0.1 mile segment. The Profile Index for each segment shall be the average of the Profile Indices for each pass in each segment. The profilograph shall be operated by a DOT approved operator. Furnish a copy of the reduced tapes to the Government at the end of each day's testing.

-- End of Section --

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PORTLAND CEMENT CONCRETE PAVEMENT FOR ROADS AND SITE FACILITIES
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PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN CONCRETE INSTITUTE INTERNATIONAL (ACI)

ACI 211.1	(1991; R 2009) Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete
ACI 301	(2016) Specifications for Structural Concrete
ACI 305.1	(2014) Specification for Hot Weather Concreting
ACI 306.1	(1990; R 2002) Standard Specification for Cold Weather Concreting
ACI 325.12R	(2002; R 2013) Guide for Design of Jointed Concrete Pavements for Streets and Local Roads
ACI 330R	(2008) Guide for the Design and Construction of Concrete Parking Lots

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C215	(2016) Extruded Polyolefin Coatings for Steel Water Pipe

ASTM INTERNATIONAL (ASTM)

ASTM A184/A184M	(2017) Standard Specification for Welded Deformed Steel Bar Mats for Concrete Reinforcement
ASTM A615/A615M	(2016) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A775/A775M	(2017) Standard Specification for Epoxy-Coated Steel Reinforcing Bars
ASTM A966/A966M	(2015) Standard Test Method for Magnetic Particle Examination of Steel Forgings Using Alternating Current

ASTM C1077	(2017) Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
ASTM C1260	(2014) Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C143/C143M	(2015) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C150/C150M	(2018) Standard Specification for Portland Cement
ASTM C1549	(2016) Standard Test Method for Determination of Solar Reflectance Near Ambient Temperature Using a Portable Solar Reflectometer
ASTM C1567	(2013) Standard Test Method for Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
ASTM C1602/C1602M	(2012) Standard Specification for Mixing Water Used in Production of Hydraulic Cement Concrete
ASTM C171	(2016) Standard Specification for Sheet Materials for Curing Concrete
ASTM C172/C172M	(2017) Standard Practice for Sampling Freshly Mixed Concrete
ASTM C231/C231M	(2017a) 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 C309	(2011) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C31/C31M	(2018a) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C33/C33M	(2018) Standard Specification for Concrete Aggregates
ASTM C494/C494M	(2017) Standard Specification for Chemical Admixtures for Concrete
ASTM C618	(2017a) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete

ASTM C78/C78M	(2018) Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
ASTM C94/C94M	(2017a) Standard Specification for Ready-Mixed Concrete
ASTM C989/C989M	(2018) Standard Specification for Slag Cement for Use in Concrete and Mortars

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-250-01	(2016) Pavement Design for Roads and Parking Areas

1.2 DESIGN

This materials and construction specification is intended to be used on projects where the design was completed using UFC 3-250-01 Pavement Design for Roads, Streets, Walks, and Open Storage Areas, ACI 330R, Guide for the Design and Construction of Concrete Parking Lots or ACI 325.12R, Guide for Design of Jointed Concrete Pavements for Streets and Local Roads, or equivalent.

1.3 RELATED SECTIONS

Portland cement concrete pavement must use Section 32 11 23 AGGREGATE BASE COURSES, in addition to this section.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance with Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Curing Materials; G

Admixtures; G

Dowel; G

Reinforcement; G

Submit a complete list of materials including type, brand and applicable reference specifications.

Cementitious Materials; G

Aggregate; G

Albedo

Provide information identifying the reflectance of the pavement.

SD-04 Samples

SD-05 Design Data

Concrete Mix Design; G

Thirty days minimum prior to concrete placement, submit a mix design, with applicable tests, for each strength and type of concrete for approval. Submit a complete list of materials including type; brand; source and amount of cement, fly ash, slag, and admixtures; and applicable reference specifications. Provide mix proportion data using at least three different water-cement ratios for each type of mixture, which will produce a range of strength encompassing those required for each class and type of concrete required. Submittal must clearly indicate where each mix design will be used when more than one mix design is submitted. Obtain acknowledgement of approvals prior to concrete placement. Submit a new mix design for each material source change.

SD-06 Test Reports

Aggregate Tests; G

Concrete Slump Tests; G

Air Content Tests; G

Flexural Strength Tests; G

Cementitious Materials; G

SD-07 Certificates

Ready-mixed Concrete Plant; G

Batch Tickets; G

Cementitious Materials; G

1.5 DELIVERY, STORAGE, AND HANDLING

ASTM C94/C94M.

1.6 QUALITY ASSURANCE

1.6.1 Ready-mixed Concrete Plant Certification

Unless otherwise approved by the Contracting Officer, ready mixed concrete must be produced and provided by a National Ready-Mix Concrete Association (NRMCA) certified plant. If a volumetric mobile mixer is used to produce the concrete, rather than ready-mixed concrete, the mixer(s) must conform to the standards of the Volumetric Mixer Manufacturers Bureau (VMMB). Verification must be made by a current VMMB conformance plate affixed to the volumetric mixer equipment.

1.6.2 Contractor Qualifications

Unless waived by the Contracting Officer, the Contractor must meet one of

the following criteria:

a. Contractor must have at least one National Ready Mixed Concrete Association (NRMCA) certified concrete craftsman and at least one American Concrete Institute (ACI) Flatwork Finisher Certified craftsman on site, overseeing each placement crew during all concrete placement.

b. Contractor must have no less than three NRMCA certified concrete installers and at least two American Concrete Institute (ACI) Flatwork Finisher Certified installers, who must be on site working as members of each placement crew during all concrete placement.

1.6.3 Required Information

Submit copies of laboratory test reports showing that the mix has been successfully tested to produce concrete with the properties specified and that mix will be suitable for the job conditions. The laboratory test reports must include mill test and all other test for cementitious materials, aggregates, and admixtures. Provide maximum nominal aggregate size, combined aggregate gradation analysis, percentage retained and passing sieve, and a graph of percentage retained verses sieve size. Submit test reports along with the concrete mix design. Sampling and testing of materials, concrete mix design, sampling and testing in the field must be performed by a commercial testing laboratory which conforms to ASTM C1077. The laboratory must be approved in writing by the Contracting Officer.

1.6.4 Batch Tickets

ASTM C94/C94M. Submit mandatory batch ticket information for each load of ready-mixed concrete.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Cementitious Materials

Cementitious materials in concrete mix must be 20 to 50 percent non-portland cement pozzolanic materials by weight. Provide test data demonstrating compatibility and performance of concrete satisfactory to Contracting Officer.

2.1.1.1 Cement

ASTM C150/C150M, Type I or II III, for high early concrete or V.

2.1.1.2 Fly Ash and Pozzolan

ASTM C618, Type F, or N. Fly ash certificates must include test results in accordance with ASTM C618.

2.1.1.3 Ultra Fine Fly Ash and Ultra Fine Pozzolan

Ultra Fine Fly Ash (UFFA) and Ultra Fine Pozzolan (UFP) must conform to ASTM C618, Class F or N, and the following additional requirements:

a. The strength activity index at 28 days of age must be at least 95

percent of the control specimens.

b. The average particle size must not exceed 6 microns.

2.1.1.4 Slag

ASTM C989/C989M, Slag Cement (formerly Ground Granulated Blast Furnace Slag) Grade 100 or 120. Certificates must include test results in accordance with ASTM C989/C989M.

2.1.1.5 Supplementary Cementitious Materials (SCM) Content

The concrete mix must always contain one of the SCMs listed in Table 1 within the range specified therein, whether or not the aggregates are found to be reactive in accordance with the paragraph ALKALI REACTIVITY TEST".

TABLE 1
SUPPLEMENTARY CEMENTITIOUS MATERIALS CONTENT

Supplementary Cementitious Material	Minimum Content (percent)	Maximum Content (percent)
Class N Pozzolan and Class F Fly Ash		
$SiO_2 + Al_2O_3 + Fe_2O_3 > 70$ percent	25	35
$SiO_2 + A1_2O_3 + Fe_2O_3 > 80$ percent	20	35
$SiO_2 + A1_2O_3 + Fe_2O_3 > 90$ percent	15	35
UFFA and UFP	7	16
GGBF Slag	40	50

2.1.2 Water

Water must conform to ASTM C1602/C1602M. Hot water must not be used unless approved by the Contracting Officer.

2.1.3 Aggregate

Coarse aggregate must consist of crushed or uncrushed gravel, crushed stone, or a combination thereof. Aggregates, as delivered to the mixers, must consist of clean, hard, uncoated particles. Coarse aggregate must be washed. Washing must be sufficient to remove dust and other coatings. Fine aggregate must consist of natural sand, manufactured sand, or a combination of the two, and must be composed of clean, hard, durable particles. Both coarse and fine aggregates must meet the requirements of ASTM C33/C33M.

2.1.3.1 Alkali Reactivity Test

Aggregates to be used in all concrete in projects over 50,000 SF in size must be evaluated and tested for alkali-aggregate reactivity in accordance with ASTM C1260. The types of aggregates must be evaluated in a combination which matches the proposed mix design (including Class F fly

ash or GGBF slag), utilizing ASTM C1567. Test results of the combination must have a measured expansion of less than 0.08 percent at 28 days. Should the test data indicate an expansion of greater than 0.08%, the aggregate(s) must be rejected and new aggregate sources must be submitted for retesting or may submit additional test results incorporating Lithium Nitrate for consideration.

ASTM C1567 must be performed as follows to include one of the following options:

a. Utilize the low alkali Portland cement and Class F fly ash in combination for the test proportioning. The laboratory must use the Contractor's proposed percentage of cement and fly ash.

b. Utilize the low alkali Portland cement and ground granulated blast furnace (GGBF) slag in combination for the test proportioning. The laboratory must use the Contractor's proposed percentage of cement and GGBF.

c. Utilize the low alkali Portland cement and Class F fly ash and ground granulated blast furnace (GGBF) slag in combination for the test proportioning. The laboratory must use the Contractor's proposed percentage of cement, fly ash and GGBF.

2.1.3.2 Fine Aggregates

ASTM C33/C33M.

2.1.3.3 Coarse Aggregates

ASTM C33/C33M.

2.1.4 Admixtures

ASTM C494/C494M: Type A, water reducing; Type B, retarding; Type C, accelerating; Type D, water-reducing and retarding; and Type E, water-reducing and accelerating admixture. Do not use calcium chloride admixtures. Where not shown or specified, the use of admixtures is subject to written approval of the Contracting Officer.

ASTM C260/C260M: Air-entraining.

2.1.5 Reinforcement

2.1.5.1 Dowel Bars

Bars must conform to ASTM A615/A615M, Grade 60 for plain billet-steel bars of the size and length indicated. Remove all burrs and projections from the bars.

2.1.5.2 Coated Dowel Bars

Bars must conform to ASTM A615/A615M, Grade 60 for plain billet-steel bars of the size and length indicated. Remove all burrs or projections from the dowel bars. Coating system must conform to AWWA C215, Type 2. Coat the bars with a double coat system or an epoxy coating system for resistance to penetration of oil and salt solutions. The systems must be in accordance with manufacturer's recommendation for coatings which are not bondable to concrete. Bond the coating to the dowel bar to resist

laps or folds during movement of the joint. Coating thickness must be 7 mils minimum and 20 mils maximum.

2.1.5.3 Tie Bars

Bars must be billet or axle steel deformed bars and conform to ASTM A615/A615M or ASTM A966/A966M Grade 60. Epoxy coated in accordance with ASTM A775/A775M.

2.1.5.4 Reinforcement

Deformed steel bar mats must conform to ASTM A184/A184M. Bar reinforcement must conform to ASTM A615/A615M, Grade 60.

2.1.6 Curing Materials

2.1.6.1 White-Burlap-Polyethylene Sheet

ASTM C171, 0.004 inch thick white opaque polyethylene bonded to 10 oz/linear yard (40 inch) wide burlap.

2.1.6.2 Liquid Membrane-Forming Compound

ASTM C309, white pigmented, Type 2, Class B, free of paraffin or petroleum.

2.1.7 Joint Fillers and Sealants

Provide as specified in Section 32 01 19 FIELD MOLDED SEALANTS FOR SEALING JOINTS IN RIGID PAVEMENTS.

2.2 CONCRETE PAVEMENT

2.2.1 Joint Layout Drawings

If jointing requirements on the project drawings are not compatible with the proposed placement sequence, submit a joint layout plan shop drawing to the Contracting Officer for approval. No work must be allowed to start until the joint layout plan is approved. The joint layout plan must indicate and describe in the detail the proposed jointing plan for contraction joints, expansion joints, and construction joints, in accordance with the following:

a. Indicate locations of contraction joints, construction joints, and expansion joints. Spacing between contraction joints must not exceed 15 feet unless noted otherwise or approved by the Contracting Officer.

b. The larger dimension of a panel must not be greater than 125% of the smaller dimension.

c. The minimum angle between two intersecting joints must be 80 degrees, unless noted otherwise or approved by the Contracting Officer.

d. Joints must intersect pavement-free edges at a 90 degree angle the pavement edge and must extend straight for a minimum of 1.5 feet from the pavement edge, where possible.

e. Align joints of adjacent panels.

f. Align joints in attached curbs with joints in pavement when possible.

g. Ensure joint depth, widths, and dimensions are specified.

h. Minimum contraction joint depth must be 1/4 of the pavement thickness. The minimum joint width must be 1/8 inch.

i. Use expansion joints only where pavement abuts buildings, foundations, manholes, and other fixed objects.

2.2.2 Albedo

Provide a system with a minimum initial Solar Reflectance of at least 0.33 and a 3-year aged of 0.28 as tested in accordance with ASTM C1549.

2.3 CONTRACTOR-FURNISHED MIX DESIGN

Contractor-furnished concrete mix must be designed in accordance with ACI 211.1 except as modified herein, and the mix design must be as specified herein under paragraph SUBMITTALS. The concrete must have a minimum flexural strength of 650 pounds per square inch at 28 days. The concrete may be air entrained. If air entrainment is used the air content must be 6.0. Maximum size aggregate for slip forming must be 1.5 inches. The slump must be one to 3 inches (or less when slip form is used). For slipformed pavement, at the start of the project, select a maximum allowable slump which will produce in-place pavement meeting the specified tolerances for control of edge slump. The selected slump must be applicable to both pilot and fill-in lanes.

If the cementitious material is not sufficient to produce concrete of the flexural strength required it must be increased as necessary, without additional compensation under the Contract. The cementitious factor must be calculated using cement, Class F fly ash, and or GGBF slag. The mix must use a SCM material by weight in accordance with Table 1 in "Supplementary Cementitious Materials (SCM) Content"

PART 3 EXECUTION

3.1 FORMS

3.1.1 Construction

Construct forms to be removable without damaging the concrete.

3.1.2 Coating

Before placing the concrete, coat the contact surfaces of forms except existing pavement sections where bonding is required, with a non-staining mineral oil, non-staining form coating compound, biodegradable form release agent, or two coats of nitro-cellulose lacquer. When using existing pavement as a form, clean existing concrete and then coat with asphalt emulsion bondbreaker before concrete is placed.

3.1.3 Grade and Alignment

Check and correct grade elevations and alignment of the forms immediately before placing the concrete.

3.2 REINFORCEMENT

3.2.1 Dowel Bars

Install bars accurately aligned, vertically and horizontally, at indicated locations and to the dimensions and tolerances indicated. Before installation thoroughly grease the sliding portion of each dowel. Dowels must remain in position during concrete placement and curing.

3.2.2 Coated Dowel Bars

Install bars, accurately aligned vertically and horizontally, at indicated locations and to the dimensions and tolerances indicated. Reject coatings which are perforated, cracked or otherwise damaged. While handling avoid scuffing or gouging of the coatings.

3.2.3 Tie Bars

Install bars, accurately aligned horizontally and vertically, at indicated locations. For slipform construction, insert bent tie bars by hand or other approved means.

3.2.4 Setting Slab Reinforcement

Reinforcement must be positioned on suitable chairs prior to concrete placement. At expansion, contraction and construction joints, place the reinforcement as indicated. Reinforcement, when placed in concrete, must be free of mud, oil, scale or other foreign materials. Place reinforcement accurately and wire securely. The laps at splices must be 12 inches minimum and the distances from ends and sides of slabs and joints must be as indicated.

3.3 MEASURING, MIXING, CONVEYING, AND PLACING CONCRETE

3.3.1 Measuring

ASTM C94/C94M.

3.3.2 Mixing

ASTM C94/C94M, except as modified herein. Begin mixing within 30 minutes after cement has been added to aggregates. When the air temperature is greater than 85 degrees F, place concrete within 60 minutes. With the approval of the Contracting Officer, a hydration stabilizer admixture meeting the requirements of ASTM C494/C494M Type D, may be used to extend the placement time to 90 minutes. Additional water may be added to bring slump within required limits as specified in Section 11.7 of ASTM C94/C94M, provided that the specified water-cement ratio is not exceeded.

3.3.3 Conveying

ASTM C94/C94M.

3.3.4 Placing

Follow guidance of ACI 301, except as modified herein. Do not exceed a free vertical drop of 5 feet from the point of discharge. Deposit concrete either directly from the transporting equipment or by conveyor on to the pre-wetted subgrade or subbase, unless otherwise specified. Do not place

concrete on frozen subgrade or subbase. Deposit the concrete between the forms to an approximately uniform height. Place concrete continuously at a uniform rate, with minimum amount of segregation, without damage to the grade and without unscheduled stops except for equipment failure or other emergencies. If this occurs within 10 feet of a previously placed expansion joint, remove concrete back to joint, repair any damage to grade, install a construction joint and continue placing concrete only after cause of the stop has been corrected.

3.3.5 Vibration

Immediately after spreading concrete, consolidate concrete with internal type vibrating equipment along the boundaries of all slabs regardless of slab thickness, and interior of all concrete slabs 6 inches or more in thickness. Limit duration of vibration to that necessary to produce consolidation of concrete. Excessive vibration will not be permitted. Vibrators must not be operated in concrete at one location for more than 15 seconds. Vibrating equipment of a type approved by the Contracting Officer may be used to consolidate concrete in unreinforced pavement slabs less than 6 inches thick.

3.3.5.1 Vibrating Equipment

Operate equipment, except hand-manipulated equipment, ahead of the finishing machine. Select the number of vibrating units and power of each unit to properly consolidate the concrete. Mount units on a frame that is capable of vertical movement and, when necessary, radial movement, so vibrators may be operated at any desired depth within the slab or be completely withdrawn from the concrete. Clear distance between frame-mounted vibrating units that have spuds that extend into the slab at intervals across the paving lane must not exceed 30 inches. Distance between end of vibrating tube and side form must not exceed 2 inches. For pavements less than 10 inches thick, operate vibrators at mid-depth parallel with or at a slight angle to the subbase. For thicker pavements, angle vibrators toward the vertical, with vibrator tip preferably about 2 inches from subbase, and top of vibrator a few inches below pavement surface. Vibrators may be pneumatic, gas driven, or electric, and must be operated at frequencies within the concrete of not less than 8,000 vibrations per minute. Amplitude of vibration must be such that noticeable vibrations occur at 1.5 foot radius when the vibrator is inserted in the concrete to the depth specified.

3.3.6 Cold Weather

Except with authorization, do not place concrete when ambient temperature is below 40 degrees F or when concrete is likely to be subjected to freezing temperatures within 24 hours. When authorized, when concrete is likely to be subjected to freezing within 24 hours after placing, heat concrete materials so that temperature of concrete when deposited is between 65 and 80 degrees F. Methods of heating materials are subject to approval of the Contracting Officer. Do not heat mixing water above 165 degrees F. Remove lumps of frozen material and ice from aggregates before placing aggregates in mixer. Follow practices found in ACI 306.1.

3.3.7 Hot Weather

Maintain required concrete temperature in accordance with Figure NRMCA NOMOGRAPH FOR ESTIMATING EVAPORATION RATE ON THE BASIS OF MENZEL FORMULA in ACI 305.1 to prevent evaporation rate from exceeding 0.2 pound of water

per square foot of exposed concrete per hour. Cool ingredients before mixing or use other suitable means to control concrete temperature and prevent rapid drying of newly placed concrete. After placement, use fog spray, apply monomolecular film, or use other suitable means to reduce the evaporation rate. Start curing when surface of fresh concrete is sufficiently hard to permit curing without damage. Cool underlying material by sprinkling lightly with water before placing concrete. Follow practices found in ACI 305.1.

3.4 PAVING

Pavement must be constructed with paving and finishing equipment utilizing fixed forms or slipforms.

3.4.1 Consolidation

The paver vibrators must be inserted into the concrete not closer to the underlying material than 2 inches. The vibrators or tamping units in front of the paver must be automatically controlled so that they stop immediately as forward motion ceases. Excessive vibration must not be permitted. Concrete in small, odd-shaped slabs or in locations inaccessible to the paver mounted vibration equipment must be vibrated with a hand-operated immersion vibrator. Vibrators must not be used to transport or spread the concrete.

3.4.2 Operation

When the paver is operated between or adjacent to previously constructed pavement (fill-in lanes), provisions must be made to prevent damage to the previously constructed pavement, including keeping the existing pavement surface free of debris, and placing rubber mats beneath the paver tracks. Transversely oscillating screeds and extrusion plates must overlap the existing pavement the minimum possible, but in no case more than 8 inches.

3.4.3 Required Results

The paver-finisher must be operated to produce a thoroughly consolidated slab throughout, true to line and grade within specified tolerances. The paver-finishing operation must produce a surface finish free of irregularities, tears, voids of any kind, and other discontinuities. It must produce only a minimum of paste at the surface. Multiple passes of the paver-finisher must not be permitted. The equipment and its operation must produce a finished surface requiring no hand finishing, other than the use of cutting straightedges, except in very infrequent instances. No water, other than true fog sprays (mist), must be applied to the concrete surface during paving and finishing.

3.4.4 Fixed Form Paving

Forms must be steel, except that wood forms may be used for curves having a radius of 150 feet or less, and for fillets. Forms may be built up with metal or wood, added only to the base, to provide an increase in depth of not more than 25 percent. The base width of the form must be not less than eight-tenths of the vertical height of the form, except that forms 8 inches or less in vertical height must have a base width not less than the vertical height of the form. Wood forms for curves and fillets must be adequate in strength and rigidly braced. Forms must be set on firm material cut true to grade so that each form section when placed will be firmly in contact with the underlying layer for its entire base. Forms

must not be set on blocks or on built-up spots of underlying material. Forms for overlay pavements and for other locations where forms must be set on existing pavements must be held securely in place with stakes or by other approved methods. Holes in existing pavements for form stakes must be carefully drilled without cracking or spalling the existing pavement. Prior to setting forms for paving operations, demonstrate the proposed form setting procedures at an approved location and do not proceed further until the proposed method is approved. Forms must remain in place at least 12 hours after the concrete has been placed. Forms must be removed without injuring the concrete.

3.4.5 Slipform Paving

The slipform paver must shape the concrete to the specified and indicated cross section in one pass, and must finish the surface and edges so that only a very minimum amount of hand finishing is required. Dowels must not be installed by dowel inserters attached to the paver or by any other means of inserting the dowels into the plastic concrete. If a keyway is required, a 26 gauge thick metal keyway liner must be installed as the keyway is extruded. The keyway liner must be protected and must remain in place and become part of the joint.

3.4.6 Placing Reinforcing Steel

Reinforcement must be positioned on suitable chairs securely fastened to the subgrade prior to concrete placement. If reinforcing for Continuously Reinforced Concrete Pavement (CRCP) is required, the entire operating procedure and equipment proposed must be submitted for approval at least 30 days prior to proposed start of paving.

3.4.7 Placing Dowels and Tie Bars

Dowels must be installed with alignment not greater than 1/8 inch per ft. Except as otherwise specified below, location of dowels must be within a horizontal tolerance of plus or minus 5/8 inch and a vertical tolerance of plus or minus 3/16 inch. The portion of each dowel intended to move within the concrete or expansion cap must be painted with one coat of rust inhibiting primer paint, and then oiled just prior to placement. Dowels and tie bars in joints must be omitted when the center of the dowel or tie bar is located within a horizontal distance from an intersecting joint equal to or less than one-fourth of the slab thickness.

3.4.7.1 Contraction Joints

Dowels and tie bars in longitudinal and transverse contraction joints within the paving lane must be held securely in place by means of rigid metal basket assemblies. The dowels and tie bars must be welded to the assembly or held firmly by mechanical locking arrangements that will prevent them from becoming distorted during paving operations. The basket assemblies must be held securely in the proper location by means of suitable anchors.

3.4.7.2 Construction Joints-Fixed Form Paving

Installation of dowels and tie bars must be by the bonded-in-place method, supported by means of devices fastened to the forms. Installation by removing and replacing in preformed holes will not be permitted.

3.4.7.3 Dowels Installed in Hardened Concrete

Installation must be by bonding the dowels into holes drilled into the hardened concrete. Holes approximately 1/8 inch greater in diameter than the dowels must be drilled into the hardened concrete. Dowels must be bonded in the drilled holes using epoxy resin injected at the back of the hole before installing the dowel and extruded to the collar during insertion of the dowel so as to completely fill the void around the dowel. Application by buttering the dowel is not permitted. The dowels must be held in alignment at the collar of the hole, after insertion and before the grout hardens, by means of a suitable metal or plastic collar fitted around the dowel. The vertical alignment of the dowels must be checked by placing the straightedge on the surface of the pavement over the top of the dowel and measuring the vertical distance between the straightedge and the beginning and ending point of the exposed part of the dowel. Where tie bars are required in longitudinal construction joints of slipform pavement, bent tie bars must be installed at the paver, in front of the transverse screed or extrusion plate. If tie bars are required, a standard keyway must be constructed, and the bent tie bars must be inserted into the plastic concrete through a 26 gauge thick metal keyway liner. Tie bars must not be installed in preformed holes. The keyway liner must be protected and must remain in place and become part of the joint. Before placement of the adjoining paving lane, the tie bars must be straightened, without spalling the concrete around the bar.

3.4.7.4 Expansion Joints

Dowels in expansion joints must be installed by the bonded-in-place method or by bonding into holes drilled in hardened concrete, using procedures specified above.

3.5 FINISHING CONCRETE

Start finishing operations immediately after placement of concrete. Use finishing machine, except hand finishing may be used in emergencies and for concrete slabs in inaccessible locations or of such shapes or sizes that machine finishing is impracticable. Finish pavement surface on both sides of a joint to the same grade. Finish formed joints from a securely supported transverse bridge. Provide hand finishing equipment for use at all times. Transverse and longitudinal surface tolerances must not exceed 1/4 inch in 10 feet.

3.5.1 Side Form Finishing

Strike off and screed concrete to the required slope and cross-section by a power-driven transverse finishing machine. Transverse rotating tube or pipe is not permitted unless approved by the Contracting Officer. Elevation of concrete must be such that, when consolidated and finished, pavement surface will be adequately consolidated and at the required grade. Equip finishing machine with two screeds which are readily and accurately adjustable for changes in pavement slope and compensation for wear and other causes. Make as many passes over each area of pavement and at such intervals as necessary to give proper compaction, retention of coarse aggregate near the finished surface, and a surface of uniform texture, true to grade and slope. Do not permit excessive operation over an area, which will result in an excess of mortar and water being brought to the surface.

3.5.1.1 Equipment Operation

Maintain the travel of machine on the forms without lifting, wobbling, or other variation of the machine which tend to affect the precision of concrete finish. Keep the tops of the forms clean by a device attached to the machine. During the first pass of the finishing machine, maintain a uniform ridge of concrete ahead of the front screed for its entire length.

3.5.1.2 Joint Finish

Before concrete is hardened, correct edge slump of pavement, exclusive of edge rounding, in excess of 0.02 foot. Finish concrete surface on each side of construction joints to the same plane, and correct deviations before newly placed concrete has hardened.

3.5.1.3 Hand Finishing

Strike-off and screed surface of concrete to elevations slightly above finish grade so that when concrete is consolidated and finished pavement surface is at the indicated elevation. Vibrate entire surface until required compaction and reduction of surface voids is secured with a strike-off template.

3.5.1.4 Longitudinal Floating

After initial finishing, further smooth and consolidate concrete by means of hand-operated longitudinal floats. Use floats that are not less than 12 feet long and 6 inches wide and stiffened to prevent flexing and warping.

3.5.2 Texturing

Before the surface sheen has disappeared and before the concrete hardens, the surface of the pavement must be given a texture as described herein. Following initial texturing on the first day of placement, the Placing Foreman, Contracting Officer representative, and a representative of the Using Agency must inspect the texturing for compliance with design requirements. After curing is complete, all textured surfaces must be thoroughly power broomed to remove all debris. Transverse texturing must produce grooves in straight lines across each lane within a tolerance of plus or minus 1/2 inch of a true line. The concrete in areas of recesses for tie-down anchors, lighting fixtures, and other outlets in the pavement must be finished to provide a surface of the same texture as the surrounding area.

3.5.2.1 Burlap Drag Finish

Before concrete becomes non-plastic, finish the surface of the slab by dragging on the surface a strip of clean, wet burlap measuring from 3 to 10 feet long and 2 feet wider than the width of the pavement. Select dimension of burlap drag so that at least 3 feet of the material is in contact with the pavement. Drag the surface so as to produce a finished surface with a fine granular or sandy texture without leaving disfiguring marks.

3.5.3 Edging

At the time the concrete has attained a degree of hardness suitable for edging, carefully finish slab edges, including edges at formed joints,

with an edge having a maximum radius of 1/8 inch. Clean by removing loose fragments and soupy mortar from corners or edges of slabs which have crumbled and areas which lack sufficient mortar for proper finishing. Refill voids solidly with a mixture of suitable proportions and consistency and refinish. Remove unnecessary tool marks and edges. Remaining edges must be smooth and true to line.

3.5.4 Repair of Surface Defects

Follow guidance of ACI 301.

3.6 CURING AND PROTECTION

Protect concrete adequately from injurious action by sun, rain, flowing water, frost, mechanical injury, tire marks and oil stains, and do not allow it to dry out from the time it is placed until the expiration of the minimum curing periods specified herein. Use White-Burlap-Polyethylene Sheet or liquid membrane-forming compound, except as specified otherwise herein. Do not use membrane-forming compound on surfaces where its appearance would be objectionable, on surfaces to be painted, where coverings are to be bonded to concrete, or on concrete to which other concrete is to be bonded. Maintain temperature of air next to concrete above 40 degrees F for the full curing periods.

3.6.1 White-Burlap-Polyethylene Sheet

Wet entire exposed surface thoroughly with a fine spray of water, saturate burlap but do not have excessive water dripping off the burlap and then cover concrete with White-Burlap-Polyethylene Sheet, burlap side down. Lay sheets directly on concrete surface and overlap 12 inches. Make sheeting not less than 18 inches wider than concrete surface to be cured, and weight down on the edges and over the transverse laps to form closed joints. Repair or replace sheets when damaged during curing. Check daily to assure burlap has not lost all moisture. If moisture evaporates, resaturate burlap and re-place on pavement (re-saturation and re-placing must take no longer than 10 minutes per sheet). Leave sheeting on concrete surface to be cured for at least 7 days.

3.6.2 Liquid Membrane-Forming Compound Curing

Apply compound immediately after surface loses its water sheen and has a dull appearance and before joints are sawed. Agitate curing compound thoroughly by mechanical means during use and apply uniformly in a two-coat continuous operation by suitable power-spraying equipment. Total coverage for the two coats must be at least one gallon of undiluted compound per 200 square feet. Compound must form a uniform, continuous, coherent film that will not check, crack, or peel and must be free from pinholes or other imperfections. Apply an additional coat of compound immediately to areas where film is defective. Respray concrete surfaces that are subject to heavy rainfall within 3 hours after curing compound has been applied in the same manner.

3.6.2.1 Protection of Treated Surfaces

Keep concrete surfaces to which liquid membrane-forming compounds have been applied free from vehicular traffic and other sources of abrasion for not less than 72 hours. Foot traffic is allowed after 24 hours for inspection purposes. Maintain continuity of coating for entire curing period and repair damage to coating immediately.

3.7 FIELD QUALITY CONTROL

3.7.1 Sampling

The Contractor's approved laboratory must collect samples of fresh concrete in accordance with ASTM C172/C172M during each working day as required to perform tests specified herein. Make test specimens in accordance with ASTM C31/C31M.

3.7.2 Consistency Tests

The Contractor's approved laboratory must perform concrete slump tests in accordance with ASTM C143/C143M. Take samples for slump determination from concrete during placement. Perform tests at the beginning of a concrete placement operation and for each batch (minimum) or every 20 cubic yards (maximum) of concrete to ensure that specification requirements are met. In addition, perform tests each time test beams and cylinders are made.

3.7.3 Flexural Strength Tests

The Contractor's approved laboratory must test for flexural strength in accordance with ASTM C78/C78M. Make four test specimens for each set of tests. Test two specimens at 14 days, and the other two at 28 days. Concrete strength will be considered satisfactory when the minimum of the 28-day test results equals or exceeds the specified 28-day flexural strength, and no individual strength test is less than 550 pounds per square inch. If the ratio of the 28-day strength test to the specified 28 -day strength is less than 95 percent, make necessary adjustments for conformance. Frequency of flexural tests on concrete beams must be not less than four test beams for each 50 cubic yards of concrete, or fraction thereof, placed. Concrete which is determined to be defective, based on the strength acceptance criteria therein, must be removed and replaced with acceptable concrete.

3.7.4 Air Content Tests

Test air-entrained concrete for air content at the same frequency as specified for slump tests. Determine percentage of air in accordance with ASTM C231/C231M on samples taken during placement of concrete in forms.

3.7.5 Surface Testing

Surface testing for surface smoothness , edge slump and plan grade must be performed as indicated below by the Testing Laboratory. The measurements must be properly referenced in accordance with paving lane identification and stationing, and a report given to the Contracting Officer within 24 hours after measurement is made. A final report of surface testing, signed by a Registered Engineer, containing all surface measurements and a description of all actions taken to correct deficiencies, must be provided to the Contracting Officer upon conclusion of surface testing.

3.7.5.1 Surface Smoothness Requirements

The finished surfaces of the pavements must have no abrupt change of 1/8 inch or more, and all pavements must be within the tolerances specified when checked with a 12 foot straightedge: 1/5 inch longitudinal and 1/4 inch transverse directions for roads and streets and 1/4 inch for both

directions for other concrete surfaces, such as parking areas.

3.7.5.2 Surface Smoothness Testing Method

The surface of the pavement must be tested with the straightedge to identify all surface irregularities exceeding the tolerances specified above. The straightedge must be 12 feet and be constructed of aluminum or other lightweight metal and must have blades of box or box-girder cross section with flat bottom reinforced to ensure rigidity and accuracy. Straightedges must have handles to facilitate movement on pavement. The entire area of the pavement must be tested in both a longitudinal and a transverse direction on parallel lines approximately 15 feet apart. The straightedge must be held in contact with the surface and moved ahead one-half the length of the straightedge for each successive measurement. The amount of surface irregularity must be determined by placing the straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length and measuring the maximum gap between the straightedge and the pavement surface, in the area between these two high points.

3.7.6 Plan Grade Testing and Conformance

The surfaces must vary not more than 0.06 foot above or below the plan grade line or elevation indicated. Each pavement category must be checked for conformance with plan grade requirements by running lines of levels at intervals to determine the elevation at each joint intersection.

3.7.7 Test for Pavement Thickness

Full depth cores of 4 inch diameter must be taken of concrete pavement every 5000 square feet to measure thickness.

3.7.8 Reinforcement

Inspect reinforcement prior to installation to assure it is free of loose flaky rust, loose scale, oil, mud, or other objectionable material.

3.7.9 Dowels

Inspect dowel placement prior to placing concrete to assure that dowels are of the size indicated, and are spaced, aligned and painted and oiled as specified. Dowels must not deviate from vertical or horizontal alignment after concrete has been placed by more than 1/8 inch per foot.

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SECTION 32 16 19

CONCRETE CURBS, GUTTERS AND SIDEWALKS
05/18

PART 1 GENERAL

1.1 UNIT PRICES

1.1.1 Measurement

1.1.1.1 Sidewalks

The quantities of sidewalks to be paid for will be the number of square yards of each depth of sidewalk constructed as indicated.

1.1.1.2 Curbs and Gutters

The quantities of curbs and gutters to be paid for will be the number of linear feet of each cross section constructed as indicated, measured along the face of the curb at the gutter line.

1.1.2 Payment

1.1.2.1 Sidewalks

Payment of the quantities of sidewalks measured as specified will be at the Contract unit price per square yard of the thickness specified.

1.1.2.2 Curbs and Gutters

Payment of the quantities of curbs and gutters measured as specified will be at the Contract unit price per linear foot of each cross section.

1.2 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 2017) Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats

ASTM INTERNATIONAL (ASTM)

ASTM A1064/A1064M	(2017) Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
ASTM A615/A615M	(2016) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete

	Reinforcement
ASTM C143/C143M	(2015) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C171	(2016) Standard Specification for Sheet Materials for Curing Concrete
ASTM C172/C172M	(2017) Standard Practice for Sampling Freshly Mixed Concrete
ASTM C173/C173M	(2016) Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C231/C231M	(2017a) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C309	(2011) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C31/C31M	(2018a) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C920	(2018) Standard Specification for Elastomeric Joint Sealants
ASTM D1751	(2004; E 2013; R 2013) Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D1752	(2004a; R 2013) Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion
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 COMM	(2017) Standard And Commentary Accessible and Usable Buildings and Facilities

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Concrete

SD-06 Test Reports

Field Quality Control

1.4 EQUIPMENT, TOOLS, AND MACHINES

1.4.1 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.

1.4.2 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.

1.5 ENVIRONMENTAL REQUIREMENTS

1.5.1 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.

1.5.2 Placing During Warm Weather

The temperature of the concrete as placed must not exceed 85 degrees F except where an approved retarder is used. Cool the mixing water and aggregates as necessary to maintain a satisfactory placing temperature. The placing temperature must not exceed 95 degrees F at any time.

PART 2 PRODUCTS

2.1 CONCRETE

Provide concrete conforming to the applicable requirements of Section 03 30 00.00 10 CAST-IN-PLACE CONCRETE except as otherwise specified. Concrete must have a minimum compressive strength of 3500 psi at 28 days. Size of aggregate must not exceed 1-1/2 inches. Submit copies of certified delivery tickets for all concrete used in the construction.

2.1.1 Air Content

Use concrete mixtures that have an air content by volume of concrete of 5 to 7 percent, based on measurements made immediately after discharge from the mixer.

2.1.2 Slump

Use concrete with a slump of 3 inches plus or minus 1 inch for hand placed concrete or 1 inch plus or minus 1/2 inch for slipformed concrete as determined in accordance with ASTM C143/C143M.

2.1.3 Reinforcement Steel

Use reinforcement bars conforming to ASTM A615/A615M. Use wire mesh reinforcement conforming to ASTM A1064/A1064M.

2.2 CONCRETE CURING MATERIALS

2.2.1 Impervious Sheet Materials

Use impervious sheet materials conforming to ASTM C171, type optional, except that polyethylene film, if used, must be white opaque.

2.2.2 Burlap

Use burlap conforming to AASHTO M 182.

2.2.3 White Pigmented Membrane-Forming Curing Compound

Use white pigmented membrane-forming curing compound conforming to ASTM C309, Type 2.

2.3 CONCRETE PROTECTION MATERIALS

Use concrete protection materials consisting of a linseed oil mixture of equal parts, by volume, of linseed oil and either mineral spirits, naphtha, or turpentine. At the option of the Contractor, commercially prepared linseed oil mixtures, formulated specifically for application to concrete to provide protection against the action of deicing chemicals may be used, except that emulsified mixtures are not acceptable.

2.4 JOINT FILLER STRIPS

2.4.1 Contraction Joint Filler for Curb and Gutter

Use hard-pressed fiberboard contraction joint filler for curb and gutter.

2.4.2 Expansion Joint Filler, Premolded

Onless otherwise indicated, use 1/2 inch thick premolded expansion joint filler conforming to ASTM D1751 or ASTM D1752.

2.5 JOINT SEALANTS

Use cold-applied joint sealant conforming to ASTM C920 or ASTM D5893/D5893M.

2.6 FORM WORK

Design and construct form work to ensure that the finished concrete will conform accurately to the indicated dimensions, lines, and elevations, and within the tolerances specified. Use wood or steel forms that are straight and of sufficient strength to resist springing during depositing and consolidating concrete.

2.6.1 Wood Forms

Use forms that are surfaced plank, 2 inches nominal thickness, straight and free from warp, twist, loose knots, splits or other defects. Use forms with a nominal length of 10 feet. Radius bends may be formed with 3/4 inch boards, laminated to the required thickness.

2.6.2 Steel Forms

Use channel-formed sections with a flat top surface and welded braces at each end and at not less than two intermediate points. Use forms with interlocking and self-aligning ends. Provide flexible forms for radius forming, corner forms, form spreaders, and fillers as needed. Use forms with a nominal length of 10 feet and that have a minimum of 3 welded stake pockets per form. Use stake pins consisting of solid steel rods with chamfered heads and pointed tips designed for use with steel forms.

2.6.3 Sidewalk Forms

Use sidewalk forms that are of a height equal to the full depth of the finished sidewalk.

2.6.4 Curb and Gutter Forms

Use curb and gutter outside forms that have a height equal to the full depth of the curb or gutter. Use rigid forms for curb returns, except that benders or thin plank forms may be used for curb or curb returns with a radius of 10 feet or more, where grade changes occur in the return, or where the central angle is such that a rigid form with a central angle of 90 degrees cannot be used. Back forms for curb returns may be made of 1-1/2 inch benders, for the full height of the curb, cleated together. In lieu of inside forms for curbs, a curb "mule" may be used for forming and finishing this surface, provided the results are approved.

2.7 Detectable Warning System

Detectable Warning Systems shown on the Contract plans are to meet requirements of ICC A117.1 COMM - 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 as indicated 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 and entrance 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 Mat Method

Cover the entire exposed surface with two or more layers of burlap. Overlap mats at least 6 inches. Thoroughly wet the mat with water prior to placing on concrete surface and keep the mat continuously in a saturated condition and in intimate contact with concrete for not less than 7 days.

3.7.1.2 Impervious Sheeting Method

Wet the entire exposed surface with a fine spray of water and then cover with impervious sheeting material. Lay sheets directly on the concrete surface with the light-colored side up and overlapped 12 inches when a continuous sheet is not used. Use sheeting that is not less than 18-inches wider than the concrete surface to be cured. Secure sheeting using heavy wood planks or a bank of moist earth placed along edges and laps in the sheets. Satisfactorily repair or replace sheets that are torn or otherwise damaged during curing. Sheeting must remain on the concrete surface to be cured for not less than 7 days.

3.7.1.3 Membrane Curing Method

Apply a uniform coating of white-pigmented membrane-curing compound to the entire exposed surface of the concrete as soon after finishing as the free water has disappeared from the finished surface. Coat formed surfaces immediately after the forms are removed and in no case longer than 1 hour after the removal of forms. Do not allow concrete surface to dry before application of the membrane. If drying has occurred, moisten the surface of the concrete with a fine spray of water and apply the curing compound as soon as the free water disappears. Apply curing compound in two coats by hand-operated pressure sprayers at a coverage of approximately 200 square feet/gallon for the total of both coats. Apply the second coat in a direction approximately at right angles to the direction of application of the first coat. The compound must form a uniform, continuous, coherent film that will not check, crack, or peel and must be free from pinholes or other imperfections. If pinholes, abrasion, or other discontinuities exist, apply an additional coat to the affected areas within 30 minutes. Respray concrete surfaces that are subjected to heavy rainfall within 3 hours after the curing compound has been applied by the method and at the coverage specified above. Respray areas where the curing compound is damaged by subsequent construction operations within the curing period. Take precautions necessary to ensure that the concrete is properly cured at sawed joints, and that no curing compound enters the joints. Tightly seal the top of the joint opening and the joint groove at exposed edges before the concrete in the region of the joint is resprayed with curing compound. Use a method used for sealing the joint groove that prevents loss of moisture from the joint during the entire specified curing period. Provide approved standby facilities for curing concrete pavement at a location accessible to the jobsite for use in the event of mechanical failure of the spraying equipment or other conditions that might prevent correct application of the membrane-curing compound at the proper time. Adequately protect concrete surfaces to which membrane-curing compounds have been applied during the entire curing period from pedestrian and vehicular traffic, except as required for joint-sawing operations and surface tests, and from other possible damage to the continuity of the membrane.

3.7.2 Backfilling

After curing, remove debris and backfill, grade, and compact the area adjoining the concrete to conform to the surrounding area in accordance with lines and grades indicated.

3.7.3 Protection

Protect completed concrete from damage until accepted. Repair damaged concrete and clean concrete discolored during construction. Remove and reconstruct concrete that is damaged for the entire length between regularly scheduled joints. Refinishing the damaged portion will not be acceptable. Dispose of removed material as directed.

3.7.4 Protective Coating

Apply a protective coating of linseed oil mixture to the exposed-to-view concrete surface after the curing period, if concrete will be exposed to de-icing chemicals within 6 weeks after placement. Moist cure concrete to receive a protective coating.

3.7.4.1 Application

Complete curing and backfilling operation prior to applying two coats of protective coating. Concrete must be surface dry and clean before each application. Spray apply at a rate of not more than 50 square yards/gallon for first application and not more than 70 square yards/gallon for second application, except that the number of applications and coverage for each application for commercially prepared mixture must be in accordance with the manufacturer's instructions. Protect coated surfaces from vehicular and pedestrian traffic until dry.

3.7.4.2 Precautions

Do not heat protective coating by direct application of flame or electrical heaters and protect the coating from exposure to open flame, sparks, and fire adjacent to open containers or applicators. Do not apply material at ambient or material temperatures lower than 50 degrees F.

3.8 FIELD QUALITY CONTROL

Submit copies of all test reports within 24 hours of completion of the test.

3.8.1 General Requirements

Perform the inspection and tests described and meet the specified requirements for inspection details and frequency of testing. Based upon the results of these inspections and tests, take the action and submit reports as required below, and additional tests to ensure that the requirements of these specifications are met.

3.8.2 Concrete Testing

3.8.2.1 Strength Testing

Take concrete samples in accordance with ASTM C172/C172M not less than once a day nor less than once for every 250 cubic yards of concrete

placed. Mold cylinders in accordance with ASTM C31/C31M for strength testing by an approved laboratory. Each strength test result must be the average of 2 test cylinders from the same concrete sample tested at 28 days, unless otherwise specified or approved. Concrete specified on the basis of compressive strength will be considered satisfactory if the averages of all sets of three consecutive strength test results equal or exceed the specified strength, and no individual strength test result falls below the specified strength by more than 500 psi.

3.8.2.2 Air Content

Determine air content in accordance with ASTM C173/C173M or ASTM C231/C231M. Use ASTM C231/C231M with concretes and mortars made with relatively dense natural aggregates. Make two tests for air content on randomly selected batches of each class of concrete placed during each shift. Make additional tests when excessive variation in concrete workability is reported by the placing foreman or the Government inspector. Notify the placing forman 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 COMM, Section 705, and by manufacturers' installation instructions.

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PAVEMENT MARKINGS
08/16

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.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 249	(2012; R2016) Standard Specification for White and Yellow Reflective Thermoplastic Striping Material (Solid Form)

ASTM INTERNATIONAL (ASTM)

ASTM D4061	(2013) Standard Test Method for Retroreflectance of Horizontal Coatings
ASTM D4280	(2012) Extended Life Type, Nonplowable, Raised, Retroreflective Pavement Markers
ASTM D6628	(2003; R 2015) Standard Specification for Color of Pavement Marking Materials
ASTM E1710	(2011) Standard Test Method for Measurement of Retroreflective Pavement Marking Materials with CEN-Prescribed Geometry Using a Portable Retroreflectometer
ASTM E2177	(2011) Standard Test Method for Measuring the Coefficient of Retroreflected Luminance (RL) of Pavement Markings in a Standard Condition of Wetness
ASTM E2302	(2003; R 2016) Standard Test Method for Measurement of the Luminance Coefficient Under Diffuse Illumination of Pavement Marking Materials Using a Portable Reflectometer

INTERNATIONAL CONCRETE REPAIR INSTITUTE (ICRI)

ICRI 03732	(1997) Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays

U.S. FEDERAL HIGHWAY ADMINISTRATION (FHWA)

MUTCD	(2015) Manual on Uniform Traffic Control Devices

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS TT-B-1325	(Rev D; Notice 1; Notice 2 2017) Beads (Glass Spheres) Retro-Reflective (Metric)

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only or as otherwise designated. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Application Equipment List; G

Exterior Surface Preparation

Safety Data Sheets; G

Reflective media for roads; G

Thermoplastic compound; G

Raised Pavement Markers Primers and Adhesives; G

SD-06 Test Reports

Reflective Media for Roads; G

Thermoplastic Compound; G

Raised Pavement Markers Primers and Adhesives; G

Test Reports

SD-07 Certificates

Qualifications; G

Reflective Media for Roads

Volatile Organic Compound, (VOC); G

Thermoplastic Compound

SD-08 Manufacturer's Instructions

Thermoplastic Compound; G

1.3 QUALITY ASSURANCE

1.3.1 Regulatory Requirements

Submit 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 Safety Data Sheets for each product.

1.3.2 Qualifications

Submit documentation certifying that pertinent personnel are qualified for equipment operation and handling of applicable chemicals. The documentation should include experience on five projects of similar size and scope with references for all personnel.

1.4 DELIVERY AND STORAGE

Deliver paint materials, thermoplastic compound materials, and reflective media in original sealed containers that plainly show the designated name, specification number, batch number, color, date of manufacture, manufacturer's directions, and name of manufacturer.

Provide storage facilities at the job site for maintaining materials at temperatures recommended by the manufacturer.

1.5 PROJECT/SITE CONDITIONS

1.5.1 Environmental Requirements

1.5.1.1 Weather Limitations for Application

Apply pavement markings to clean, dry surfaces, and unless otherwise approved, only when the air and pavement surface temperature is at least 5 degrees F above the dew point and the air and pavement temperatures are within the limits recommended by the pavement marking manufacturer. Allow pavement surfaces to dry after water has been used for cleaning or rainfall has occurred prior to striping or marking. Test the pavement surface for moisture before beginning work each day and after cleaning. Do not commence marking until the pavement is sufficiently dry and the pavement condition has been approved by the Contracting Officer. Employ the "plastic wrap method" to test the pavement for moisture as specified in paragraph TESTING FOR MOISTURE.

1.5.1.2 Weather Limitations for Removal of Pavement Markings on Roads and Automotive Parking Areas

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 or sand blasting or grinding. Cease operation during thunderstorms, or during rainfall, except for waterblasting and removal of previously applied chemicals. Cease waterblasting where surface water accumulation alters the effectiveness of material removal.

1.5.2 Traffic Controls

Place warning signs conforming to MUTCD near the beginning of the worksite

and well ahead of the worksite for alerting approaching traffic from both directions. Place small markers along newly painted lines or freshly placed raised markers to control traffic and prevent damage to newly painted surfaces or displacement of raised pavement markers. Mark painting equipment with large warning signs indicating slow-moving painting equipment in operation.

When traffic must be rerouted or controlled to accomplish the work, provide necessary warning signs, flag persons, and related equipment for the safe passage of vehicles.

PART 2 PRODUCTS

2.1 EQUIPMENT

2.1.1 Application Equipment

Submit application equipment list appropriate for the material(s) to be used. Include manufacturer's descriptive data and certification for the planned use that indicates 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 them 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.

2.1.1.1 Paint Application Equipment

2.1.1.1.1 Hand-Operated, Push-Type Machines

Provide hand-operated push-type applicator machine of a type commonly used for application of water based paint or two-component, chemically curing paint, thermoplastic, or preformed tape, to pavement surfaces for small marking projects, such as legends and cross-walks, automotive parking areas, or surface painted signs. Provide applicator machine equipped with the necessary tanks and spraying nozzles capable of applying paint uniformly at coverage specified. Hand operated spray guns may be used in areas where push-type machines cannot be used.

2.1.1.1.2 Self-Propelled or Mobile-Drawn Spraying Machines

Provide self-propelled or mobile-drawn spraying machine with suitable arrangements of atomizing nozzles and controls to obtain the specified results. Provide machine having a speed during application capable of applying the stripe widths indicated at the paint coverage rate specified herein and of even uniform thickness with clear-cut edges.

2.1.1.1.2.1 Road Marking

Provide equipment used for marking roads capable of placing the prescribed number of lines at a single pass as solid lines, intermittent lines, or a combination of solid and intermittent lines using a maximum of three different colors of paint as specified.

2.1.1.1.2.2 Hand Application

Provide spray guns for hand application of paint in areas where the mobile paint applicator cannot be used.

2.1.1.2 Thermoplastic Application Equipment

2.1.1.2.1 Thermoplastic Material

Apply thermoplastic material with equipment that is capable of providing continuous uniformity in the dimensions and reflectorization of the marking.

2.1.1.2.2 Application Equipment

a. Provide application equipment capable of continuous mixing and agitation of the material, with conveying parts which prevent accumulation and clogging between the main material reservoir and the extrusion shoe or spray gun. All parts of the equipment which come into contact with the material must be easily accessible and exposed for cleaning and maintenance. All mixing and conveying parts up to and including the extrusion shoes and spray guns must maintain the material at the required temperature with heat-transfer oil or electrical-element-controlled heat.

b. Provide application equipment constructed to ensure continuous uniformity in the dimensions of the stripe. Provide an applicator with a means for cleanly cutting off stripe ends squarely and providing a method of applying "skiplines." Provide equipment capable of applying varying widths of traffic markings.

c. Provide mobile and maneuverable application equipment allowing straight lines to be followed and normal curves to be made in a true arc. Provide equipment used for the placement of thermoplastic pavement markings of two general types: mobile applicator and portable applicator.

d. Equip the applicator with a pressurized or drop-on type bead dispenser capable of uniformly dispensing reflective glass spheres at controlled rates of flow. The bead dispenser must operate automatically to begin flow prior to the flow of binder to assure that the strip is fully reflectorized.

2.1.1.2.3 Mobile Application Equipment

Provide a truck-mounted, self-contained pavement marking machine that is capable of hot applying thermoplastic by either the extrusion or spray method.

a. Equip the unit to apply the thermoplastic marking material at temperatures according to the manufacturer's instructions, at widths varying from 3 to 12 inches, with an automatic pressurized or drop-on bead dispensing system, capable of operating continuously, and of installing a minimum of 20,000 lineal feet of longitudinal markings in an 8-hour day.

b. Equip the mobile unit with a melting kettle which holds a minimum of 6000 pounds of molten thermoplastic material; capable of heating the thermoplastic composition to temperatures as recommended by the manufacturer. Use a thermostatically controlled heat transfer liquid. Heating of the composition by direct flame is not allowed. Oil and material temperature gauges must be visible at both ends of the kettle.

c. Equip mobile units for application of extruded markings with a minimum of two extrusion shoes; located one on each side of the truck, capable of marking simultaneous edge line and centerline stripes; each being a closed, oil-jacketed unit; holding the molten thermoplastic at a temperature as recommended by the manufacturer; and capable of extruding a line of 3 to 8 inches in width; and at a thickness of not less than 0.120 inch nor more than 0.190 inch, of generally uniform cross section.

d. Equip mobile units for application of spray markings with a spray gun system capable of marking simultaneous edgeline and centerline stripes. Surround (jacket) the spray system with heating oil to maintain the molten thermoplastic at a temperature of 375 to 425 degrees F, capable of spraying a stripe of 3 to 12 inches in width, and in thicknesses varying from 0.060 inch to 0.098 inch, of generally uniform cross section.

e. Equip the mobile unit with an electronic programmable line pattern control system, capable of applying skip or solid lines in any sequence, through any and all of the extrusion shoes, or the spray guns, and in programmable cycle lengths. In addition, equip the mobile unit with an automatic counting mechanism capable of recording the number of lineal feet of thermoplastic markings applied to the pavement surface with an accuracy of 0.5 percent.

2.1.1.2.4 Portable Application Equipment

Provide portable hand-operated equipment, specifically designed for placing special markings such as crosswalks, stop bars, legends, arrows, and short lengths of lane, edge and centerlines; and capable of applying thermoplastic pavement markings by the extrusion method. Equip the portable applicator with all the necessary components, including a materials storage reservoir, bead dispenser, extrusion shoe, and heating accessories, capable of holding the molten thermoplastic at the temperature recommended by the manufacturer, and of extruding a line of 3 to 12 inches in width, and in thickness of not less than 0.120 inch nor more than 0.190 inch and of generally uniform cross section.

2.1.1.3 Reflective Media Dispenser

Attach the dispenser for applying the reflective media to the thermoplastic dispenser and designed to operate automatically and simultaneously with the applicator through the same control mechanism. The bead applicator must be capable of adjustment and designed to provide uniform flow of reflective media over the full length and width of the stripe at the rate of coverage specified in paragraph APPLICATION.

2.1.1.4 Preformed Tape Application Equipment

Provide and use mechanical application equipment for the placement of preformed marking tape which is a mobile pavement marking machine specifically designed for use in applying pressure-sensitive pavement marking tape of varying widths. Equip the applicator with rollers, or other suitable compaction device to provide initial adhesion of the material with the pavement surface. Use additional tools and devices as needed to properly seat the applied material as recommended by the manufacturer.

2.2 MATERIALS

Use thermoplastic for roads and parking areas. The maximum allowable VOC content of pavement markings is 150 grams per liter. Color of markings are indicated on the drawings and must conform to ASTM D6628 for roads and automotive parking areas. Provide materials conforming to the requirements specified herein. All materials used shall be on the NCDOT Qualified Products List, and shall be high visibility. All components shall meet NCDOT Standard Specifications.

2.2.1 Thermoplastic Compound

2.2.1.1 Composition Requirements

Thermoplastic compound must conform to AASHTO M 249. Formulate the binder component as an alkyd resin.

2.2.1.2 Primer

a. Asphalt concrete primer: Provide thermosetting adhesive primer with a solids content of pigment reinforced synthetic rubber and synthetic plastic resin dissolved or dispersed in a volatile organic solvent for asphaltic concrete pavements. The solids content must not be less than 10 percent by weight at 70 degrees F and 60 percent relative humidity. A wet film thickness of 0.005 inch, plus or minus 0.001 inch, must dry to a tack-free condition in less than 5 minutes.

b. Portland cement concrete primer: Provide an epoxy resin primer for portland cement concrete pavements, of the type recommended by the manufacturer of the thermoplastic composition.

2.2.2 Raised Pavement Markers Primers and Adhesives

Use either metallic or nonmetallic markers of the button or prismatic reflector type. Provide permanent color markers as specified for pavement marking, which retain the color and brightness under the action of traffic. Provide button markers with a diameter of not less than 4 inches, spaced not more than 40 feet apart on solid longitudinal lines. Make broken centerline marker spacing in segments indicated with gaps indicated between segments. Provide button markers with rounded surfaces presenting a smooth contour to traffic and not projecting more than 3/4 inch above level of pavement. Provide plowable pavement markers and adhesive epoxy conforming to ASTM D4280.

2.2.3 Reflective Media

2.2.3.1 Reflective Media for Roads

FS TT-B-1325, Type I, Gradation A or Type IV, Gradation A or B.

PART 3 EXECUTION

3.1 EXAMINATION

3.1.1 Testing for Moisture

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 pavement condition has been approved by the Contracting Officer or authorized representative.

Employ the "plastic wrap method" to test the pavement for moisture as follows: Cover the pavement with a 12 inch by 12 inch section of clear plastic wrap and seal the edges with tape. After 15 minutes, examine the plastic wrap for any visible moisture accumulation inside the plastic. Do not begin marking operations until the test can be performed with no visible moisture accumulation inside the plastic wrap. Re-test surfaces when work has been stopped due to rain.

3.1.2 Surface Preparation Demonstration

Prior to surface preparation, demonstrate the proposed procedures and equipment. Prepare areas large enough to determine cleanliness, adhesion of remaining coating and rate of cleaning. Approved demonstration area establishes the standard for the remainder of the work.

3.1.3 Test Stripe Demonstration

Prior to paint application, demonstrate test stripe application within the work area using the proposed materials and equipment. Apply separate test stripes in each of the line widths and configurations required herein using the proposed equipment. Make the test stripes long enough to determine the proper speed and operating pressures for the vehicle(s) and machinery, but not less than 50 feet long.

3.1.4 Application Rate Demonstration

During the Test Stripe Demonstration, demonstrate compliance with the application rates specified herein. Document the equipment speed and operating pressures required to meet the specified rates in each configuration of the equipment and provide a copy of the documentation to the Contracting Officer prior to proceeding with the work.

3.1.5 Retroreflective Value Demonstration

After the test stripes have cured to a "no-track" condition, demonstrate compliance with the average retroreflective values specified herein. Take a minimum of ten readings on each test stripe with a Retroreflectometer with a direct readout in millicandelas per square meter per lux (mcd/m2/lx). Perform testing in accordance with ASTM D4061, ASTM E1710, ASTM E2177, and ASTM E2302.

3.1.6 Level of Performance Demonstration

The Contracting Officer will be present at the application demonstrations to observe the results obtained and to validate the operating parameters of the vehicle(s) and equipment. If accepted by the Contracting Officer, the test stripe is the measure of performance required for this project. Do not proceed with the work until the demonstration results are satisfactory to the Contracting Officer.

3.2 EXTERIOR SURFACE PREPARATION

Allow new pavement surfaces to cure for a period of not less than 30 days before application of marking materials. Thoroughly clean surfaces to be marked before application of the paint. Remove dust, dirt, and other granular surface deposits by sweeping, blowing with compressed air,

rinsing with water, or a combination of these methods as required. Remove rubber deposits, residual curing compounds, and other coatings adhering to the pavement by water blasting.

For Portland Cement Concrete pavement, grinding, light shot blasting, or light scarification, to a resulting profile equal to ICRI 03732 CSP 2, CSP 3, and CSP 4, respectively, can be used in addition to water blasting on most pavements, to either remove existing coatings, or for surface preparation.

3.2.1 Early Painting of Rigid Pavements

Pretreat rigid pavements that require early painting with an aqueous solution containing 3 percent phosphoric acid and 2 percent zinc chloride. Apply the solution to the areas to be marked.

3.2.2 Early Painting of Asphalt Pavements

For asphalt pavement systems requiring painting application at less than 30 days, apply the paint and beads at half the normal application rate, followed by a second application at the normal rate after 30 days.

3.3 APPLICATION

Apply pavement markings to dry pavements only. Application shall be in accordance wit this specification and guidelines as provided in NCDOT Standard Specifications for Roads and Structures Division 12 Pavement Markings, Markers and Delineation.

3.3.1 Thermoplastic Compound

Place thermoplastic pavement markings, free from dirt or tint, upon dry pavement. The temperature must be a minimum of 40 degrees F and rising at the time of installation. Apply all centerline, skipline, edgeline, and other longitudinal type markings with a mobile applicator. Place all special markings, crosswalks, stop bars, legends, arrows, and similar patterns with a portable applicator, using the extrusion method.

3.3.1.1 Primer

After surface preparation has been completed, prime the asphalt or concrete pavement surface with spray equipment. Allow primer materials to "set-up" prior to applying the thermoplastic composition. Allow the asphalt concrete primer to dry to a tack-free condition, usually occurring in less than 10 minutes. Allow the Portland Cement concrete primer to dry in accordance with the thermoplastic manufacturer recommendations. To shorten the curing time of the epoxy resins, an infrared heating device may be used on the concrete primer. Apply asphalt concrete primer to all asphalt concrete pavements at a wet film thickness of 0.005 inch, plus or minus 0.001 inch (265 to 400 square feet per gallon). Apply portland cement concrete primer to all concrete pavements (including concrete bridge decks) at a wet film thickness of between 0.04 to 0.05 inch 320 to 400 square feet per gallon.

After the primer has "set-up", apply the thermoplastic at temperatures no lower than 375 degrees F nor higher than 425 degrees F at the point of deposition. Apply all extruded thermoplastic markings at the specified width and at a thickness of not less than 0.125 inch nor more than 0.190 inch. Apply all sprayed thermoplastic markings at the specified width and

the thickness designated in the contract plans. If the plans do not specify a thickness, apply centerline markings at a wet thickness of 0.090 inch, plus or minus 0.005 inch, and edgeline markings at a wet thickness of 0.060 inch, plus or minus 0.005 inch.

3.3.1.2 Reflective Media

Immediately after installation of the thermoplastic material, mechanically apply drop-on reflective glass spheres conforming to FS TT-B-1325 Type I (Gradation A) at the rate of one pound per 20 square feet such that the spheres are held by and imbedded in the surface of the molten material. Accomplish drop-on application of the glass spheres to ensure even distribution at the specified rate of coverage. If there is a malfunction of either thermoplastic applicator or reflective media dispenser, discontinue operations until deficiency is corrected.

3.3.2 Raised Pavement Markers

Align prefabricated markers carefully at the spacing indicated on the drawings and permanently fix in place by means of epoxy adhesives. To ensure good bond prior to applying adhesive, thoroughly clean all areas where markers are to be set by water blasting and use of compressed air.

3.3.3 Preformed Tape

The pavement surface and ambient air temperature must be a minimum of 60 degrees F and rising. Place the preformed markings in accordance with the manufacturer's written instructions.

3.3.4 Cleanup and Waste Disposal

Keep the worksite clean and free of debris and waste from the removal and application operations. Dispose of debris at approved sites.

3.4 FIELD QUALITY CONTROL

3.4.1 Sampling and Testing

As soon as the paint and thermoplastic materials and reflective media are available for sampling, obtain by random selection from the sealed containers, two quart samples of each batch in the presence of the Contracting Officer. Accomplish adequate mixing prior to sampling to ensure a uniform, representative sample. A batch is defined as that quantity of material processed by the manufacturer at one time and identified by number on the label. Clearly identify samples by designated name, specification number, batch number, project contract number, intended use, and quantity involved.

Test samples by an approved laboratory. If a sample fails to meet specification, replace the material in the area represented by the samples and retest the replacement material as specified above. Submit certified copies of the test reports, prior to the use of the materials at the jobsite. Include in the report of test results a listing of any specification requirements not verified by the test laboratory.

3.4.2 Material Inspection

Examine material at the job site to determine that it is the material referenced in the report of test results or certificate of

compliance.Provide test results substantiating conformance to the specified requirements with each certificate of compliance.

3.4.3 Dimensional Tolerances

Apply all markings in the standard dimensions provide in the drawings. New markings may deviate a maximum of 10 percent larger than the standard dimension. The maximum deviation allowed when painting over an old marking is up to 20 percent larger than the standard dimensions.

3.4.4 Bond Failure Verification

Inspect newly applied markings for signs of bond failure based on visual inspection and comparison to results from Test Stripe Demonstration paragraph.

3.4.5 Reflective Media and Coating Application Verification

Use a wet film thickness gauge to measure the application of wet paint. Use a microscope or magnifying glass to evaluate the embedment of glass beads in the paint. Verify the glass bead embedment with approximately 50 percent of the individual bead spheres embedded and 50 percent of the individual bead spheres exposed.

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SECTION 32 32 23

SEGMENTAL CONCRETE BLOCK RETAINING WALL
04/08

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 252	(2009; R 2017) Standard Specification for Corrugated Polyethylene Drainage Pipe
AASHTO M 288	(2017) Standard Specification for Geosynthetic Specification for Highway Applications

ASTM INTERNATIONAL (ASTM)

ASTM C1262	(2010) Standard Test Method for Evaluating the Freeze-Thaw Durability of Manufactured Concrete Masonry Units and Related Concrete Units
ASTM C136/C136M	(2014) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C1372	(2017) Standard Specification for Dry-Cast Segmental Retaining Wall Units
ASTM C140/C140M	(2018a) Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units
ASTM C920	(2018) Standard Specification for Elastomeric Joint Sealants
ASTM C94/C94M	(2018) Standard Specification for Ready-Mixed Concrete
ASTM D1241	(2015) Materials for Soil-Aggregate Subbase, Base, and Surface Courses
ASTM D1556/D1556M	(2015; E 2016) Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
ASTM D2487	(2017) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification

	System)
ASTM D2488	(2017; E 2018) Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)
ASTM D4355/D4355M	(2014) Deterioration of Geotextiles from Exposure to Light, Moisture and Heat in a Xenon-Arc Type Apparatus
ASTM D448	(2012; R 2017) Standard Classification for Sizes of Aggregate for Road and Bridge Construction
ASTM D4491/D4491M	(2017) Standard Test Methods for Water Permeability of Geotextiles by Permittivity
ASTM D4595	(2017) Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method
ASTM D4632/D4632M	(2015a) Grab Breaking Load and Elongation of Geotextiles
ASTM D4751	(2016) Standard Test Method for Determining Apparent Opening Size of a Geotextile
ASTM D4873/D4873M	(2017) Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
ASTM D5321/D5321M	(2017) Standard Test Method for Determining the Shear Strength of Soil-Geosynthetic and Geosynthetic-Geosynthetic Interfaces by Direct Shear
ASTM D6638	(2011) Determining Connection Strength Between Geosynthetic Reinforcement and Segmental Concrete Units (Modular Concrete Blocks)
ASTM D6706	(2001; R 2013) Standard Test Method for Measuring Geosynthetic Pullout Resistance in Soil
ASTM D6938	(2017a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM D698	(2012; E 2014; E 2015) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft. (600 kN-m/cu. m.))

GEOSYNTHETIC INSTITUTE (GSI)

GSI GRI GG6	(1996) Grip Types for Use in Wide Width Testing of Geotextiles and Geogrids

NATIONAL CONCRETE MASONRY ASSOCIATION (NCMA)

NCMA TR127B	(2010) Design Manual for Segmental Retaining Walls

U.S. FEDERAL HIGHWAY ADMINISTRATION (FHWA)

FHWA NHI-00-043	(2000) Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Design and Construction Guidelines (ISDDC)

1.2 DEFINITIONS

1.2.1 Blocks

Segmental concrete retaining wall units will be referred to as blocks.

1.2.2 Drainage Aggregate

Granular soil or aggregate which is placed within, between, and/or immediately behind segmental concrete units.

1.2.3 Fill

Soil or aggregate placed in, behind, or below the wall will be referred to as fill.

1.2.4 Reinforced Fill

Soil which is placed and compacted within the neat line volume of reinforcement as outlined on the plans.

1.2.5 Retained Fill

Soil which is placed and compacted behind the reinforced fill.

1.2.6 Reinforcement

Reinforcement shall consist of a geogrid or a geotextile product manufactured for use as reinforcing. Reinforcement shall not include steel products.

1.2.7 Long Term Design Strength

The long term design strength (LTDS) is:

$$LTDS = T_{ult} / (RF_D * RF_{ID} * RF_{CR})$$

where:

T_{ult} is the ultimate strength
RF_D is the reduction factor for chemical and biological durability
RF_{ID} is the reduction factor for installation damage
RF_{CR} is the reduction factor for creep

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Shop Drawings; G

SD-03 Product Data

Components and Equipment
Supplier Qualifications
Manufacturer's Representative
Soil Testing; G
Reinforcement Testing; G
Calculations; G

SD-04 Samples

Segmental Concrete Units; G
Reinforcement; G

SD-07 Certificates

Reinforcement

1.4 QUALITY ASSURANCE

1.4.1 Contractor Qualifications

Furnish Components and equipment that are standard products of a manufacturer regularly engaged in the manufacturing of products that are of a similar material, design and workmanship. Submit descriptive technical data on the blocks, wall caps, masonry adhesive, reinforcement, geotextile filter materials and equipment to be used. The submittal shall include all material properties specified under PART 2 PRODUCTS. The submittal shall also include a copy of any standard manufacturer's warranties for the products. The standard products shall have been in satisfactory commercial or industrial use for 2 years before award of this contract. The job foreman or the company directly responsible for the wall installation shall have at least 2 years experience.

1.4.2 Supplier Qualifications

Submit documentation showing that the installer and supplier meet the qualifications listed. Suppliers of segmental retaining wall system components shall have demonstrated experience in the supply of similar size and types of segmental retaining walls on previous projects.

1.4.3 Manufacturer's Representative

Provide a qualified and experienced representative from the block or

reinforcement manufacturer available on an as-needed basis during the wall construction. The representative shall visit the site for consultation as requested by the Contracting Officer.

1.5 DELIVERY, STORAGE, AND HANDLING

Check products upon delivery to assure that the proper material has been received and is undamaged. For geosynthetics, the guidelines presented in ASTM D4873/D4873M shall be followed.

1.5.1 Segmental Concrete Units and Wall Caps

Protect blocks from damage and exposure to cement, paint, excessive mud, and like materials. Check materials upon delivery to assure that the block dimensions are within the tolerances specified.

1.5.2 Geosynthetic Labeling

Each roll shall be labeled with the manufacturer's name, product identification, roll dimensions, lot number, and date manufactured.

1.5.3 Geosynthetic Handling

Geosynthetic rolls shall be handled and unloaded by hand, or with load carrying straps, a fork lift with a stinger bar, or an axial bar assembly. Geosynthetic rolls shall not be dragged, lifted by one end, lifted by cables or chains, or dropped to the ground.

1.5.4 Geosynthetic Storage

Protect geosynthetics from cement, paint, excessive mud, chemicals, sparks and flames, temperatures in excess of 160 degrees F, and any other environmental condition that may degrade the physical properties. If stored outdoors, the rolls shall be elevated from the ground surface. Geosynthetics, except for extruded grids, shall be protected with an opaque waterproof cover. Geosynthetics shall be delivered to the site in a dry and undamaged condition. Geotextiles shall not be exposed to direct sunlight for more than 7 days.

PART 2 PRODUCTS

2.1 SYSTEM REQUIREMENTS

This work element includes engineering services in addition to the construction requirements. The Contractor is responsible for engineering services that include design of the wall in accordance with the National Concrete Masonry Association design method, and providing shop drawings indicating all features of the complete design. This work element includes engineering in addition to the construction requirements. The NCMA design method for segmental retaining walls considers potential failure modes categorized by external, internal, local, compound, and global stability. The Government has considered the global stability and has provided the minimum design requirements on the drawings. The Contractor is responsible for engineering services that include analysis of the wall for all modes of stability, and providing shop drawings indicating all features of the complete design.

2.1.1 Design Requirements

Complete all stability analyses in accordance with either the NCMA TR127B, or the Federal Highway Administration/AASHTO method detailed in FHWA NHI-00-043. Only one method shall be followed for the complete design, including reinforcement design strength, layout, stability calculations, and seismic effects. The segmental retaining wall system shall be designed under the direction of, and be signed by, a professional engineer.

2.1.2 Design Parameters

Calculations shall include determination of long term design strength of reinforcement specific to this project in accordance with the NCMA TR127B or FHWA NHI-00-043. Submit calculations of the long term design strength for the reinforcement in accordance with the NCMA or FHWA design method. The ultimate strength or index strength shall be based on the minimum average roll value tensile strength of the product using the wide width strength test in ASTM D4595. Submit Design calculations, including computer output data and program documentation. The calculations shall include all items described under PARAGRAPH: SEGMENTAL RETAINING WALL DESIGN. The calculation shall itemize each reduction factor and include backup data to justify each reduction factor. Calculations shall include analysis of all failure modes listed in the NCMA TR127B. Design calculations shall include a clear outline of material properties and assumptions.

2.1.2.1 External Stability Design Requirements

As a minimum requirement, the length of the reinforcing at the base of the wall shall not be less than 0.7 times the total height of the blocks.

2.1.2.2 Global Stability Design Requirements

The long term design strength of the lowest reinforcement layer shall equal or exceed the requirements listed in Table 1. Reinforcement lengths shall be no less than the lengths as recommended by the manufacturer.

2.1.3 Layout

Shop drawings shall reflect all information needed to fabricate and erect the walls including the leveling pad elevations; the shape and dimensions of wall elements; the number, size, type, and details of the soil reinforcing system and anchorage; and identification of areas requiring coping. Submit Fabrication and installation drawings. Include with the shop drawings all items described under paragraph SEGMENTAL RETAINING WALL DESIGN.If approved by the Contracting Officer, shop drawings may consist of marked up contract drawings showing exact dimensions for the blocks supplied, required coping, and other minor revisions. The design and layout of the internal reinforcement shall be subject to the following:

a. All features indicated in the contract documents shall be incorporated in the final design and construction.

b. The leveling pad elevations may vary, but shall be no higher than the embedment depth profile shown.

c. Each reinforcement level shall run as continuous as practical throughout the profile. If a geotextile filter is present, the

reinforcement shall be laid out so that interference with the geotextile is minimized.

d. Any reinforcement not placed with the machine direction as the design reinforcement direction shall be identified on the shop drawings.

e. Reinforcement attached to the wall facing shall not combine geogrid and geotextile, nor products from different manufacturers, within one wall. The number of reinforcement products shall be limited to avoid confusion in placement. For walls under 12 feet high, all reinforcement shall be the same grade and strength (i.e. design with one reinforcement strength).

2.2 SEGMENTAL CONCRETE UNITS

Submit two samples of each proposed block. Each sample shall be typical of the size, texture, color, and finish.

2.2.1 Architectural requirements

2.2.1.1 Face color

To match building face.

2.2.1.2 Face Texture

Split face typical of broken mortar.

2.2.1.3 Face Appearance

Straight, single-surface face.

2.2.1.4 Batter

Engagae blocks to the block below by use of keys, lips, pins, clips, or other reliable mechanism to provide a consistent wall batter between 1H:6V and 1H:16V.

2.2.1.5 Block Size

A minimum of 2/3 square feet of face area, and minimum 6 inch height

2.2.1.6 Bond Configuration

No bond configuration is required for straight face blocks. Design beveled or sculptured face blocks to stack with a half-bond (joints located at midpoint of vertically adjacent blocks). Finish the block edges so that vertical joints are flush.

2.2.2 Structural requirements

The blocks must be manufactured to the requirements of ASTM C1372 or ASTM C94/C94M, except for the following modifications:

a. Minimum 28-day compressive strength of 4000 psi, based on net area in accordance with ASTM C140/C140M.

b. A maximum moisture absorption rate of 9 pcf, in accordance with ASTM C140/C140M.

c. The minimum oven dry density of concrete shall be 125 pcf.

d. The blocks shall provide a minimum of 80 psf of wall face area (determined without void filling).

e. For freeze-thaw durability tested in accordance with ASTM C1262, specimens shall comply with either of the following: (1) the weight loss of each of 5 specimens after 100 cycles shall not exceed 1 percent; or (2) the weight loss of each of 5 specimens after 150 cycles shall not exceed 1.5 percent. when tested in a 3 percent saline solution: (1) the weight loss of each of 5 specimens after 40 cycles shall not exceed 1 percent; or (2) the weight loss of 4 out of 5 specimens after 50 cycles shall not exceed 1.5 percent.

f. The shear strength between blocks determined in accordance with NCMA TR127B shall have shear strength meeting minimum design requirements as stated by manufacturer.

2.2.3 Wall Caps

Segmental concrete block units shall be placed as caps on top of all segmental concrete retaining walls. The cap blocks shall have a color and texture on exposed faces to match that of the other blocks and meet the requirements for the other blocks except that the minimum height shall be 3 inches. Each cap block shall have abutting edges saw cut or formed to provide tight, flush abutting joints with no gaps in the joints when placed end to end in the alignment shown on the drawings.

2.3 REINFORCEMENT

2.3.1 Geogrid Reinforcement

Geogrid shall be a geosynthetic manufactured for reinforcement applications. The geogrid shall be a regular network of integrally connected polymer tensile elements with aperture geometry sufficient to permit significant mechanical interlock with the surrounding soil, aggregate, or other fill materials. The geogrid structure shall be dimensionally stable and able to retain its geometry under manufacture, transport and installation. The geogrid shall be manufactured with 100 percent virgin resin consisting of polyethylene, polypropylene, or polyester, and with a maximum of 5 percent in-plant regrind material. Polyester resin shall have a minimum molecular weight of 25,000 and a carboxyl end group number less than 30. Polyethylene and polypropylene shall be stabilized with long term antioxidants.

2.3.2 Geotextile Reinforcement

Geotextile shall be a pervious sheet of polymeric material and shall consist of long-chain synthetic polymers composed of at least 95 percent by weight polyethylene, polypropylene, or polyesters. The geotextile shall be manufactured with 100 percent virgin resin, and with a maximum of 5 percent in-plant regrind material. Geotextile shall be formed into a network such that the filaments or yarns retain dimensional stability relative to each other, including the selvages. Polyester resin shall have a minimum molecular weight of 20,000 and a carboxyl end group number less than 50. Polyethylene and polypropylene shall be stabilized with long term antioxidants. For survivability during installation, and in addition to installation damage used in calculating the long term design

strength, the geotextile shall meet the minimum requirements in AASHTO M 288 Class 1, and shall have a minimum mass per unit area of 8 oz/sy.

2.3.3 Reinforcement Properties

The reinforcement shown in the approved shop drawing submittal shall meet the long term design strength requirements used in the design, and shall meet the properties listed in Table 1. Reinforcement strength requirements represent minimum average roll values in the machine direction.
The reinforcement indicated must meet the property requirements listed in Table 1. Reinforcement strength requirements represent minimum average roll values in the machine direction.
The reinforcement indicated must meet the property requirements listed in Table 1. Additional reinforcement shown in the approved shop drawing submittal must meet the long term design strength requirements used in the design and shall meet other properties listed in Table 1. Submit affidavit certifying that the reinforcement meets the project specifications. The affidavit must be signed by an official authorized to certify on behalf of the manufacturer and shall be accompanied by a mill certificate that verifies physical properties were tested during manufacturing and lists the manufacturer's quality control testing. If the affidavit is dated after award of the contract and/or is not specific to the project, the supplier must attach a statement certifying that the affidavit addressed to the wholesale company is representative of the material supplied. Include in the documents a statement confirming that all purchased resin used to produce reinforcement is virgin resin. Include in the mill certificate the tensile strength tested in accordance with ASTM D4595. Reinforcement strength requirements represent minimum average roll values in the machine direction.

TABLE 1. REINFORCEMENT PROPERTIES

PROPERTY	REQUIREMENT	TEST DESIGNATION
Permittivity (geotextiles)	0.5 per second	ASTM D4491/D4491M
UV Resistance	70 percent after 500 HOURS	ASTM D4355/D4355M
Coefficient of Interaction for Pullout	.85	ASTM D6706

2.3.3.1 Long Term Design Strength

The long term design strength shall be based on reduction factors for installation damage and durability that are applicable to the fill that will be used. Minimum reduction factors for durability include: 1.1 for polyethylene and polypropylene geosynthetics, 1.15 for coated polyester geogrids, and 1.6 for polyester geotextiles. The creep reduction factor must be consistent with the test procedure used for determining the ultimate strength.

2.3.3.2 Connection Strength

The connection strength between the blocks and reinforcement determined in accordance with ASTM D6638 shall have connection strength meeting the minimum requirements as directed by the manufacturer.

2.4 GEOTEXTILE FILTER

Geotextiles used as filters shall meet the requirements specified in Table 2. The property values (except for AOS) represent minimum average roll values (MARV) in the weakest principal direction. For survivability during installation, the geotextile shall meet the minimum requirements in AASHTO M 288 Class 2, and shall have a minimum mass per unit area of 8 oz/sy.

TABLE 2. GEOTEXTILE PHYSICAL PROPERTIES

PROPERTY	TEST REQUIREMENT	TEST METHOD
Grab Tensile, lbs.	160 nonwoven 250 woven	ASTM D4632/D4632M
Apparent Opening Size (U.S. Sieve)	70 - 100	ASTM D4751
Permittivity, sec-1	0.5	ASTM D4491/D4491M

2.5 SOILS AND AGGREGATES

All material placed as fill shall consist of material classified by ASTM D2487 as GW, GP, GC, GM, SP, SM, SC, CL, ML, or SW. The material shall be free of ice; snow; frozen earth; trash; debris; sod; roots; organic matter; contamination from hazardous, toxic or radiological substances; or stones larger than 3 inches in any dimension. Each material shall be obtained entirely from one borrow source, unless the Contracting Officer determines that quality control is adequate and the alternate source produces material that is similar in gradation, texture, and interaction with the reinforcement. Supply any testing required by the Contracting Officer to evaluate alternate sources. All materials shall be of a character and quality satisfactory for the purpose intended.

2.5.1 Drainage Aggregate

Meet the requirements of ASTM D448, size No.7.

2.5.2 Aggregate Base Material

For the wall leveling pads meet the requirements of ASTM D1241, gradation C.

2.5.3 Reinforced Fill

Soil placed in the reinforced fill zone must consist of granular material with less than 5 percent passing the No. 200 sieve.

2.5.4 Retained Fill

Soil placed in the retained fill zone must meet the minimum requirements above.

2.6 MASONRY ADHESIVE

The masonry adhesive shall meet the following requirements:

a. ASTM C920, Type S, Grade NS, Class 25

b. Recommendations of the block manufacturer

2.7 DRAINAGE PIPE

Provide corrugated polyethylene pipe drainage pipe meeting requirements of AASHTO M 252.

PART 3 EXECUTION

3.1 CLASSIFICATION OF SOIL MATERIALS

Perform classification of soil materials in accordance with ASTM D2488. The Contracting Officer reserves the right to revise the Contractor classifications. In the case of disagreement, the Contracting Officer's classification will govern unless the soils are classified in accordance with ASTM D2487. All testing completed by the Contractor in conjunction with soil material classification will be considered incidental to the contract work.

3.2 EARTHWORK

The leveling pad and reinforced fill zone shall bear on undisturbed native soils, or acceptably placed and compacted fill. In the event that it is necessary to remove material to a depth greater than specified or to place fill below the leveling pad not otherwise provided for in the contract, the Contracting Officer shall be notified prior to work and an adjustment in the contract price will be considered in accordance with the contract. Additional work not authorized by the Contracting Officer shall be at the Contractor's expense.

3.2.1 Excavation

Foundation soil shall be excavated as required for leveling pad dimensions and reinforcement placement shown on the construction drawings. Material for backfilling shall be stockpiled in a neat and orderly manner at a sufficient distance from the banks of the excavation to avoid overloading and to prevent slides or caving. Excavation and fill shall be performed in a manner and sequence that will provide proper drainage at all times. The Contractor is responsible for disposal of surplus material, waste material, and material that does not meet specifications, including any soil which is disturbed by the Contractor's operations or softened due to exposure to the elements and water.

3.2.2 Stockpiles

Stockpiles of all material to be incorporated into the work shall be kept in a neat and well drained condition, giving due consideration to drainage at all times. The ground surface at stockpile locations shall be cleared,

grubbed, and sealed. Topsoil shall be stockpiled separately from suitable backfill material. Stockpiles of aggregates and granular soils shall be protected from contamination which may destroy the quality and fitness of the stockpiled material. If the Contractor fails to protect the stockpiles, and any material becomes frozen, saturated, intermixed with other materials, or otherwise out of specification or unsatisfactory for the use intended, such material shall be removed and replaced with new material from approved sources at no additional cost to the Government.

3.3 LEVELING PAD

3.3.1 Aggregate Base Leveling Pad

The subgrade below the leveling pad shall be compacted with at least 3 passes with a vibratory plate compactor with an operating weight not less than 450 pounds. The aggregate base material shall be placed in lifts not exceeding 6 inches and compacted with at least 3 passes with a vibratory plate compactor. If the subgrade or aggregate base pumps, bleeds water, or cracks during compaction, the Contracting Officer shall be notified and, if no other changes are directed, the aggregate shall be replaced with a concrete leveling pad.

3.3.2 Concrete Leveling Pad

Tolerances in screeding shall be sufficient to place the blocks directly on the leveling pad without mortar, pointing, or leveling course between the blocks and leveling pad.

3.4 BLOCK INSTALLATION

The wall system components shall be constructed in accordance with the wall supplier's recommendations and construction manual. Damaged blocks shall not be incorporated in the retaining wall.

a. Block placement shall begin at the lowest leveling pad elevation. The blocks shall be in full contact with the leveling pad. Each course of block shall be placed sequentially for the entire wall alignment to maintain a level working platform for layout of reinforcement and placement of fill.

b. The grade and alignment of the first course shall be surveyed and the results furnished to the Contracting Officer prior to placing the second course. Survey control for alignment shall include a string line, offset from a base line, or suitable provisions that can be reproduced for quality assurance.

c. Place the blocks with the edges in tight contact. No gap are allowed for wall batter and curvature. Maintain the vertical joints with a minimum 4 inch overlap on the underlying block. Do coping required to keep block alignment with a full depth saw cut. No splitting is allowed.

d. Stacking of blocks prior to filling any lower course of block with drainage aggregate will not be allowed.

e. Join cap units and the top two course of blocks using masonry adhesive. Take care to keep adhesive from coming into contact with the face of wall units.

3.5 REINFORCEMENT INSTALLATION

a. Before placing reinforcement, compact the subgrade or subsequent lift of fill and grade level with the top of the blocks. The surface must be smooth and free of windrows, sheepsfoot impressions, and rocks.

b. Place reinforcement at the elevations and to the extent shown on the construction drawings and the approved shop drawing submittal. Reinforcement shall be oriented with the design strength axis perpendicular to the wall face. Each segment of reinforcement shall be continuous. Spliced connections between shorter pieces of reinforcement will not be allowed. Place reinforcement strips immediately next to adjacent strips to provide 100 percent coverage.

c. Install the reinforcement in tension. Pull the reinforcement taut and anchor with staples or stakes prior to placing the overlying lift of fill. The tension must be uniform along the length of the wall and consistent between layers.

d. All reinforcement must be 100 percent covered by soil so that reinforcement panels do not contact in overlaps. Where the wall bends, place a veneer of fill to a nominal thickness of 3 inches to separate overlapping reinforcement.

3.6 FILL PLACEMENT

a. Fill placement, including drainage aggregate, shall be completed to the top of each course of facing blocks prior to stacking the subsequent course of blocks.

b. Reinforced fill shall be placed from the wall back toward the fill area to ensure that the reinforcement remains taut. Fill shall be placed, spread, and compacted in such manner that minimizes the development of wrinkles in or movement of the reinforcement.

c. A minimum fill thickness of 6 inches is required prior to operation of vehicles over the reinforcement. Sudden braking and sharp turning shall be avoided. Tracked equipment shall not turn within the reinforced fill zone to prevent tracks from displacing the fill and damaging the reinforcement. Construction equipment shall not be operated directly upon the reinforcement as part of the planned construction sequence. Rubber tired equipment may operate directly on the reinforcement if: the Contractor submits information documenting testing of equipment operating on a similar geogrid product on similar soils, the travel is infrequent, equipment travels slow, turning is minimized, and no damage or displacement to the reinforcement is observed.

d. Drainage aggregate shall be placed and tamped directly behind, between, and within the cells of the facing units. Compaction of the drainage aggregate shall be achieved by at least two passes on each lift with a vibratory plate compactor. Care shall be taken not to contact or chip the blocks with the compactor. Aggregate placed within the block cores and recesses shall be compacted by hand tamping and rodding.

e. At the end of each day, slope the last lift of fill away from the wall in a manner that will allow drainage and direct runoff away from the wall face.

3.7 COMPACTION

Fill shall not be placed on surfaces that contain mud, frost, organic soils, fill soils that have not met compaction requirements, or where the Contracting Officer determines that unsatisfactory material remains in or under the fill. Fill shall be spread and compacted in lifts not exceeding the height of one course of blocks.

3.7.1 Degree of Compaction

Degree of compaction required is expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D698. The maximum density is hereafter abbreviated as the "Standard Proctor" value.

3.7.2 Moisture Control

Control of moisture in the fill shall be maintained to provide acceptable compaction. Disking and plowing will not be allowed in the reinforced fill zone. Moisture content of cohesive soils shall be adjusted at the borrow source before placement. Adding water directly to the reinforced fill zone shall only be conducted under conditions where the soil has sufficient porosity and capillarity to provide uniform moisture throughout the fill during compaction.

3.7.3 Compaction

Reinforced and retained fill shall be compacted to 95 percent of the Standard Proctor Density. Care shall be exercised in the compaction process to avoid misalignment of the facing blocks. Heavy compaction equipment (including vibratory drum rollers) shall not be used within3 feet from the wall face.

3.8 SOIL TESTING

All testing expenses shall be the Contractor's responsibility. Prior to sampling and testing the work, testing laboratories shall be inspected and approved in accordance with Section 01 45 00.00 10 QUALITY CONTROL. The Contracting Officer reserves the right to direct the location and select the material for samples to be tested and to direct where and when moisture-density tests shall be performed. Use nuclear density testing equipment in general accordance with ASTM D6938.

3.8.1 Transmittal

The Contracting Officer shall be informed of test results daily for direction on corrective action required. Draft copies of field testing results shall be furnished to the Contracting Officer on a frequent and regular basis, as directed.

3.8.2 Corrective Action.

Tests of materials which do not meet the contract requirements (failing test) will not be counted as part of the required testing. Each such failing test must be retaken at the same location as the failing test was taken. If testing indicates material does not meet the contract requirements, the material represented by the failing test shall not be placed in the contract work or shall be recompacted or removed. The quantity of material represented by the failing test shall be determined

by the Contracting Officer up to the quantity represented by the testing frequency. The Contractor may increase testing frequency in the vicinity of a failing test in order to reduce removal requirements, as approved by the Contracting Officer. Such increases in testing frequency shall be at the Contractor's expense and at no additional cost to the Government.

3.8.3 Testing Schedule

3.8.3.1 Moisture-Density Relations

ASTM D698. One test for each material variation.

3.8.3.2 In-Place Densities

ASTM D1556/D1556M or ASTM D6938. Not less than 1 test for each 2 vertical feet per 300 linear feet along wall face.

3.8.3.3 Sieve Analysis

ASTM C136/C136M. Drainage Aggregate, 1 test for each source.

3.9 REINFORCEMENT TESTING

All testing expenses shall be the Contractor's responsibility. Testing shall be performed by a commercial testing laboratory selected by the Contractor and approved by the Contracting Officer or performed by the Contractor if approved by the Contracting Officer. The Contracting Officer reserves the right to direct the location and select the material for samples. Testing data specific to the blocks and reinforcement to be supplied shall be as follows:

a. The shear strength between blocks shall be established in accordance with NCMA TR127B.

b. The connection strength between the blocks and the reinforcement shall be established in accordance with ASTM D6638. If the FHWA design method is used, the modifications in FHWA NHI-00-043 shall be implemented.

c. The coefficient for direct shear of the reinforcement on a soil similar in gradation and texture to the material that will be used for fill in the reinforced zone shall be established in accordance with ASTM D5321/D5321M.

d. The coefficient of interaction for pull-out resistance of the reinforcement in a soil similar in gradation and texture to the material that will be used for fill in the reinforced zone shall be established in accordance with ASTM D6706.

TABLE 3. REINFORCEMENT TESTING

PROPERTY	TEST DESIGNATION	FREQUENCY
Wide Width Strip Tensile Strength	ASTM D4595	1 per lot

Modify ASTM D4595 for geogrids considering recommendations in GSI GRI GG6; and the tensile strength shall be expressed on a unit length basis by

substituting n*a for Ws, where:

Ws = specimen width, (inches)
n = number of ribs in the sample (must be a whole number)
a = nominal rib spacing for the product tested, (inches)

3.10 DRAINAGE PIPE

Drain pipe shall be placed as indicated on the drawings. Drain lines shall be laid to true grades and alignment with a continuous fall in the direction of flow. The interior of the pipe shall be kept clean from soil and debris; and open ends shall be temporarily capped as necessary.

3.11 CONSTRUCTION TOLERANCES

3.11.1 Horizontal

The top of wall must be within 6 inches of the plan location.

3.11.2 Vertical

The top of wall elevations must be within 0.25 feet above to 0.25 feet below the prescribed top of wall elevations indicated.

3.11.3 Plumbness and Alignment

The wall batter and alignment offset measured as deviation from a straight edge must be within plus or minus 1.25 inches per 10 feet section. The batter measured from vertical must be within 2 degrees of the plan dimension.

3.11.4 Block Defects

The blocks will be accepted on the basis of tolerances specified in ASTM C1372.

3.11.5 Block Gaps

Gaps between adjacent blocks must not exceed 1/8 inches.

3.12 PROTECTION OF WORK

Protect work against damage from subsequent operations. Remove disturbed or displaced blocks and replace to conform to all requirements of this section. Do not incorporate damaged material into the wall. Upon completion of wall erection, clean the wall face to remove any loose soil deposits or stains.

-- End of Section --

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SEEDING
08/17

PART 1 GENERAL

1.1 REFERENCES

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

ASTM INTERNATIONAL (ASTM)

ASTM C602	(2013a) Agricultural Liming Materials
ASTM D4427	(2018) Standard Classification of Peat Samples by Laboratory Testing
ASTM D4972	(2013) pH of Soils

U.S. DEPARTMENT OF AGRICULTURE (USDA)

AMS Seed Act	(1940; R 1988; R 1998) Federal Seed Act
DOA SSIR 42	(1996) Soil Survey Investigation Report No. 42, Soil Survey Laboratory Methods Manual, Version 3.0

1.2 DEFINITIONS

1.2.1 Stand of Turf

95 percent ground cover of the established species.

1.3 RELATED REQUIREMENTS

Section 31 00 00 EARTHWORK, Section 32 92 23 SODDING, Section 32 93 00 EXTERIOR PLANTS, and Section 32 05 33 LANDSCAPE ESTABLISHMENT 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" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance with Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Wood Cellulose Fiber Mulch

Fertilizer

Include physical characteristics, and recommendations.

SD-06 Test Reports

Topsoil Composition Tests (reports and recommendations).

SD-07 Certificates

State Certification and Approval for Seed

SD-08 Manufacturer's Instructions

Erosion Control Materials

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery

1.5.1.1 Seed 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 Seed, Fertilizer Gypsum Sulfur Iron and Lime Storage

Store in cool, dry locations away from contaminants.

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 frozen, snow covered, muddy, or when air temperature exceeds 90 degrees Fahrenheit.

1.7 TIME LIMITATIONS

1.7.1 Seed

Apply seed within twenty four hours after seed bed preparation.

PART 2 PRODUCTS

2.1 SEED

2.1.1 Classification

Provide State-certified State-approved Endophyte-enhanced seed of the latest season's crop delivered in original sealed packages, bearing producer's guaranteed analysis for percentages of mixtures, purity, germination, weedseed content, and inert material. Label in conformance with AMS Seed Act and applicable state seed laws. Wet, moldy, or otherwise damaged seed will be rejected. Field mixes will be acceptable when field mix is performed on site in the presence of the Contracting Officer.

2.1.2 Planting Dates

2.1.2.1 Permanent Seeding

"Cool Season": planted between 1 September and 28 February
50 pounds per acre Winter Wheat (Triticum spelta). NO RYE GRASS.
25 pounds per acre common Bermuda (Cynodon dactylon), hulled
25 pounds per acre common Bermuda (Cynodon dactylon), unhulled

"Warm Season": planted between 1 March and 31 August
50 pounds per acre German (Setaria italica), Brown Top (Setaria italica), or Fox Tail Millet (Brachiaria ramosum)
50 pounds per acre common Bermuda (Cynodon dactylon), hulled

2.1.2.2 Temporary Seeding

"Cool Season": planted between 1 September and 28 February
120 pounds per acre Winter Wheat (Triticum spelta)

"Warm Season": planted between 1 March and 31 August
65 pounds per acre German (Setaria italica), Brown Top (Setaria italica), or Fox Tail Millet (Brachiaria ramosum)

2.1.3 Hydroseeding

Hydroseeding shall only be allowable on slopes steeper than 1 horizontal to
1 vertical. Steps 1 through 4 must be completed prior to hydroseeding. Hydroseeding should be applied in two applications. The first application will consist of 1/3 of the mulch and 2/3 of the seed and the second application will consist of 2/3 of the mulch and 1/3 of the seed. The mulch will include a tackifier and will be applied at a rate of 2,000 pounds per acre or the manufacturer's recommendation, whichever is higher.

Proportion seed mixtures by weight. Temporary seeding must later be replaced by permanent seeding plantings for a permanent stand of grass. The same requirements of turf establishment for permanent seeding apply for temporary seeding.

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 must 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 must 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 must be tested in accordance with ASTM D4972. Topsoil must be free of sticks, stones, roots, and other debris and objectionable materials. Other components must 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 110 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 80 percent, calcium 18 percent, sulfur 14 percent; minimum 96 percent passing through 20 mesh screen, 100 percent passing thru 16 mesh screen.

2.3.10 Calcined Clay

Calcined clay must be granular particles produced from montmorillonite clay calcined to a minimum temperature of 1200 degrees F. Gradation: A minimum 90 percent must pass a No. 8 sieve; a minimum 99 percent must be retained on a No. 60 sieve; and material passing a No. 100 sieve must not exceed 2 percent. Bulk density: A maximum 40 pounds per cubic foot.

2.4 FERTILIZER

2.4.1 Granular Fertilizer

Organic and synthetic, granular controlled release fertilizer:

Apply fertilizer/Lime at rates as determined by laboratory soil analysis of soils at the job site. In the absence of the soil analysis, apply soil amendments at the rates indicated in steps 2 and 3.

1. Area will be tilled to 4 inch depth

2. Apply lime at 70 pounds per 1000 square feet, or 1.5 tons per acre

3. Apply 10-20-20 at a rate of 850 pounds per acre or 20 pounds per 1000 square feet. The fertilizer should be either slow time release or applied in two applications, half at time of planting and the second half after permanent seed germinates.

4. The lime and fertilizer will be worked into the top 2 to 4 inches of soil prior to seeding.

5. Seed Mix and Rate

2.4.2 Hydroseeding Fertilizer

Controlled release fertilizer, to use with hydroseeding and composed of pills coated with plastic resin to provide a continuous release of nutrients for at least 6 months. Apply fertilizer/Lime at rates as determined by laboratory soil analysis of soils at the job site. In the absence of the soil analysis, apply soil amendments at the rates indicated in steps 2 and 3.

1. Area will be tilled to 4 inch depth

2. Apply lime at 70 pounds per 1000 square feet, or 1.5 tons per acre

3. Apply 10-20-20 at a rate of 850 pounds per acre or 20 pounds per 1000 square feet. The fertilizer should be either slow time release or applied in two applications, half at time of planting and the second half after permanent seed germinates.

4. The lime and fertilizer will be worked into the top 2 to 4 inches of soil prior to seeding.

5. Seed Mix and Rate

2.5 MULCH

Mulch must be free from noxious weeds, mold, and other deleterious materials.

2.5.1 Straw

Stalks from oats, wheat, rye, barley, or rice. Furnish in air-dry condition and of proper consistency for placing with commercial mulch blowing equipment. Straw must contain no fertile seed.

2.5.2 Hay

Air-dry condition and of proper consistency for placing with commercial mulch blowing equipment. Hay must be sterile, containing no fertile seed.

2.5.3 Wood Cellulose Fiber Mulch

Use recovered materials of either paper-based (100 percent post-consumer content) or wood-based (100 percent total recovered content) hydraulic mulch. Processed to contain no growth or germination-inhibiting factors and dyed an appropriate color to facilitate visual metering of materials application. Composition on air-dry weight basis: 9 to 15 percent

moisture, pH range from 5.5 to 8.2. Use with hydraulic application of grass seed and fertilizer.

2.6 WATER

Source of water must be approved by Contracting Officer and of suitable quality for irrigation, containing no elements toxic to plant life.

2.7 EROSION CONTROL MATERIALS

Erosion control material must conform to the following:

2.7.1 Erosion Control Blanket

100 percent agricultural straw or 70 percent agricultural straw/30 percent coconut fiber matrix stitched with a degradable nettings, designed to degrade within 12 months.

2.7.2 Erosion Control Fabric

Fabric must be knitted construction of polypropylene yarn with uniform mesh openings 3/4 to 1 inch square with strips of biodegradable paper. Filler paper strips must have a minimum life of 6 months.

2.7.3 Erosion Control Net

Net must be heavy, twisted jute mesh, weighing approximately 1.22 pounds per linear yard and 4 feet wide with mesh openings of approximately one inch square.

2.7.4 Hydrophilic Colloids

Hydrophilic colloids must be physiologically harmless to plant and animal life without phytotoxic agents. Colloids must be naturally occurring, silicate powder based, and must form a water insoluble membrane after curing. Colloids must resist mold growth.

2.7.5 Erosion Control Material Anchors

Erosion control anchors must be as recommended by the manufacturer.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 EXTENT OF WORK

Provide soil preparation prior to planting (including soil conditioners as required), fertilizing, seeding, and surface topdressing 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.

3.1.1.1 Topsoil

Provide 4 inches of 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.

3.1.1.2 Soil Conditioner Application Rates

Apply soil conditioners at rates as determined by laboratory soil analysis of the soils at the job site.

3.1.1.3 Fertilizer Application Rates

Apply fertilizer at rates as determined by laboratory soil analysis of the soils at the job site.

3.2 SEEDING

3.2.1 Seed Application Seasons and Conditions

Immediately before seeding, restore soil to proper grade. Do not seed when ground is muddy frozen snow covered or in an unsatisfactory condition for seeding. If special conditions exist that may warrant a variance in the above seeding dates or conditions, submit a written request to the Contracting Officer stating the special conditions and proposed variance. Apply seed within twenty four hours after seedbed preparation. Sow seed by approved sowing equipment. Sow one-half the seed in one direction, and sow remainder at right angles to the first sowing.

3.2.2 Seed Application Method

Seeding method must be hydroseeding.

3.2.2.1 Hydroseeding

First, mix water and fiber. Wood cellulose fiber, paper fiber, or recycled paper must be applied as part of the hydroseeding operation. Fiber must be added at 1,000 pounds, dry weight, per acre. Then add and mix seed and fertilizer to produce a homogeneous slurry. When hydraulically sprayed on the ground, material must form a blotter like cover impregnated uniformly with grass seed. Spread with one application with no second application of mulch.

3.2.3 Mulching

3.2.3.1 Hay or Straw Mulch

Hay or straw mulch must be spread uniformly at the rate of 2 tons per acre. Mulch must be spread by hand, blower-type mulch spreader, or other approved method. Mulching must be started on the windward side of relatively flat areas or on the upper part of steep slopes, and continued uniformly until the area is covered. The mulch must not be bunched or clumped. Sunlight must not be completely excluded from penetrating to the ground surface. All areas installed with seed must be mulched on the same day as the seeding. Mulch must be anchored immediately following spreading.

3.2.3.2 Mechanical Anchor

Mechanical anchor must be a V-type-wheel land packer; a scalloped-disk

land packer designed to force mulch into the soil surface; or other suitable equipment.

3.2.3.3 Asphalt Adhesive Tackifier

Asphalt adhesive tackifier must be sprayed at a rate between 10 to 13 gallons per 1000 square feet. Sunlight must not be completely excluded from penetrating to the ground surface.

3.2.3.4 Non-Asphaltic Tackifier

Hydrophilic colloid must be applied at the rate recommended by the manufacturer, using hydraulic equipment suitable for thoroughly mixing with water. A uniform mixture must be applied over the area.

3.2.3.5 Asphalt Adhesive Coated Mulch

Hay or straw mulch may be spread simultaneously with asphalt adhesive applied at a rate between 10 to 13 gallons per 1000 square feet, using power mulch equipment which must be equipped with suitable asphalt pump and nozzle. The adhesive-coated mulch must be applied evenly over the surface. Sunlight must not be completely excluded from penetrating to the ground surface.

3.2.4 Rolling

Immediately after seeding, 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. If seeding is performed with cultipacker-type seeder or by hydroseeding, rolling may be eliminated.

3.2.5 Erosion Control Material

Install in accordance with manufacturer's instructions, where indicated or as directed by the Contracting Officer.

3.2.6 Watering

Start watering areas seeded as required by temperature and wind conditions. Apply water at a rate sufficient to insure thorough wetting of soil to a depth of 2 inches without run off. During the germination process, seed is to be kept actively growing and not allowed to dry out.

3.3 PROTECTION OF TURF AREAS

Immediately after turfing, protect area against traffic and other use.

3.4 RENOVATION OF EXISTING TURF AREA

3.4.1 Aeration

Upon completion of weed eradication operations and Contracting Officer's approval to proceed, aerate turf areas indicated, by approved device. Core, by pulling soil plugs, to a minimum depth of 3 inches. Leave all soil plugs, that are produced, in the turf area. After aeration operations are complete, topdress entire area 1/4 inch depth with the following mixture:

10 percent sand

20 percent humus

10 percent gypsum

40 percent organic fertilizer

20 percent synthetic fertilizer

Blend all parts of topdressing mixture to a uniform consistency throughout. Keep clean at all times at least one paved pedestrian access route and one paved vehicular access route to each building. Clean all soil plugs off of other paving when work is complete.

3.4.2 Vertical Mowing

Upon completion of aerating operation and Contracting Officer's approval to proceed, vertical mow turf areas indicated, by approved device, to a depth of 1/4 inch above existing soil level, to reduce thatch build-up, grain, and surface compaction. 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 is complete. Remove all debris generated during this operation off site.

3.4.3 Dethatching

Upon completion of aerating operation and Contracting Officer's approval to proceed, dethatch turf areas indicated, by approved device, to a depth of 1/4 inch below existing soil level, to reduce thatch build-up, grain, and surface compaction. 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 is complete. Remove all debris generated during this operation off site.

3.4.4 Overseeding

Apply seed in accordance with and at rates indicated in applicable portions of paragraph SEED APPLICATION METHOD.

3.5 RESTORATION

Restore to original condition existing turf areas which have been damaged during turf installation operations at the Contractor's expense. 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 32 92 23

SODDING
04/06

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	(2013a) Agricultural Liming Materials
ASTM D4427	(2018) Standard Classification of Peat Samples by Laboratory Testing
ASTM D4972	(2013) pH of Soils

TURFGRASS PRODUCERS INTERNATIONAL (TPI)

TPI GSS	(1995) Guideline Specifications to Turfgrass Sodding

U.S. DEPARTMENT OF AGRICULTURE (USDA)

DOA SSIR 42	(1996) Soil Survey Investigation Report No. 42, Soil Survey Laboratory Methods Manual, Version 3.0

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, Section 32 92 19 SEEDING, Section 32 93 00 EXTERIOR PLANTS, and Section 32 05 33 LANDSCAPE ESTABLISHMENT 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" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.00 37 SUSTAINABILITY. 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

Nursery or 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 frozen, snow covered, 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.Wood pegs and wire staples for anchorage shall be as recommended by sod supplier.

2.1.2 Purity

Sod species shall be genetically pure, free of weeds, pests, and disease.

2.1.3 Planting Dates

Lay sod from 1 March to 31 August for warm season spring planting and from 1 September to 28 February for cool season fall planting.

2.1.4 Composition

2.1.4.1 Proportion

Proportion grass species as follows.

"Cool Season": planted between 1 September and 28 February
50 pounds per acre Winter Wheat (Triticum spelta). NO RYE GRASS.
25 pounds per acre common Bermuda (Cynodon dactylon), hulled
25 pounds per acre common Bermuda (Cynodon dactylon), unhulled

"Warm Season": planted between 1 March and 31 August
50 pounds per acre German (Setaria italica), Brown Top (Setaria italica), or Fox Tail Millet (Brachiaria ramosum)
50 pounds per acre common Bermuda (Cynodon dactylon), hulled

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 entitled "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 entitled "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 110 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 or synthetic, granular controlled release fertilizer containing the following minimum percentages, by weight, of plant food nutrients:

10 percent available nitrogen
20 percent available phosphorus
20 percent available potassium

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 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 Sodding Slopes and Ditches

For slopes 2:1 and greater, lay sod with long edge perpendicular to the contour. For V-ditches and flat bottomed ditches, lay sod with long edge perpendicular to flow of water. Anchor each piece of sod with wood pegs or wire staples maximum 2 feet on center. On slope areas, start sodding at bottom of the slope.

3.2.4 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.

3.2.5 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.

3.2.6 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 RENOVATION OF EXISTING TURF AREA

3.4.1 Aeration

Upon completion of weed eradication operations and Contracting Officer's approval to proceed, aerate turf areas indicated, by approved device. Core, by pulling soil plugs, to a minimum depth of 3 inches. Leave all soil plugs, that are produced, in the turf area. After aeration operations are complete, topdress entire area 1/4 inch depth with the following mixture:

10 percent sand
20 percent humus
10 percent gypsum
40 percent organic fertilizer
20 percent synthetic fertilizer

Blend all parts of topdressing mixture to a uniform consistency throughout. Keep clean at all times at least one paved pedestrian access route and one paved vehicular access route to each building. Clean all soil plugs off of other paving when work is complete.

3.4.2 Vertical Mowing

Upon completion of aerating operation and Contracting Officer's approval to proceed, vertical mow turf areas indicated, by approved device, to a depth of 1/4 inch above existing soil level, to reduce thatch build-up, grain, and surface compaction. 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 is complete. Remove all debris generated during this operation off site.

3.4.3 Dethatching

Upon completion of aerating operation and Contracting Officer's approval to proceed, dethatch turf areas indicated, by approved device, to a depth of 1/4 inch below existing soil level, to reduce thatch build-up, grain, and surface compaction. 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 is complete. Remove all debris generated during this operation off site.

3.5 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 32 93 00

EXTERIOR PLANTS
08/17

PART 1 GENERAL

1.1 REFERENCES

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

AMERICANHORT (AH)

ANSI/ANLA Z60.1	(2004) American Standard for Nursery Stock

ASTM INTERNATIONAL (ASTM)

ASTM A580/A580M	(2018) Standard Specification for Stainless Steel Wire
ASTM C602	(2013a) Agricultural Liming Materials
ASTM D4427	(2018) Standard Classification of Peat Samples by Laboratory Testing
ASTM D4972	(2013) pH of Soils
ASTM D5268	(2013) Topsoil Used for Landscaping Purposes
ASTM D5852	(2000; R 2007; E 2014) Standard Test Method for Erodibility Determination of Soil in the Field or in the Laboratory by the Jet Index Method
ASTM D6629	(2001; E 2012; R 2012) Selection of Methods for Estimating Soil Loss by Erosion

L.H. BAILEY HORTORIUM (LHBH)

LHBH	(1976) Hortus Third

TREE CARE INDUSTRY ASSOCIATION (TCIA)

TCIA A300P1	(2017) ANSI A300 Part1: Tree Care Operations - Trees, Shrubs and Other Woody Plant Maintenance Standard Practices - Pruning
TCIA Z133	(2017) American National Standard for Arboricultural Operations - Pruning, Repairing, Maintaining, and Removing Trees, and Cutting Brush - Safety Requirements

U.S. DEPARTMENT OF AGRICULTURE (USDA)

DOA SSIR 42	(1996) Soil Survey Investigation Report No. 42, Soil Survey Laboratory Methods Manual, Version 3.0

1.2 RELATED REQUIREMENTS

Section 31 00 00 EARTHWORK, Section 32 92 19 SEEDING, Section 32 92 23 SODDING, and Section 32 05 33 LANDSCAPE ESTABLISHMENT applies to this section for pesticide use and plant establishment requirements, with additions and modifications herein.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance with Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

State Landscape Contractor's License

Time Restrictions and Planting Conditions

Indicate anticipated dates and locations for each type of planting.

SD-03 Product Data

Peat

Composted Derivatives

Rotted Manure

Organic Mulch Materials

Gypsum

Mulch; G

Ground Stakes

Fertilizer

Weed Control Fabric; G

Root Control Barrier; G

Staking Material

Metal Anchors

Antidesiccants

Erosion Control Materials

Photographs; G

SD-04 Samples

Mulch; G

Submit one pint of mulch.

SD-06 Test Reports

Topsoil Composition Tests; Soil Test of proposed area; Soil Test location map

Percolation Test; Percolation Test of proposed area

SD-07 Certificates

Nursery Certifications

SD-10 Operation and Maintenance Data

Plastic Identification

When not labeled, identify types in Operation and Maintenance Manual.

1.4 QUALITY ASSURANCE

1.4.1 Topsoil Composition Tests

Commercial test from an independent testing laboratory including basic soil groups (moisture and saturation percentages, Nitrogen-Phosphorus-Potassium (N-P-K) ratio, pH (ASTM D4972), soil salinity), secondary nutrient groups (calcium, magnesium, sodium, Sodium Absorption Ratio (SAR)), micronutrients (zinc, manganese, iron, copper), toxic soil elements (boron, chloride, sulfate), cation exchange and base saturation percentages, and soil amendment and fertilizer recommendations with quantities for plant material being transplanted. Soil required for each test must include a maximum depth of 18 inches of approximately one quart volume for each test. Areas sampled should not be larger than one acre and should contain at least 6-8 cores for each sample area and be thoroughly mixed. Problem areas should be sampled separately and compared with samples taken from adjacent non-problem areas. The location of the sample areas should be noted and marked on a parcel or planting map for future reference.

1.4.2 Nursery Certifications

a. Indicate on nursery letterhead the name of plants in accordance with the LHBH, including botanical common names, quality, and size.

b. Inspection certificate.

c. Mycorrhizal fungi inoculum for plant material treated

1.4.3 State Landscape Contractor's License

Construction company must hold a landscape contractors license in the state where the work is performed and have a minimum of five years landscape construction experience. Submit copy of license and three references for similar work completed in the last five years.

1.4.4 Plant Material Photographs

Contractor must submit nursery photographs, for government approval prior to ordering, for each tree larger than 24-inch box/ 2-inch caliper size.

1.4.5 Percolation Test

Immediately following rough grading operation, identify a typical location for one of the largest trees and or shrubs and excavate a pit per the project details. Fill the pit with water to a depth of 12 inches. The length of time required for the water to percolate into the soil, leaving the pit empty, must be measured by the project Landscape Architect and verified by the Contracting Officer. Within six hours of the time the water has drained from the pit, the Contractor, with the Contracting Officer and project Landscape Architect present, must again fill the pit with water to a depth of 12 inches. If the water does not completely percolate into the soil within 9 hours, a determination must be made whether a drainage system or a soil penetrant will be required for each tree and or shrub being transplanted.

1.4.6 Erosion Assessment

Assess potential effects of soil management practices on soil loss in accordance with ASTM D6629. Assess erodibility of soil with dominant soil structure less than 2.8 to 3.1 inches in accordance with ASTM D5852.

1.4.7 Pre-Installation Meeting

Convene a pre-installation meeting a minimum of one week prior to commencing work of this section. Require attendance of parties directly affecting work of this section. Review conditions of operations, procedures and coordination with related work. Agenda must include the following:

a. Tour, inspect, and discuss conditions of planting materials.

b. Review planting schedule and maintenance.

c. Review required inspections.

d. Review environmental procedures.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery

1.5.1.1 Branched Plant Delivery

Deliver with branches tied and exposed branches covered with material which allows air circulation. Prevent damage to branches, trunks, root systems, and root balls and desiccation of leaves.

1.5.1.2 Soil Amendment Delivery

Deliver to the site in original, unopened containers bearing manufacturer's chemical analysis, name, trade name, or trademark, and indication of conformance to state and federal laws. Instead of containers, fertilizer, gypsum, sulfur, iron, and lime may be furnished in bulk with a certificate indicating the above information. Store in dry locations away from contaminates.

1.5.1.3 Plant Labels

Deliver plants with durable waterproof labels in weather-resistant ink. Provide labels stating the correct botanical and common plant name and variety as applicable and size as specified in the list of required plants. Attach to plants, bundles, and containers of plants. Groups of plants may be labeled by tagging one plant. Labels must be legible for a minimum of 60 days after delivery to the planting site.

1.5.2 Storage

1.5.2.1 Plant Storage and Protection

Store and protect plants not planted on the day of arrival at the site as follows:

a. Shade and protect plants in outside storage areas from the wind and direct sunlight until planted.

b. Heel-in bare root plants.

c. Protect balled and burlapped plants from freezing or drying out by covering the balls or roots with moist burlap, sawdust, wood chips, shredded bark, peat moss, or other approved material. Provide covering which allows air circulation.

d. Keep plants in a moist condition until planted by watering with a fine mist spray.

e. Do not store plant material directly on concrete or bituminous surfaces.

1.5.2.2 Fertilizer, Gypsum, pH Adjusters and Mulch Storage

Store in dry locations away from contaminants.

1.5.2.3 Topsoil

Prior to stockpiling topsoil, eradicate on site undesirable growing vegetation. Clear and grub existing vegetation three to four weeks prior to stockpiling existing topsoil.

1.5.2.4 Root Control Barrier and Weed Control Fabric

Store materials on site in enclosures or under protective covering in dry location. Store under cover out of direct sunlight. Do not store materials directly on ground.

1.5.3 Handling

Do not drop or dump plants from vehicles. Avoid damaging plants being moved from nursery or storage area to planting site. Handle plants carefully to avoid damaging or breaking the earth ball or root structure. Do not handle plants by the trunk or stem. Puddle bare-root plants after removal from the heeling-in bed to protect roots from drying out. Remove damaged plants from the site.

1.5.4 TIME LIMITATION

Except for container-grown plant material, the time limitation from digging to installing plant material must be a maximum of 90 days. The time limitation between installing the plant material and placing the mulch must be a maximum of 24 hours.

1.6 TIME RESTRICTIONS AND PLANTING CONDITIONS

Coordinate installation of planting materials during optimal planting seasons for each type of plant material required.

1.6.1 Planting Dates

Plant all plants from March 1 to December 15.

1.6.1.1 Deciduous Material

Deciduous material from March 1 to June 1 for spring/summer planting and from October 15 to December 15 for fall/winter planting.

1.6.1.2 Evergreen Material

Evergreen material from March 1 to June 1 for spring/summer planting and from October 15 to December 15 for fall/winter planting.

1.6.2 Restrictions

Do not plant when ground is frozen, snow covered, muddy, or when air temperature exceeds 90 degrees Fahrenheit

1.7 GUARANTEE

All plants must be guaranteed for one year beginning on the date of inspection by the Contracting Officer to commence the plant establishment period, against defects including death and unsatisfactory growth, except for defects resulting from lack of adequate maintenance, neglect, or abuse by the Government or by weather conditions unusual for the warranty period.

Remove and replace dead planting materials immediately unless required to plant in the succeeding planting season. At end of warranty period, replace planting materials that die or have 25 percent or more of their branches that die during the construction operations or the guarantee period.

1.8 PLASTIC IDENTIFICATION

Provide product data indicating polymeric information in Operation and Maintenance Manual.
Type 1: Polyethylene Terephthalate (PET, PETE).

Type 2: High Density Polyethylene (HDPE).
Type 3: Vinyl (Polyvinyl Chloride or PVC).
Type 4: Low Density Polyethylene (LDPE).
Type 5: Polypropylene (PP).
Type 6: Polystyrene (PS).
Type 7: Other. Use of this code indicates that the package in question is made with a resin other than the six listed above, or is made of more than one resin listed above, and used in a multi-layer combination.

PART 2 PRODUCTS

2.1 PLANTS

2.1.1 Regulations and Varieties

Existing trees and shrubs to remain must be protected and a planting plan be arranged around them. Furnish nursery stock in accordance with ANSI/ANLA Z60.1, except as otherwise specified or indicated. Each plant or group of planting must have a "key" number indicated on the nursery certifications of the plant schedule. Furnish plants, including turf grass, grown under climatic conditions similar to those in the locality of the project. Plants specified must be indigenous, low maintenance varieties, tolerant of site's existing soils and climate without supplemental irrigation or fertilization once established. Spray plants budding into leaf or having soft growth with an antidesiccant before digging. Plants of the same specified size must be of uniform size and character of growth. Plants must be chosen with their mature size and growth habit in mind to avoid over-planting and conflict with other plants, structures or underground utility lines. All plants must comply with all Federal and State Laws requiring inspection for plant diseases and infestation.

2.1.2 Shape and Condition

Well-branched, well-formed, sound, vigorous, healthy planting stock free from disease, sunscald, windburn, abrasion, and harmful insects or insect eggs and having a healthy, normal, and undamaged root system.

2.1.2.1 Deciduous Trees and Shrubs

Symmetrically developed and of uniform habit of growth, with straight boles or stems, and free from objectionable disfigurements.

2.1.2.2 Evergreen Trees and Shrubs

Well developed symmetrical tops with typical spread of branches for each particular species or variety.

2.1.2.3 Ground Covers and Vines

Number and length of runners and clump sizes indicated, and of the proper age for the grade of plants indicated, furnished in removable containers, integral containers, or formed homogeneous soil section.

2.1.3 Plant Size

Minimum sizes measured after pruning and with branches in normal position, must conform to measurements indicated, based on the average width or

height of the plant for the species as specified in ANSI/ANLA Z60.1. Plants larger in size than specified may be provided with approval of the Contracting Officer. When larger plants are provided, increase the ball of earth or spread of roots in accordance with ANSI/ANLA Z60.1.

2.1.4 Root Ball Size

All box-grown, field potted, field boxed, collected, plantation grown, bare root, balled and burlapped, container grown, processed-balled, and in-ground fabric bag-grown root balls must conform to ANSI/ANLA Z60.1. All wrappings and ties must be biodegradable. Root growth in container grown plants must be sufficient to hold earth intact when removed from containers. Root bound plants will not be accepted.

2.1.4.1 Mycorrhizal fungi inoculum

Before shipment, root systems must contain mycorrhizal fungi inoculum.

2.1.5 Growth of Trunk and Crown

2.1.5.1 Deciduous Trees

A height to caliper relationship must be provided in accordance with ANSI/ANLA Z60.1. Height of branching must bear a relationship to the size and species of tree specified and with the crown in good balance with the trunk. The trees must not be "poled" or the leader removed.

a. Single stem: The trunk must be reasonably straight and symmetrical with crown and have a persistent main leader.

b. Multi-stem: All countable stems, in aggregate, must average the size specified. To be considered a stem, there must be no division of the trunk which branches more than 6 inches from ground level.

2.1.5.2 Palms

Palms must have the specified height as measured from the base of the trunk to the base of the fronds or foliage in accordance with ANSI/ANLA Z60.1. The palm must have straight trunk and healthy fronds or foliage as typical for the variety grown in the region of the project. Palms trimmed or pruned for delivery must retain a minimum of 6 inches of foliage at the crown as a means of determining plant health.

2.1.5.3 Deciduous Shrubs

Deciduous shrubs must have the height and number of primary stems recommended by ANSI/ANLA Z60.1. Acceptable plant material must be well shaped, with sufficient well-spaced side branches, and recognized by the trade as typical for the species grown in the region of the project.

2.1.5.4 Coniferous Evergreen Plant Material

Coniferous Evergreen plant material must have the height-to-spread ratio recommended by ANSI/ANLA Z60.1. The coniferous evergreen trees must not be "poled" or the leader removed. Acceptable plant material must be exceptionally heavy, well shaped and trimmed to form a symmetrical and tightly knit plant. The form of growth desired must be as indicated.

2.1.5.5 Broadleaf Evergreen Plant Material

Broadleaf evergreen plant material must have the height-to-spread ratio recommended by ANSI/ANLA Z60.1. Acceptable plant material must be well shaped and recognized by the trade as typical for the variety grown in the region of the project.

2.1.5.6 Ground Cover and Vine Plant Material

Ground cover and vine plant material must have the minimum number of runners and length of runner recommended by ANSI/ANLA Z60.1. Plant material must have heavy, well developed and balanced crown with vigorous, well developed root system and must be furnished in containers.

2.2 TOPSOIL

2.2.1 Existing Soil

Modify to conform to requirements specified in paragraph COMPOSITION.

2.2.2 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 must be existing surface soil stripped and stockpiled on-site in accordance with Section 31 00 00 EARTHWORK.

2.2.3 Off-Site Topsoil

Conform to requirements specified in paragraph COMPOSITION. Additional topsoil must be furnished by the Contractor.

2.2.4 Composition

Evaluate soil for use as topsoil in accordance with ASTM D5268. 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 must be tested in accordance with ASTM D4972. Topsoil must be free of sticks, stones, roots, plants, and other debris and objectionable materials. Other components must 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

Provide singly or in combination as required to meet specified requirements for topsoil. Soil conditioners must be nontoxic to plants.

2.3.1 Lime

Commercial grade hydrated limestone containing a calcium carbonate equivalent (C.C.E.) as specified in ASTM C602 of not less than 110 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 as modified herein. Shred and granulate peat to pass a 1/2 inch mesh screen and condition in storage pile for minimum 6 months after excavation. Peat must not contain invasive species, including seeds.

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, invasive species, including seeds, 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 80 percent, calcium 18 percent, sulfur 14 percent; minimum 96 percent passing through 20 mesh screen, 100 percent passing thru 16 mesh screen.

2.3.10 Vermiculite

Horticultural grade for planters.

2.3.11 Rotted Manure

Well rotted horse or cattle manure containing maximum 25 percent by volume of straw, sawdust, or other bedding materials; free of seeds, stones, sticks, soil, and other invasive species.

2.4 PLANTING SOIL MIXTURES

100 percent topsoil as specified herein.

2.5 FERTILIZER

Fertilizer for groundcover, wildflowers and grasses is not permitted. Fertilizer for trees, plants, and shrubs must be as recommended by plant supplier, except synthetic chemical fertilizers are not permitted. Fertilizers containing petrochemical additives or that have been treated with pesticides or herbicides are not permitted.

2.5.1 Granular Fertilizer

Organic, granular controlled release fertilizer containing the following minimum percentages, by weight, of plant food nutrients:

10 percent available nitrogen
15 percent available phosphorus
10 percent available potassium
5 percent sulfur
10 percent iron

2.5.2 Fertilizer Tablets

Organic, plant tablets composed of tightly compressed fertilizer chips forming a tablet that is insoluble in water, is designed to provide a continuous release of nutrients for at least 24 months and contains the following minimum percentages, by weight, of plant food nutrients:

20 percent available nitrogen
20 percent available phosphorus
5 percent available potassium

2.6 WEED CONTROL FABRIC

2.6.1 Roll Type Polypropylene or Polyester Mats

Fabric must be woven, needle punched or non-woven and treated for protection against deterioration due to ultraviolet radiation. Fabric must be minimum 99 percent opaque to prevent photosynthesis and seed germination from occurring, yet allowing air, water and nutrients to pass thru to the roots. Minimum weight must be 5 ounces per square yard with a minimum thickness of 20 mils with a 20 year (minimum) guarantee.

2.7 MULCH

Free from noxious weeds, mold, pesticides, or other deleterious materials.

2.7.1 Organic Mulch Materials

Provide shredded hardwood from site when available. Wood cellulose fiber must be processed to contain no growth or germination-inhibiting factors, dyed with non-toxic, biodegradable dye to an appropriate color to facilitate visual metering of materials application. Paper-based hydraulic mulch must contain 100 percent post-consumer recycled content. Wood-based hydraulic mulch must contain 100 percent total recovered materials content.

2.7.2 Recycled Organic Mulch

Recycled mulch may include compost, tree trimmings, or pine needles with a gradation that passes through a 2-1/2 by 2-1/2 inch screen. It must be cleaned of all sticks a minimum one inch in diameter and plastic materials a minimum 3 inches length. The material must be treated to retard the growth of mold and fungi.

2.8 STAKING AND GUYING MATERIAL

2.8.1 Staking Material

2.8.1.1 Tree Support Stakes

Rough sawn hard wood free of knots, rot, cross grain, bark, long slivers, or other defects that impair strength. Stakes must be minimum 2 inches square or 2-1/2 inch diameter by 8 feet long, pointed at one end. Paint or stain wood stakes dark brown..

2.8.1.2 Ground Stakes

Rough sawn hard wood or plastic, 2 inches square are by 3 feet long, pointed at one end.

2.8.2 Guying Material

2.8.2.1 Guying Wire

12 gauge annealed galvanized steel, ASTM A580/A580M.

2.8.2.2 Guying Cable

Minimum five-strand, 3/16 inch diameter galvanized steel cable plastic coated.

2.8.3 Hose Chafing Guards

New or used 2 ply 3/4 inch diameter reinforced rubber or plastic hose, black or dark green, all of same color.

2.8.4 Flags

White surveyor's plastic tape, 1/2 inch diameter PVC pipe, 12 inches long, fastened to guying wires or cables.

2.8.5 Turnbuckles

Galvanized or cadmium-plated steel with minimum 3 inch long openings fitted with screw eyes. Eye bolts must be galvanized or cadmium-plated

steel with one inch diameter eyes and screw length 1-1/2 inches, minimum.

2.8.6 Deadmen

4 by 8 inch rectangular or 8 inch diameter by 36 inch long, pine or fir wood material.

2.8.7 Metal Anchors

2.8.7.1 Driven Anchors

Malleable iron, arrow shaped, galvanized, sized as follows:

Tree Caliper	Anchor Size
2 inches and under	3 inches
3 to 6 inches	4 inches
6 to 8 inches	6 inches
8 to 10 inches	8 inches
10 to 12 inches	10 inches

2.8.7.2 Screw Anchors

Steel, screw type with welded-on 3 inch round helical steel plate, minimum 3/8 inch diameter, 15 inches long.

2.9 ANTIDESICCANTS

Sprayable, water insoluble vinyl-vinledine complex which produce a moisture retarding barrier not removable by rain or snow. Film must form at temperatures commonly encountered out of doors during planting season and have a moisture vapor transmission rate (MVT) of the resultant film of maximum 10 grams per 24 hours at 70 percent humidity.

2.10 EROSION CONTROL MATERIALS

Erosion control material must conform to the following:

2.10.1 Erosion Control Blanket

100 percent agricultural straw or 70 percent agricultural straw/30 percent coconut fiber matrix stitched with a degradable nettings, designed to degrade within 12 months.

2.10.2 Erosion Control Fabric

Fabric must be knitted construction of polypropylene yarn with uniform mesh openings 3/4 to 1 inch square with strips of biodegradable paper. Filler paper strips must have a minimum life of 6 months.

2.10.3 Erosion Control Net

Net must be heavy, twisted jute mesh, weighing approximately 1.22 pounds per linear yard and 4 feet wide with mesh openings of approximately one inch square.

2.10.4 Hydrophilic Colloids

Hydrophilic colloids must be physiologically harmless to plant and animal life without phytotoxic agents. Colloids must be naturally occurring, silicate powder based, and must form a water insoluble membrane after curing. Colloids must resist mold growth.

2.10.5 Erosion Control Material Anchors

Erosion control anchors must be as recommended by the manufacturer.

2.11 ROOT CONTROL BARRIER

Flexible and permeable geotextile fabric with permanently attached time-released nodules. Color to be black. 2.12 WATER

Source of water to be approved by Contracting Officer and suitable quality for irrigation and must not contain elements toxic to plant life, including acids, alkalis, salts, chemical pollutants, and organic matter. Use collected storm water or graywater when available.

2.13 MYCORRHIZAL FUNGI INOCULUM

Mycorrhizal fungi inoculum must be composed of multiple-fungus inoculum as recommended by the manufacturer for the plant material specified.

2.14 SOURCE QUALITY CONTROL

The Contracting Officer will inspect plant materials at the project site and approve them. Tag plant materials for size and quality.

PART 3 EXECUTION

3.1 EXTENT OF WORK

Provide soil preparation, including soil conditioners and soil amendments prior to planting. Provide tree, shrub, vine, groundcover, seed, and sod planting, post-planting fertilizer, edging, staking, guying, weed control fabric, erosion control material, root control barrier installation, and mulch topdressing 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.

3.2 ALTERNATIVE HERBICIDE TREATMENT (SOLARIZING SOIL)

Within 48 hours of subsoil preparation, saturate soil with water to a depth of 3 feet. Immediately stake polyethylene sheeting over area to be planted. Stake tightly to surface of soil. Maintain sheeting in place for a minimum of 6 weeks. Immediately after removing sheeting, cover area to be planted with topsoil. Do not till soil prior to applying topsoil.

3.3 PREPARATION

3.3.1 Protection

Protect existing and proposed landscape features, elements, and sites from damage or contamination. Protect trees, vegetation, and other designated features by erecting high-visibility, reusable construction fencing. Locate fence no closer to trees than the drip line. Plan equipment and vehicle access to minimize and confine soil disturbance and compaction to areas indicated on Drawings.

3.3.2 Layout

Stake out approved plant material locations and planter bed outlines on the project site before digging plant pits or beds. The Contracting Officer reserves the right to adjust plant material locations to meet field conditions. Do not plant closer than 36 inches to a building wall, pavement edge, fence or wall edge and other similar structures. Provide on-site locations for excavated rock, soil, and vegetation.

3.3.3 Erosion Control

Provide erosion control and seeding with native plant species to protect slopes.

3.3.4 Soil Preparation

3.3.4.1 pH Adjuster Application Rates

Apply pH adjuster at rates as determined by laboratory soil analysis of the soils at the job site.

3.3.4.2 Soil Conditioner Application Rates

Apply soil conditioners at rates as determined by laboratory soil analysis of the soils at the job site.

3.3.4.3 Fertilizer Application Rates

Apply fertilizer at rates as determined by laboratory soil analysis of the soils at the job site.

3.3.5 Root Control Barrier

Install geotextile fabric in the soil in a vertical horizontal and surrounding application. Use appropriate holding device to assure fabric position. For vertical or horizontal application, a minimum 2 inch soil cover is required over the top surface. A minimum 18 inch extension of fabric beyond the structure area to be protected is required to prevent root growth from growing around fabric edges.Install linear polypropylene barrier a minimum 1/2 inch above finish grade to prevent root growth over the barrier. Backfill the outside of the barrier with 3/4 to one gravel a minimum width of 2 inches. For linear barrier application use appropriate device to connect two pieces.

3.4 PLANT BED PREPARATION

Verify location of underground utilities prior to excavation. Protect existing adjacent turf before excavations are made. Do not disturb

topsoil and vegetation in areas outside those indicated on Drawings. Where planting beds occur in existing turf areas, remove turf to a depth that will ensure removal of entire root system. Measure depth of plant pits from finished grade. Depth of plant pit excavation must be as indicated and provide proper relation between top of root ball and finished grade. Install plant material as specified in paragraph PLANT INSTALLATION. Do not install trees within 10 feet of any utility lines or building walls.

3.5 PLANT INSTALLATION

3.5.1 Individual Plant Pit Excavation

Excavate pits at least twice as large in diameter as the size of ball or container to depth shown.

3.5.2 Plant Beds with Multiple Plants

Excavate plant beds continuously throughout entire bed as outlined to depth shown.

3.5.3 Handling and Setting

Move plant materials only by supporting the root ball or container. Set plants on hand compacted layer of prepared backfill soil mixture 6 inches thick and hold plumb in the center of the pit until soil has been tamped firmly around root ball. Set plant materials, in relation to surrounding finish grade, one to 2 inches below depth at which they were grown in the nursery, collecting field or container. Replace plant material whose root balls are cracked or damaged either before or during the planting process.

Plant material must be set in plant beds according to the drawings. Backfill soil mixture must be placed on previously scarified subsoil to completely surround the root balls, and must be brought to a smooth and even surface, blending to existing areas.

3.5.3.1 Balled and Burlapped Stock

Backfill with topsoil to approximately half the depth of ball and then tamp and water. Carefully remove or fold back excess burlap and tying materials from the top a minimum 1/3 depth from the top of the rootball. Tamp and complete backfill, place mulch topdressing, and water. Remove wires and non-biodegradable materials from plant pit prior to backfill operations.

3.5.3.2 Bare-Root Stock

Plant so roots are arranged in a natural position. Place roots in water a minimum of 30 minutes prior to planting. Carefully work topsoil among roots. Tamp remainder of backfill, place mulch topdressing and water.

3.5.3.3 Container Grown Stock

Remove from container and prevent damage to plant or root system.

3.5.3.4 Ground Covers and Vines

Plant after placing mulch topdressing. Do not remove plant materials from flats or containers until immediately before planting. Space at intervals

indicated. Plant at a depth to sufficiently cover all roots. Start watering areas planted as required by temperature and wind conditions. Apply water at a rate sufficient to ensure thorough wetting of soil to a depth of 6 inches without run off or puddling. Smooth planting areas after planting to provide even, smooth finish. Mulch as indicated.

3.5.4 Earth Mounded Watering Basin for Individual Plant Pits

Form with topsoil around each plant by replacing a mound of topsoil around the edge of each plant pit. Watering basins must be 6 inches deep for trees and 4 inches deep for shrubs. Eliminate basins around plants in plant beds containing multiple plants.

Form with topsoil around each plant by placing a mound of topsoil around the edge of each plant pit. Watering basins must be 6 inches deep for trees and 4 inches deep for shrubs. Construct watering basin in a 4-1/2 foot diameter circle around specimen (not planted in a close group) trees and shrubs.

3.5.5 Weed Control Fabric Installation

Remove grass and weed vegetation, including roots, from within the area enclosed by edging. Completely cover areas enclosed by edging with specified weed control fabric prior to placing mulch layer. Overlap cut edges 6 inches.

3.5.6 Erosion Control Material

Install in accordance with manufacturer's instructions.

3.5.7 Placement of Mulch Topdressing

Place specified mulch topdressing on top of weed control fabric covering total area enclosed by edging. Place mulch topdressing to a depth of 3 inches.

3.5.8 Mulch Topdressing

Provide mulch topdressing over entire planter bed surfaces and individual plant surfaces including earth mound watering basin around plants to a depth of 3 inches after completion of plant installation and before watering. Keep mulch out of the crowns of shrubs. Place mulch a minimum 2 to 3 inches away from trunk of shrub or tree. Place on top of any weed control fabric.

3.5.9 Fertilization

3.5.9.1 Fertilizer Tablets

Place fertilizer planting tablets evenly spaced around the plant pits to the manufacturer's recommended depth.

3.5.9.2 Granular Fertilizer

Apply granular fertilizer as a top coat prior to placing mulch layer and water thoroughly.

3.5.10 Watering

Start watering areas planted as required by temperature and wind conditions. Slow deep watering must be used. Apply water at a rate sufficient to ensure thorough wetting of soil to a depth of 12 inches without run off or puddling. Watering of other plant material or adjacent areas must be prevented.

3.5.11 Staking and Guying

3.5.11.1 Staking

Stake plants with the number of stakes indicated as detailed. Attach guy wire half the tree height but not more than 5 feet high. Drive stakes to a depth of 2-1/2 to 3 feet into the ground outside the plant pit. Do not injure the root ball. Use hose chafer guards where guy wire comes in contact with tree trunk.

3.5.11.2 Guying

Guy plants as indicated. Attach two strands of guying wire or guying cable around the tree trunk at an angle of 45 degrees at approximately 1/2 of the trunk height. Protect tree trunks with chafing guards where guying wire or cable contacts the tree trunk. Anchor guys to deadmen wood blocks or wood ground stakes. Fasten flags to each guying wire or cable approximately 2/3 of the distance up from ground level. Provide turnbuckles as indicated.

3.5.11.3 Chafing Guards

Use hose chafing guards, as specified where guy wire or cable will contact the plant.

3.5.11.4 Deadmen

Place deadmen minimum 18 inches below ground surface. Place equal distance from tree trunk and around the plant pit.

3.5.11.5 Wood Ground Stakes

Drive wood ground stakes into firm ground outside of plant pit with top of stake flush with ground. Place equal distance from tree trunk and around the plant pit.

3.5.11.6 Flags

Securely fasten flags on each guy wire andcable approximately two-thirds of the distance up from ground level.

3.5.12 Pruning

Prune in accordance with safety requirement of TCIA Z133.

3.5.12.1 Trees and Shrubs

Remove dead and broken branches. Prune to correct structural defects only. Retain typical growth shape of individual plants with as much height and spread as practical. Do not cut central leader on trees. Make cuts with sharp instruments. Do not flush cut with trunk or adjacent

branches. Collars must remain in place. Pruning must be accomplished by trained and experienced personnel and must be accordance with TCIA A300P1.

3.5.12.2 Wound Dressing

Do not apply tree wound dressing to cuts.

3.6 RESTORATION AND CLEAN UP

3.6.1 Restoration

Turf areas, pavements and facilities that have been damaged from the planting operation must be restored to original condition at the Contractor's expense.

3.6.2 Clean Up

Excess and waste material must be removed from the installed area and must be disposed offsite at an approved landfill, recycling center, or composting center. Separate and recycle or reuse the following landscape waste materials: nylon straps, wire, ball wrap, burlap, wood stakes,. Adjacent paved areas must be cleared.

-- End of Section --

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DIVISION 33 - UTILITIES

SECTION 33 11 00

WATER UTILITY DISTRIBUTION PIPING

02/18

PART 1 GENERAL

PART 2 PRODUCTS

PART 3 EXECUTION

-- End of Section Table of Contents --

SECTION 33 11 00

WATER UTILITY DISTRIBUTION PIPING
02/18

PART 1 GENERAL

All water distribution piping to be installed by American States Utility Services (ASUS). Contractor to coordinate water distribution with ASUS.

PART 2 PRODUCTS

PART 3 EXECUTION

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 33 - UTILITIES

SECTION 33 30 00

SANITARY SEWERAGE

05/18

PART 1 GENERAL

PART 2 PRODUCTS

PART 3 EXECUTION

-- End of Section Table of Contents --

SECTION 33 30 00

SANITARY SEWERAGE
05/18

PART 1 GENERAL

All sanitary sewer service to be installed by American States Utility Services (ASUS). Contractor to coordinate sewer service with ASUS.

PART 2 PRODUCTS

PART 3 EXECUTION

-- End of Section --

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DIVISION 33 - UTILITIES

SECTION 33 40 00

STORM DRAINAGE UTILITIES

02/10

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SECTION 33 40 00

STORM DRAINAGE UTILITIES
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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 294	(2017) Standard Specification for Corrugated Polyethylene Pipe, 300- to 1500-mm (12- to 60-in.) Diameter
AASHTO MP 20	(2013; R 2017) Standard Specification for Steel-Reinforced Polyethylene (PE) Ribbed Pipe, 300- to 1500-mm (12- to 60-in) Diameter

AMERICAN CONCRETE INSTITUTE INTERNATIONAL (ACI)

ACI 346	(2009) Specification for Cast-in-Place Concrete Pipe

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE-OF-WAY ASSOCIATION (AREMA)

AREMA Eng Man	(2017) Manual for Railway Engineering

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A48/A48M	(2003; R 2012) Standard Specification for Gray Iron Castings
ASTM A536	(1984; R 2014) Standard Specification for Ductile Iron Castings
ASTM A807/A807M	(2017) Standard Practice for Installing Corrugated Steel Structural Plate Pipe for Sewers and Other Applications
ASTM A929/A929M	(2018) Standard Specification for Steel Sheet, Metallic-Coated by the Hot-Dip Process for Corrugated Steel Pipe
ASTM B26/B26M	(2014; E 2015) Standard Specification for

	Aluminum-Alloy Sand Castings
ASTM C1103	(2014) Standard Practice for Joint Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines
ASTM C139	(2017) Standard Specification for Concrete Masonry Units for Construction of Catch Basins and Manholes
ASTM C14	(2015) Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe
ASTM C1433	(2016b) Standard Specification for Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains, and Sewers
ASTM C231/C231M	(2017a) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C270	(2014a) Standard Specification for Mortar for Unit Masonry
ASTM C32	(2013; R 2017) Standard Specification for Sewer and Manhole Brick (Made from Clay or Shale)
ASTM C444	(2017) Standard Specification for Perforated Concrete Pipe
ASTM C478	(2018) Standard Specification for Circular Precast Reinforced Concrete Manhole Sections
ASTM C506	(2016a) Standard Specification for Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe
ASTM C507	(2018) Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe
ASTM C55	(2017) Standard Specification for Concrete Building Brick
ASTM C62	(2017) Standard Specification for Building Brick (Solid Masonry Units Made from Clay or Shale)
ASTM C76	(2018) Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
ASTM C828	(2011) Low-Pressure Air Test of Vitrified Clay Pipe Lines
ASTM C923	(2008; R 2013; E 2016) Standard

	Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals
ASTM C969	(2017) Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines
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 D1751	(2004; E 2013; R 2013) Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D1752	(2004a; R 2013) Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion
ASTM D1784	(2011) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D2167	(2015) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D2321	(2018) Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
ASTM D2729	(2017) Standard Specification for Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D3034	(2016) Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D3350	(2012) Polyethylene Plastics Pipe and Fittings Materials
ASTM D6938	(2017a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM F1417	(2011a) Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low Pressure Air
ASTM F2562/F2562M	(2015) Specification for Steel Reinforced Thermoplastic Ribbed Pipe and Fittings for Non-Pressure Drainage and Sewerage

ASTM F2736	(2013; E 2014) Standard Specification for 6 to 30 in. (152 To 762 mm) Polypropylene (PP) Corrugated Single Wall Pipe And Double Wall Pipe
ASTM F2764/F2764M	(2017; E 2017) Standard Specification for 6 to 60 in. 150 to 1500 mm Polypropylene (PP) Corrugated Double and Triple Wall Pipe and Fittings for Non-Pressure Sanitary Sewer Applications
ASTM F2881	(2011) Standard Specification for 12 to 60 in. (300 to 1500 mm) Polypropylene (PP) Dual Wall Pipe and Fittings for Non-Pressure Storm Sewer Applications
ASTM F679	(2016) Standard Specification for Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings
ASTM F714	(2013) Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter
ASTM F794	(2003; R 2014) Standard Specification for Poly(Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter
ASTM F894	(2013) Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe
ASTM F949	(2015) Poly(Vinyl Chloride) (PVC) Corrugated Sewer Pipe with a Smooth Interior and Fittings

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-04 Samples

Pipe for Culverts and Storm Drains

SD-07 Certificates

Resin Certification

Leakage Test

Determination of Density

Frame and Cover for Gratings

Post-Installation Inspection Report

SD-08 Manufacturer's Instructions

Placing Pipe

1.3 DELIVERY, STORAGE, AND HANDLING

1.3.1 Delivery and Storage

Materials delivered to site shall be inspected for damage, unloaded, and stored with a minimum of handling. Materials shall not be stored directly on the ground. The inside of pipes and fittings shall be kept free of dirt and debris. Before, during, and after installation, plastic pipe and fittings shall be protected 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. Solvents, solvent compounds, lubricants, elastomeric gaskets, and any similar materials required to install plastic pipe shall be stored in accordance with the manufacturer's recommendations and shall be discarded if the storage period exceeds the recommended shelf life. Solvents in use shall be discarded when the recommended pot life is exceeded.

1.3.2 Handling

Materials shall be handled in a manner that ensures delivery to the trench in sound, undamaged condition. Pipe shall be carried to the trench, not dragged.

PART 2 PRODUCTS

2.1 PIPE FOR CULVERTS AND STORM DRAINS

Pipe for culverts and storm drains shall be of the sizes indicated and shall conform to the requirements specified.

2.1.1 Concrete Pipe

Manufactured in accordance with and conforming to ASTM C76, Class III, IV, or V, as shown on plans.

2.1.1.1 Reinforced Arch Culvert and Storm Drainpipe

Manufactured in accordance with and conforming to ASTM C506, Class A-IV.

2.1.1.2 Reinforced Elliptical Culvert and Storm Drainpipe

Manufactured in accordance with and conforming to ASTM C507. Horizontal elliptical pipe shall be Class HE-IV. Vertical elliptical pipe shall be Class VE-V.

2.1.1.3 Nonreinforced Pipe

Manufactured in accordance with and conforming to ASTM C14, Class 3.

2.1.1.4 Cast-In-Place Nonreinforced Conduit

ACI 346, except that testing shall be the responsibility of and at the expense of the Contractor. In the case of other conflicts between ACI 346 and project specifications, requirements of ACI 346 shall govern.

2.1.2 Poly Vinyl Chloride (PVC) Pipe

Submit the pipe manufacturer's resin certification, indicating the cell classification of PVC used to manufacture the pipe, prior to installation of the pipe.

2.1.2.1 Type PSM PVC Pipe

ASTM D3034, Type PSM, maximum SDR 35, produced from PVC certified by the Manufacturer as meeting the requirements of ASTM D1784, minimum cell class 12454-B.

2.1.2.2 Profile PVC Pipe

ASTM F794, Series 46, produced from PVC certified by the Manufacturer as meeting the requirements of ASTM D1784, minimum cell class 12454-B.

2.1.2.3 Smooth Wall PVC Pipe

ASTM F679 produced from PVC certified by the Manufacturer as meeting the requirements of ASTM D1784, minimum cell class 12454-B.

2.1.2.4 Corrugated PVC Pipe

ASTM F949 produced from PVC certified by the Manufacturer as meeting the requirements of ASTM D1784, minimum cell class 12454-B.

2.1.3 Polyethylene (PE) Pipe

Submit the pipe manufacturer's resin certification, indicating the cell classification of PE used to manufacture the pipe, prior to installation of the pipe. The minimum cell classification for polyethylene plastic shall apply to each of the seven primary properties of the cell classification limits in accordance with ASTM D3350.

2.1.3.1 Smooth Wall PE Pipe

ASTM F714, maximum DR of 21 for pipes 3 to 24 inches in diameter and maximum DR of 26 for pipes 26 to 48 inches in diameter. Pipe shall be produced from PE certified by the resin producer as meeting the requirements of ASTM D3350, minimum cell class 335434C.

2.1.3.2 Corrugated PE Pipe

AASHTO M 294, Type S. For slow crack growth resistance, acceptance of resins shall be determined by using the notched constant ligament-stress (NCLS) test meeting the requirements of AASHTO M 294. Pipe walls shall have the following properties:

Nominal Size (inch))	Minimum Wall Area (square in/ft)	Minimum Moment of Inertia of Wall Section (in. to the 4th/in.)
12	1.5	0.024
15	1.91	0.053
18	2.34	0.062
24	3.14	0.116
30	3.92	0.163
36	4.50	0.222
42	4.69	0.543
48	5.15	0.543
54	5.67	0.800
60	6.45	0.800

2.1.3.3 Profile Wall PE Pipe

ASTM F894, RSC 160, produced from PE certified by the resin producer as meeting the requirements of ASTM D3350, minimum cell class 334433C. Pipe walls shall have the following properties:

Nominal Size (inch)	Minimum Wall Area (square in/ft)	Minimum Moment of Inertia of Wall Section (in to the 4th/in)	
		Cell Class 334433C	Cell Class 335434C
18	2.96	0.052	0.038
21	4.15	0.070	0.051
24	4.66	0.081	0.059
27	5.91	0.125	0.091
30	5.91	0.125	0.091
33	6.99	0.161	0.132
36	7.81	0.202	0.165
42	8.08	0.277	0.227
48	8.82	0.338	0.277

2.1.4 Steel Reinforced Polyethylene (SRPE) Pipe

SRPE pipe will meet the requirements of ASTM F2562/F2562M 8 - 120 inch diameter pipe and AASHTO MP 20 (12 - 60 inch diameter pipe).

2.1.5 Polypropylene (PP) Pipe

Double wall and triple wall pipe with a diameter of 12 to 60 inches shall meet the requirements of ASTM F2736, ASTM F2764/F2764M, or ASTM F2881.

2.2 PERFORATED PIPING

2.2.1 Concrete Pipe

Manufactured in accordance with and conforming to ASTM C444, and applicable requirements of ASTM C14, Class III.

2.2.2 Polyvinyl Chloride (PVC) Pipe

ASTM D2729.

2.3 DRAINAGE STRUCTURES

2.3.1 Flared End Sections

Sections shall be of a standard design fabricated from zinc coated steel sheets meeting requirements of ASTM A929/A929M.

2.3.2 Precast Reinforced Concrete Box

Manufactured in accordance with and conforming to ASTM C1433.

2.4 MISCELLANEOUS MATERIALS

2.4.1 Concrete

Unless otherwise specified, concrete and reinforced concrete shall conform to the requirements for 3500 psi concrete under Section 03 30 00.00 10 CAST-IN-PLACE CONCRETE . The concrete mixture shall have air content by volume of concrete, based on measurements made immediately after discharge from the mixer, of 5 to 7 percent when maximum size of coarse aggregate exceeds 1-1/2 inches. Air content shall be determined in accordance with ASTM C231/C231M. The concrete covering over steel reinforcing shall not be less than 1 inch thick for covers and not less than 1-1/2 inches thick for walls and flooring. Concrete covering deposited directly against the ground shall have a thickness of at least 3 inches between steel and ground. Expansion-joint filler material shall conform to ASTM D1751, or ASTM D1752, or shall be resin-impregnated fiberboard conforming to the physical requirements of ASTM D1752.

2.4.2 Mortar

Mortar for pipe joints, connections to other drainage structures, and brick or block construction shall conform to ASTM C270, Type M, except that the maximum placement time shall be 1 hour. Water shall be clean and free of harmful acids, alkalis, and organic impurities. The mortar shall be used within 30 minutes after the ingredients are mixed with water. The inside of the joint shall be wiped clean and finished smooth. The mortar head on the outside shall be protected from air and sun with a proper

covering until satisfactorily cured.

2.4.3 Precast Concrete Segmental Blocks

Precast concrete segmental block shall conform to ASTM C139, not more than 8 inches thick, not less than 8 inches long, and of such shape that joints can be sealed effectively and bonded with cement mortar.

2.4.4 Brick

Brick shall conform to ASTM C62, Grade SW; ASTM C55, Grade S-I or S-II; or ASTM C32, Grade MS. Mortar for jointing and plastering shall consist of one part portland cement and two parts fine sand. Lime may be added to the mortar in a quantity not more than 25 percent of the volume of cement. The joints shall be filled completely and shall be smooth and free from surplus mortar on the inside of the structure. Brick structures shall be plastered with 1/2 inch of mortar over the entire outside surface of the walls. For square or rectangular structures, brick shall be laid in stretcher courses with a header course every sixth course. For round structures, brick shall be laid radially with every sixth course a stretcher course.

2.4.5 Precast Reinforced Concrete Manholes

Conform to ASTM C478. Joints between precast concrete risers and tops shall be full-bedded in cement mortar and shall be smoothed to a uniform surface on both interior and exterior of the structure.

2.4.6 Prefabricated Corrugated Metal Manholes

Manholes shall be of the type and design recommended by the manufacturer. Manholes shall be complete with frames and cover, or frames and gratings.

2.4.7 Frame and Cover for Gratings

Submit certification on the ability of frame and cover or gratings to carry the imposed live load. Frame and cover for gratings shall be cast gray iron, ASTM A48/A48M, Class 35B; cast ductile iron, ASTM A536, Grade 65-45-12; or cast aluminum, ASTM B26/B26M, Alloy 356.O-T6. Weight, shape, size, and waterway openings for grates and curb inlets shall be as indicated on the plans. The word "Storm Sewer" shall be stamped or cast into covers so that it is plainly visible.

2.4.8 Joints

Joints shall be per manufacturer's recommendations.

2.4.9 Flap Gates

Flap Gates shall be medium or heavy-duty with circular opening and double-hinged. Top pivot points shall be adjustable. The seat shall be one-piece cast iron with a raised section around the perimeter of the waterway opening to provide the seating face. The seating face of the seat shall be stainless steel. The cover shall be one-piece cast iron with necessary reinforcing rib, lifting eye for manual operation, and bosses to provide a pivot point connection with the links. The seating face of the cover shall be stainless steel. Links or hinge arms shall be cast or ductile iron. Holes of pivot points shall be bronze bushed. All fasteners shall be either galvanized steel, bronze or stainless steel.

2.5 STEEL LADDER

Steel ladder shall be provided where the depth of the storm drainage structure exceeds 12 feet. These ladders shall be not less than 16 inches in width, with 3/4 inch diameter rungs spaced 12 inches apart. The two stringers shall be a minimum 3/8 inch thick and 2-1/2 inches wide. Ladders and inserts shall be galvanized after fabrication in conformance with ASTM A123/A123M.

2.6 RESILIENT CONNECTORS

Flexible, watertight connectors used for connecting pipe to manholes and inlets shall conform to ASTM C923.

2.7 EROSION CONTROL RIP RAP

Provide non-erodible rock not exceeding 15 inches in its greatest dimension and choked with sufficient small rocks to provide a dense mass with a minimum thickness of 8 inches or as indicated.

PART 3 EXECUTION

3.1 INSTALLATION OF PIPE CULVERTS, STORM DRAINS, AND DRAINAGE STRUCTURES

Excavation of trenches, and for appurtenances and backfilling for culverts and storm drains, shall be in accordance with the applicable portions of Section 31 00 00 EARTHWORK and the requirements specified below.

3.1.1 Trenching

The width of trenches at any point below the top of the pipe shall be not greater than the outside diameter of the pipe plus 24 inches to permit satisfactory jointing and thorough tamping of the bedding material under and around the pipe. Sheeting and bracing, where required, shall be placed within the trench width as specified, without any overexcavation. Where trench widths are exceeded, redesign with a resultant increase in cost of stronger pipe or special installation procedures will be necessary. Cost of this redesign and increased cost of pipe or installation shall be borne by the Contractor without additional cost to the Government.

3.1.2 Removal of Rock

Rock in either ledge or boulder formation shall be replaced with suitable materials to provide a compacted earth cushion having a thickness between unremoved rock and the pipe of at least 8 inches or 1/2 inch for each foot of fill over the top of the pipe, whichever is greater, but not more than three-fourths the nominal diameter of the pipe. Where bell-and-spigot pipe is used, the cushion shall be maintained under the bell as well as under the straight portion of the pipe. Rock excavation shall be as specified and defined in Section 31 00 00 EARTHWORK.

3.1.3 Removal of Unstable Material

Where wet or otherwise unstable soil incapable of properly supporting the pipe, as determined by the Contracting Officer, is unexpectedly encountered in the bottom of a trench, such material shall be removed to the depth required and replaced to the proper grade with select granular

material, compacted as provided in paragraph BACKFILLING. When removal of unstable material is due to the fault or neglect of the Contractor while performing shoring and sheeting, water removal, or other specified requirements, such removal and replacement shall be performed at no additional cost to the Government.

3.2 BEDDING

The bedding surface for the pipe shall provide a firm foundation of uniform density throughout the entire length of the pipe.

3.2.1 Concrete Pipe Requirements

When no bedding class is specified or detailed on the drawings, concrete pipe shall be bedded in granular material minimum 4 inch in depth in trenches with soil foundation. Depth of granular bedding in trenches with rock foundation shall be 1/2 inch in depth per foot of depth of fill, minimum depth of bedding shall be 8 inch up to maximum depth of 24 inches. The middle third of the granular bedding shall be loosely placed. Bell holes and depressions for joints shall be removed and formed so entire barrel of pipe is uniformly supported. The bell hole and depressions for the joints shall be not more than the length, depth, and width required for properly making the particular type of joint.

3.2.2 Plastic Pipe

Bedding for PVC, PE, SRPE and PP pipe shall meet the requirements of ASTM D2321. Use Class IB or II material for bedding, haunching, and initial backfill. Use Class I, II, or III material for PP pipe bedding, haunching and initial backfill.

3.3 PLACING PIPE

Each pipe shall be thoroughly examined before being laid; defective or damaged pipe shall not be used. Plastic pipe, excluding SRPE pipe shall be protected from exposure to direct sunlight prior to laying, if necessary to maintain adequate pipe stiffness and meet installation deflection requirements. Pipelines shall be laid to the grades and alignment indicated. Proper facilities shall be provided for lowering sections of pipe into trenches. Lifting lugs in vertically elongated pipe shall be placed in the same vertical plane as the major axis of the pipe. Pipe shall not be laid in water, and pipe shall not be laid when trench conditions or weather are unsuitable for such work. Diversion of drainage or dewatering of trenches during construction shall be provided as necessary. Deflection of installed flexible pipe shall not exceed the following limits:

TYPE OF PIPE	MAXIMUM ALLOWABLE DEFLECTION (percent)
Corrugated Steel and Aluminum	5
Concrete-Lined Corrugated Steel	3

TYPE OF PIPE	MAXIMUM ALLOWABLE DEFLECTION (percent)
Plastic (PVC, PE, SRPE, and PP)	5

Note post installation requirements of paragraph DEFLECTION TESTING in PART 3 of this specification for all pipe products including deflection testing requirements for flexible pipe.

3.3.1 PVC, Ribbed PVC

Laying shall proceed upgrade with spigot ends of bell-and-spigot pipe and tongue ends of tongue-and-groove pipe pointing in the direction of the flow.

3.3.2 Elliptical and Elliptical Reinforced Concrete Pipe

The manufacturer's reference lines, designating the top of the pipe, shall be within 5 degrees of a vertical plane through the longitudinal axis of the pipe, during placement. Damage to or misalignment of the pipe shall be prevented in all backfilling operations.

3.3.3 PE, SRPE, and Dual Wall and Triple Wall PP Pipe

Laying shall be with the separate sections joined firmly on a bed shaped to line and grade and shall follow manufacturer's guidelines.

3.3.4 Structural-Plate Steel

Structural plate shall be installed in accordance with ASTM A807/A807M. Structural plate shall be assembled in accordance with instructions furnished by the manufacturer. Instructions shall show the position of each plate and the order of assembly. Bolts shall be tightened progressively and uniformly, starting at one end of the structure after all plates are in place. The operation shall be repeated to ensure that all bolts are tightened to meet the torque requirements of 200 foot-pounds plus or minus 50 foot-pounds. Any power wrenches used shall be checked by the use of hand torque wrenches or long-handled socket or structural wrenches for amount of torque produced. Power wrenches shall be checked and adjusted frequently as needed, according to type or condition, to ensure proper adjustment to supply the required torque.

3.3.5 Structural-Plate Aluminum

Structural plate shall be assembled in accordance with instructions furnished by the manufacturer. Instructions shall show the position of each plate and the order of assembly. Bolts shall be tightened progressively and uniformly, starting at one end of the structure after all plates are in place. The operation shall be repeated to ensure that all bolts are torqued to a minimum of 100 foot-pounds on aluminum alloy bolts and a minimum of 150 foot-pounds on galvanized steel bolts. Any power wrenches used shall be checked by the use of hand torque wrenches or long-handled socket or structural wrenches for the amount of torque produced. Power wrenches shall be checked and adjusted as frequently as needed, according to type or condition, to ensure that they are in proper adjustment to supply the required torque.

3.3.6 Multiple Culverts

Where multiple lines of pipe are installed, adjacent sides of pipe shall be at least half the nominal pipe diameter or 3 feet apart, whichever is less.

3.3.7 Jacking Pipe Through Fills

Methods of operation and installation for jacking pipe through fills shall conform to requirements specified in Volume 1, Chapter 1, Part 4 of AREMA Eng Man.

3.4 JOINTING

3.4.1 Concrete

3.4.1.1 Cement-Mortar Bell-and-Spigot Joint

The first pipe shall be bedded to the established grade line, with the bell end placed upstream. The interior surface of the bell shall be thoroughly cleaned with a wet brush and the lower portion of the bell filled with mortar as required to bring inner surfaces of abutting pipes flush and even. The spigot end of each subsequent pipe shall be cleaned with a wet brush and uniformly matched into a bell so that sections are closely fitted. After each section is laid, the remainder of the joint shall be filled with mortar, and a bead shall be formed around the outside of the joint with sufficient additional mortar. If mortar is not sufficiently stiff to prevent appreciable slump before setting, the outside of the joint shall be wrapped or bandaged with cheesecloth to hold mortar in place.

3.4.1.2 Cement-Mortar Oakum Joint for Bell-and-Spigot Pipe

A closely twisted gasket shall be made of jute or oakum of the diameter required to support the spigot end of the pipe at the proper grade and to make the joint concentric. Joint packing shall be in one piece of sufficient length to pass around the pipe and lap at top. This gasket shall be thoroughly saturated with neat cement grout. The bell of the pipe shall be thoroughly cleaned with a wet brush, and the gasket shall be laid in the bell for the lower third of the circumference and covered with mortar. The spigot of the pipe shall be thoroughly cleaned with a wet brush, inserted in the bell, and carefully driven home. A small amount of mortar shall be inserted in the annular space for the upper two-thirds of the circumference. The gasket shall be lapped at the top of the pipe and driven home in the annular space with a caulking tool. The remainder of the annular space shall be filled completely with mortar and beveled at an angle of approximately 45 degrees with the outside of the bell. If mortar is not sufficiently stiff to prevent appreciable slump before setting, the outside of the joint thus made shall be wrapped with cheesecloth. Placing of this type of joint shall be kept at least five joints behind laying operations.

3.4.1.3 Cement-Mortar Diaper Joint for Bell-and-Spigot Pipe

The pipe shall be centered so that the annular space is uniform. The annular space shall be caulked with jute or oakum. Before caulking, the inside of the bell and the outside of the spigot shall be cleaned.

a. Diaper Bands: Diaper bands shall consist of heavy cloth fabric to

hold grout in place at joints and shall be cut in lengths that extend one-eighth of the circumference of pipe above the spring line on one side of the pipe and up to the spring line on the other side of the pipe. Longitudinal edges of fabric bands shall be rolled and stitched around two pieces of wire. Width of fabric bands shall be such that after fabric has been securely stitched around both edges on wires, the wires will be uniformly spaced not less than 8 inches apart. Wires shall be cut into lengths to pass around pipe with sufficient extra length for the ends to be twisted at top of pipe to hold the band securely in place; bands shall be accurately centered around lower portion of joint.

b. Grout: Grout shall be poured between band and pipe from the high side of band only, until grout rises to the top of band at the spring line of pipe, or as nearly so as possible, on the opposite side of pipe, to ensure a thorough sealing of joint around the portion of pipe covered by the band. Silt, slush, water, or polluted mortar grout forced up on the lower side shall be forced out by pouring, and removed.

c. Remainder of Joint: The remaining unfilled upper portion of the joint shall be filled with mortar and a bead formed around the outside of this upper portion of the joint with a sufficient amount of additional mortar. The diaper shall be left in place. Placing of this type of joint shall be kept at least five joints behind actual laying of pipe. No backfilling around joints shall be done until joints have been fully inspected and approved.

3.4.1.4 Cement-Mortar Tongue-and-Groove Joint

The first pipe shall be bedded carefully to the established grade line with the groove upstream. A shallow excavation shall be made underneath the pipe at the joint and filled with mortar to provide a bed for the pipe. The grooved end of the first pipe shall be thoroughly cleaned with a wet brush, and a layer of soft mortar applied to the lower half of the groove. The tongue of the second pipe shall be cleaned with a wet brush; while in horizontal position, a layer of soft mortar shall be applied to the upper half of the tongue. The tongue end of the second pipe shall be inserted in the grooved end of the first pipe until mortar is squeezed out on interior and exterior surfaces. Sufficient mortar shall be used to fill the joint completely and to form a bead on the outside.

3.4.1.5 Cement-Mortar Diaper Joint for Tongue-and-Groove Pipe

The joint shall be of the type described for cement-mortar tongue-and-groove joint in this paragraph, except that the shallow excavation directly beneath the joint shall not be filled with mortar until after a gauze or cheesecloth band dipped in cement mortar has been wrapped around the outside of the joint. The cement-mortar bead at the joint shall be at least 1/2 inch, thick and the width of the diaper band shall be at least 8 inches. The diaper shall be left in place. Placing of this type of joint shall be kept at least five joints behind the actual laying of the pipe. Backfilling around the joints shall not be done until the joints have been fully inspected and approved.

3.4.1.6 Plastic Sealing Compound Joints for Tongue-and-Grooved Pipe

Sealing compounds shall follow the recommendation of the particular manufacturer in regard to special installation requirements. Surfaces to receive lubricants, primers, or adhesives shall be dry and clean. Sealing

compounds shall be affixed to the pipe not more than 3 hours prior to installation of the pipe, and shall be protected from the sun, blowing dust, and other deleterious agents at all times. Sealing compounds shall be inspected before installation of the pipe, and any loose or improperly affixed sealing compound shall be removed and replaced. The pipe shall be aligned with the previously installed pipe, and the joint pulled together. If, while making the joint with mastic-type sealant, a slight protrusion of the material is not visible along the entire inner and outer circumference of the joint when the joint is pulled up, the pipe shall be removed and the joint remade. After the joint is made, all inner protrusions shall be cut off flush with the inner surface of the pipe. If non-mastic-type sealant material is used, the "Squeeze-Out" requirement above will be waived.

3.4.1.7 Flexible Watertight Joints

Gaskets and jointing materials shall be as recommended by the particular manufacturer in regard to use of lubricants, cements, adhesives, and other special installation requirements. Surfaces to receive lubricants, cements, or adhesives shall be clean and dry. Gaskets and jointing materials shall be affixed to the pipe not more than 24 hours prior to the installation of the pipe, and shall be protected from the sun, blowing dust, and other deleterious agents at all times. Gaskets and jointing materials shall be inspected before installing the pipe; any loose or improperly affixed gaskets and jointing materials shall be removed and replaced. The pipe shall be aligned with the previously installed pipe, and the joint pushed home. If, while the joint is being made the gasket becomes visibly dislocated the pipe shall be removed and the joint remade.

3.4.1.8 External Sealing Band Joint for Noncircular Pipe

Surfaces to receive sealing bands shall be dry and clean. Bands shall be installed in accordance with manufacturer's recommendations.

3.5 DRAINAGE STRUCTURES

3.5.1 Manholes and Inlets

Construction shall be of reinforced concrete, plain concrete, brick, precast reinforced concrete, precast concrete segmental blocks, prefabricated corrugated metal, or bituminous coated corrugated metal; complete with frames and covers or gratings; and with fixed galvanized steel ladders where indicated. Pipe studs and junction chambers of prefabricated corrugated metal manholes shall be fully bituminous-coated and paved when the connecting branch lines are so treated. Pipe connections to concrete manholes and inlets shall be made with flexible, watertight connectors.

3.5.2 Walls and Headwalls

Construction shall be as indicated.

3.6 STEEL LADDER INSTALLATION

Ladder shall be adequately anchored to the wall by means of steel inserts spaced not more than 6 feet vertically, and shall be installed to provide at least 6 inches of space between the wall and the rungs. The wall along the line of the ladder shall be vertical for its entire length.

3.7 BACKFILLING

3.7.1 Backfilling Pipe in Trenches

After the pipe has been properly bedded, selected material from excavation or borrow, at a moisture content that will facilitate compaction, shall be placed along both sides of pipe in layers not exceeding 6 inches in compacted depth. The backfill shall be brought up evenly on both sides of pipe for the full length of pipe. The fill shall be thoroughly compacted under the haunches of the pipe. Each layer shall be thoroughly compacted with mechanical tampers or rammers. This method of filling and compacting shall continue until the fill has reached an elevation equal to the midpoint (spring line) of concrete pipe or has reached an elevation of at least 12 inches above the top of the pipe for flexible pipe. The remainder of the trench shall be backfilled and compacted by spreading and rolling or compacted by mechanical rammers or tampers in layers not exceeding 8 inches. Tests for density shall be made as necessary to ensure conformance to the compaction requirements specified below. Where it is necessary, in the opinion of the Contracting Officer, that sheeting or portions of bracing used be left in place, the contract will be adjusted accordingly. Untreated sheeting shall not be left in place beneath structures or pavements.

3.7.2 Backfilling Pipe in Fill Sections

For pipe placed in fill sections, backfill material and the placement and compaction procedures shall be as specified below. The fill material shall be uniformly spread in layers longitudinally on both sides of the pipe, not exceeding 6 inches in compacted depth, and shall be compacted by rolling parallel with pipe or by mechanical tamping or ramming. Prior to commencing normal filling operations, the crown width of the fill at a height of 12 inches above the top of the pipe shall extend a distance of not less than twice the outside pipe diameter on each side of the pipe or 12 feet, whichever is less. After the backfill has reached at least 12 inches above the top of the pipe, the remainder of the fill shall be placed and thoroughly compacted in layers not exceeding 8 inches. Use select granular material for this entire region of backfill for flexible pipe installations.

3.7.3 Movement of Construction Machinery

When compacting by rolling or operating heavy equipment parallel with the pipe, displacement of or injury to the pipe shall be avoided. Movement of construction machinery over a culvert or storm drain at any stage of construction shall be at the Contractor's risk. Any damaged pipe shall be repaired or replaced.

3.7.4 Compaction

3.7.4.1 General Requirements

Cohesionless materials include gravels, gravel-sand mixtures, sands, and gravelly sands. Cohesive materials include clayey and silty gravels, gravel-silt mixtures, clayey and silty sands, sand-clay mixtures, clays, silts, and very fine sands. When results of compaction tests for moisture-density relations are recorded on graphs, cohesionless soils will show straight lines or reverse-shaped moisture-density curves, and cohesive soils will show normal moisture-density curves.

3.7.4.2 Minimum Density

Backfill over and around the pipe and backfill around and adjacent to drainage structures shall be compacted at the approved moisture content to the following applicable minimum density, which will be determined as specified below.

a. Under airfield and heliport pavements, paved roads, streets, parking areas, and similar-use pavements including adjacent shoulder areas, the density shall be not less than 90 percent of maximum density for cohesive material and 95 percent of maximum density for cohesionless material, up to the elevation where requirements for pavement subgrade materials and compaction shall control.

b. Under unpaved or turfed traffic areas, density shall not be less than 90 percent of maximum density for cohesive material and 95 percent of maximum density for cohesionless material.

c. Under nontraffic areas, density shall be not less than that of the surrounding material.

3.8 FIELD PAINTING

3.8.1 Cast-Iron Covers, Frames, Gratings, And Steps

After installation, clean cast-iron, not buried in masonry or concrete, of mortar, rust, grease, dirt, and other deleterious materials to bare metal and apply a coat of bituminous paint.

3.8.2 Steel Covers And Frames Or Concrete Frames

After installation, clean steel or concrete, not buried in masonry or concrete, of mortar, dirt, grease, and other deleterious materials to bare metal. Apply a coat of primer; and apply a top coat. Do not paint surfaces subject to abrasion.

3.9 FIELD QUALITY CONTROL

3.9.1 Tests

Testing is the responsibility of the Contractor. Perform all testing and retesting at no additional cost to the Government.

3.9.1.1 Leakage Test

Lines shall be tested for leakage by low pressure air or water testing or exfiltration tests, as appropriate, prior to completing backfill. Low pressure air testing for vitrified clay pipes shall conform to ASTM C828. Low pressure air testing for concrete pipes shall conform to ASTM C969. Low pressure air testing for plastic pipe shall conform to ASTM F1417. Low pressure air testing procedures for other pipe materials shall use the pressures and testing times prescribed in ASTM C828 or ASTM C969, after consultation with the pipe manufacturer. Testing of individual joints for leakage by low pressure air or water shall conform to ASTM C1103. Prior to exfiltration tests, the trench shall be backfilled up to at least the lower half of the pipe. If required, sufficient additional backfill shall be placed to prevent pipe movement during testing, leaving the joints uncovered to permit inspection. Visible leaks encountered shall be corrected regardless of leakage test results. When the water table is 2

feet or more above the top of the pipe at the upper end of the pipeline section to be tested, infiltration shall be measured using a suitable weir or other device acceptable to the Contracting Officer. An exfiltration test shall be made by filling the line to be tested with water so that a head of at least 2 feet is provided above both the water table and the top of the pipe at the upper end of the pipeline to be tested. The filled line shall be allowed to stand until the pipe has reached its maximum absorption, but not less than 4 hours. After absorption, the head shall be reestablished. The amount of water required to maintain this water level during a 2-hour test period shall be measured. Leakage as measured by the exfiltration test shall not exceed 250 gallons per inch in diameter per mile of pipeline per day.

3.9.1.2 Determination of Density

Testing shall be performed by an approved commercial testing laboratory or by the Contractor subject to approval. Tests shall be performed in sufficient number to ensure that specified density is being obtained. Laboratory tests for moisture-density relations shall be made in accordance with ASTM D1557 except that mechanical tampers may be used provided the results are correlated with those obtained with the specified hand tamper. Field density tests shall be determined in accordance with ASTM D2167 or ASTM D6938. When ASTM D6938 is used, the calibration curves shall be checked and adjusted, if necessary, using the sand cone method as described in paragraph Calibration of the referenced publications. ASTM D6938 results in a wet unit weight of soil and ASTM D6938 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gauges shall be checked along with density calibration checks as described in ASTM D6938. Test results shall be furnished the Contracting Officer. The calibration checks of both the density and moisture gauges shall be made at the beginning of a job on each different type of material encountered and at intervals as directed.

3.9.2 Inspection

3.9.2.1 Post-Installation Inspection

Visually inspect each segment of concrete pipe for alignment, settlement, joint separations, soil migration through the joint, cracks, buckling, bulging and deflection. An engineer must evaluate all defects to determine if any remediation or repair is required.

3.9.2.1.1 Concrete

Cracks with a width greater than 0.01 inches. An engineer must evaluate all pipes with cracks with a width greater than 0.01 inches but less than 0.10 inches to determine if any remediation or repair is required.

3.9.2.1.2 Flexible Pipe

Check each flexible pipe (PE, PVC, PP) for rips, tears, joint separations, soil migration through the joint, cracks, localized bucking, bulges, settlement and alignment.

3.9.2.1.3 Post-Installation Inspection Report

The deflection results and final post installation inspection report must include: a copy of all video taken, pipe location identification, equipment used for inspection, inspector name, deviation from design,

grade, deviation from line, deflection and deformation of flexible pipe, inspector notes, condition of joints, condition of pipe wall (e.g. distress, cracking, wall damage dents, bulges, creases, tears, holes, etc.).

3.9.3 Repair Of Defects

3.9.3.1 Leakage Test

When leakage exceeds the maximum amount specified, correct source of excess leakage by replacing damaged pipe and gaskets and retest.

3.9.3.2 Deflection Testing

When deflection readings are in excess of the allowable deflection of average inside diameter of pipe are obtained, remove pipe which has excessive deflection and replace with new pipe. Retest 30 days after completing backfill, leakage testing and compaction testing.

3.9.3.3 Inspection

Replace pipe or repair defects indicated in the Post-Installation Inspection Report.

3.9.3.3.1 Concrete

Replace pipes having cracks with a width greater than 0.1 inches.

3.9.3.3.2 Flexible Pipe

Replace pipes having cracks or splits.

3.10 PROTECTION

Protect storm drainage piping and adjacent areas from superimposed and external loads during construction.

3.11 WARRANTY PERIOD

Pipe segments found to have defects during the warranty period must be replaced with new pipe and retested.

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SUBDRAINAGE PIPING
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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 252	(2009; R 2017) Standard Specification for Corrugated Polyethylene Drainage Pipe

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A27/A27M	(2017) Standard Specification for Steel Castings, Carbon, for General Application
ASTM A47/A47M	(1999; R 2014) Standard Specification for Ferritic Malleable Iron Castings
ASTM A48/A48M	(2003; R 2012) Standard Specification for Gray Iron Castings
ASTM C478	(2018) Standard Specification for Circular Precast Reinforced Concrete Manhole Sections
ASTM D2321	(2018) 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 D3753	(2012; E 2013) Glass-Fiber-Reinforced Polyester Manholes and Wetwells
ASTM D4632/D4632M	(2015a) Grab Breaking Load and Elongation of Geotextiles
ASTM F758	(2014) Smooth-Wall Poly(Vinyl Chloride) (PVC) Plastic Underdrain Systems for Highway, Airport, and Similar Drainage

ASTM F949	(2015) Poly(Vinyl Chloride) (PVC) Corrugated Sewer Pipe with a Smooth Interior and Fittings

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-04 Samples

Geotextile

Pipe and Pipe Fittings

SD-06 Test Reports

Geotextile JP-4 Fuel Resistance Test

SD-07 Certificates

Geotextile

Pipe and Pipe Fittings

1.3 DELIVERY, STORAGE, AND HANDLING

1.3.1 Delivery and Storage

Inspect materials delivered to site for damage; unload, and store with minimum handling. Do not store materials directly on the ground. Keep the inside of pipes and fittings sfree of dirt and debris. Keep, during shipment and storage, geotextile wrapped in burlap or similar heavy duty protective covering. Protect the geotextile from mud, soil, dust, and debris. Do not store geotextile materials in direct sunlight. Install plastic pipe within 6 months from the date of manufacture unless otherwise approved.

1.3.2 Handling

Handle materials in such a manner as to ensure delivery to the trench in sound undamaged condition. Carry pipe to the trench.

PART 2 PRODUCTS

2.1 PIPE FOR SUBDRAINS

Submit samples of pipe and pipe fittings, before starting the work. Provide type and sizes of subdrain pipe indicated. Submit certifications from the manufacturers attesting that materials meet specification requirements. Certificates are required for drain pipe and fittings.

2.1.1 Plastic

Provide plastic pipe containing ultraviolet inhibitor to provide protection from exposure to direct sunlight. Provide pipe with with bell and spigot or solvent cement joints. Provide manufacturer's standard type fittings conforming to the indicated specification.

2.1.1.1 Polyvinyl Chloride (PVC) and Fittings

ASTM D3034, ASTM F949 or ASTM F758, Type PS 46.

2.1.1.2 Corrugated Polyethylene (PE) and Fittings

AASHTO M 252, Type S or SP as indicated.

2.1.1.3 Pipe Perforations

Provide pipe perforations with a minimum water inlet area of 0.5 square inch per linear foot and as specified below.

2.1.1.3.1 Circular Perforations in Plastic Pipe

Cleanly cut circular holes not more than 3/8 inch or less than 3/16 inch in diameter and arrange in rows parallel to the longitudinal axis of the pipe. Provide pipe with perforations spaced uniformly along rows. Unless otherwise recommended by the pipe manufacturer, provide pipe with rows approximately 1-1/2 inches apart and arranged in a staggered pattern so that all perforations lie at the midpoint between perforations in adjacent rows. Space the rows over not more than 155 degrees of circumference. Provide pipe that is not perforated for a length equal to the depth of the socket at the spigot or tongue end and provide perforations that continue at uniform spacing over the entire length of the pipe.

2.1.1.3.2 Slotted Perforations in Plastic Pipe

Cleanly cut circumferential slots so as not to restrict the inflow of water and uniformly spaced along the length and circumference of the pipe. Provide pipe with slots not exceeding 1/8 inch nor less than 1/32 inch in width. Provide pipe with individual slot lengths not exceeding 10 percent of the pipe inside nominal circumference on 6 to 8 inch diameter pipe, and 2-1/2 inches on 10 inch diameter pipe. Symmetrically space rows of slots so that they are fully contained in 2 quadrants of the pipe. Center slots in the valleys of the corrugations of profile wall pipe.

2.2 GEOTEXTILE

Provide geotextile meeting the requirements in Section 31 05 22 GEOTEXTILES USED AS FILTERS.

Submit samples of geotextile and certifications from the manufacturers attesting that geotextile meets specification requirements.

2.3 DRAINAGE LAYER MATERIAL

Provide aggregate drainage layer material meeting the requirements in Section 32 11 23 AGGREGATE BASE COURSES.

2.4 DRAINAGE STRUCTURES

2.4.1 Concrete

Provide concrete and reinforced concrete conforming to the requirements for 3,000 psi concrete in Section 03 30 00.00 10 CAST-IN-PLACE CONCRETE .

2.4.2 Mortar

Provide mortar for connections to drainage structures that is composed of one part by volume of portland cement and two parts of sand. Provide sufficient quantity of water in the mixture to produce a stiff workable mortar. Use water that is clean and free of injurious acids, alkalies, and organic impurities. Use the mortar within 30 minutes from the time the ingredients are mixed with water.

2.4.3 Manholes and Appurtenances

2.4.3.1 Precast Reinforced Concrete Manhole Risers and Tops

ASTM C478.

2.4.3.2 Precast Concrete Manhole Bases

ASTM C478. Provide bases that allow suitable connection with influent and effluent lines and to provide a suitable base structure for riser sections.

2.4.3.3 Glass Fiber-Reinforced Polyester (FRP)

ASTM D3753.

2.4.3.4 Frames and Covers or Gratings

Except as otherwise permitted, provide frames and gratings, or frames and covers of either cast iron with tensile strength test not less than ASTM A48/A48M Class 25 or steel conforming to ASTM A27/A27M, Class 65-35. Required weight, shape, and size are indicated on the drawings. Frames and covers not subjected to vehicular traffic or storage may be of malleable iron where indicated. Provide malleable-iron frames and covers conforming to ASTM A47/A47M and of the weight, shape, and size indicated.

2.4.3.5 Steel Ladder

Provide a steel ladder where the depth of a manhole exceeds 12 feet. The ladder will be not less than 16 inches in width, with 3/4 inch diameter rungs spaced 12 inches apart. Provide two stringers that are a minimum 3/8 inch thick and 2 inches wide. Adequately anchor ladder to the wall by means of steel inserts spaced not more than 6 feet apart vertically, and install so as to provide at least 6 inches of space between the wall and the rungs. Galvanize ladders and inserts after fabrication in conformance with ASTM A123/A123M.

2.5 TESTS, INSPECTIONS, AND VERIFICATIONS

2.5.1 Geotextile JP-4 Fuel Resistance Test

Immerse five unaged geotextile samples, 4 (plus or minus 0.2) by 6 (plus or minus 0.2) inches in JP-4 fuel at room temperature for a period of 7 days. Test each sample for tensile strength and elongation in accordance

with ASTM D4632/D4632M. Provide geotextile with a strength in any direction of not less than 85 percent of the strength specified in paragraph GEOTEXTILE.

PART 3 EXECUTION

3.1 EXCAVATION AND BEDDING FOR SUBDRAIN SYSTEMS

Excavate trenches, including the removal of rock and unstable material, in accordance with Section 31 00 00 EARTHWORK. Bedding material shall be placed in the trench as indicated or as required as replacement materials used in those areas where unstable materials were removed. Compaction of the bedding material shall be as specified for cohesionless material in Section 31 00 00 EARTHWORK.

3.2 MANHOLES AND FLUSHING AND OBSERVATION RISERS

3.2.1 Manholes

Install manholes complete with frames and covers or gratings at the locations and within the limits and sizes indicated. Construct manholes of one of the materials specified for manholes in paragraph DRAINAGE STRUCTURES. Completely fill precast concrete manhole joints so that they are smooth and free of surplus mortar or mastic on the inside of the structure. Use either precast or cast-in-place concrete manhole bases.

3.2.2 Flushing and Observation Risers

Install flushing and observation riser pipes with frames and covers at the locations indicated. Construct risers of non-perforated plastic or bituminous coated pipe. Join riser pipes to the subdrain system as indicated.

3.3 INSTALLATION OF GEOTEXTILE AND PIPE FOR SUBDRAINS

3.3.1 Installation of Geotextile

3.3.1.1 Trench Lining and Overlaps

Grade trenches to be lined with geotextile to obtain smooth side and bottom surfaces so that the geotextile will not bridge cavities in the soil or be damaged by projecting rock. Lay the geotextile flat but not stretched on the soil, and secure it with anchor pins in accordance with manufacturer's instructions. Overlap at least 6 to 12 inches, and secure with anchor pins along the overlaps.

3.3.2 Installation of Pipe for Subdrains

3.3.2.1 Pipelaying

Install pipe in accordance with the manufacturer's recommendations. Thoroughly examine each section of pipe before being laid; do not use defective or damaged pipe. Do not lay pipe when the trench conditions or weather is unsuitable for such work. Remove water from trenches by sump pumping or other approved methods. Lay the pipe to the grades and alignment as indicated. Bed the pipe to the established gradeline. Center perforations on the bottom of the pipe. Lay bell-and-spigot type with the bell ends upstream. Approval of all in-place pipes by the Contracting Officer is required prior to backfilling.

3.3.2.2 Jointings

Provide joints per manufacturer's recommendations

3.4 INSTALLATION OF DRAINAGE LAYER FILTER MATERIAL AND BACKFILLING FOR PERFORATED SUBDRAINS

After perforated pipe for subdrains has been laid, inspected, and approved, place drainage layer filter material around and over the pipe to the depth indicated. Place the drainage layer filter material in layers not to exceed 8 inches thick. Saturate by flooding. Thoroughly compact each layer using mechanical tampers or rammers.

3.5 INSTALLATION OF BEDDING AND BACKFILL FOR NON-PERFORATED SUBRAIN OUTFALL PIPE

3.5.1 Plastic Pipe

Place and compact pipe embedment for plastic pipe in accordance with ASTM D2321. Use Class IB or II embedment materials.

3.6 INSTALLATION OF AND BACKFILLING FOR BLIND OR FRENCH DRAINS

Place filter material as indicated and compact as specified for cohesionless materials in Section 31 00 00 EARTHWORK. Extend filter material to a suitable outlet or to an outlet through a pipeline as indicated. Place and compact overlying backfill material as specified in Section 31 00 00 EARTHWORK .

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SECTION 33 61 13.13

PREFABRICATED UNDERGROUND HYDRONIC ENERGY DISTRIBUTION
02/16

PART 1 GENERAL

1.1 SUMMARY

The system consists of a buried prefabricated chilled water distribution system including service connections to a point 6 inches inside of the building. The contract drawings show the specific arrangement of piping, sizes and grades of pipe, and other details.

1.2 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.

ASME INTERNATIONAL (ASME)

ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2016) Forged Fittings, Socket-Welding and Threaded
ASME B31.1	(2018) Power Piping
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2018) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A105/A105M	(2018) Standard Specification for Carbon Steel Forgings for Piping Applications
ASTM A106/A106M	(2018) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A234/A234M	(2018) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM C518	(2017) Standard Test Method for

	Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus
ASTM C591	(2019) Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
ASTM D1784	(2011) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D3350	(2012) Polyethylene Plastics Pipe and Fittings Materials

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00.00 37 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Fabrication and Assembly Drawings

SD-03 Product Data

Support of the Equipment

Markers For Underground Piping

SD-07 Certificates

Welding

Written Certification

SD-10 Operation and Maintenance Data

Maintenance; G, RO

1.4 QUALITY ASSURANCE

Weld piping in accordance with qualified procedures using performance qualified welders and welding operators. Qualify procedures and welders in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.1. Prior to welding operations, submit a copy of qualified procedures and a list of names and identification symbols of qualified welders and welding operators. Notify the Contracting Officer 24 hours in advance of tests performed at the work site, if practicable. Apply welder's personal assigned symbol near each weld made as a permanent record.

1.5 DELIVERY, STORAGE, AND HANDLING

After delivery to the jobsite, protect all materials and equipment from anything which could cause damage to the material or equipment. Seal piping at each end to keep the interior clean and free of dirt and debris. Keep fittings together and keep their interior surfaces clean at all times. Keep insulation dry and clean.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Provide system components which are standard products of a manufacturer regularly engaged in the manufacture of the product and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Provide a service organization that is, in the opinion of the Contracting Officer, convenient to the site.

Equipment items must be supported by service organizations. Submit a certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. These service organizations must be reasonably convenient to the equipment installation and able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

a. Submit detail drawings consisting of fabrication and assembly drawings, for all parts of the work in sufficient detail to check conformity with the requirements of the contract documents, prior to installation. In the detail drawings show complete piping, wiring and schematic diagrams and any other details to demonstrate that the system has been coordinated and will properly function as a unit. Show on the drawings proposed layout, method of compensation for pipe expansion and contraction, anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearances required for maintenance and operation.

b. Submit the manufacturer's or system fabricator's written certification stating that the distribution system furnished meets all the requirements of this specification. Clearly identify on the drawings any proposed deviations from the requirements of the contract documents.

2.2 PIPING AND CASING MATERIALS

2.2.1 General

Provide metallic pressure pipe, fittings, and piping accessories that conform to the requirements of ASME B31.1 and are types suitable for the temperature and pressure of the water.

2.2.2 Piping

2.2.2.1 Steel Pipe

Provide piping conforming to ASTM A53/A53M, Grade B, standard weight, black or to ASTM A106/A106M, Grade B, standard weight.

2.2.3 Casings

2.2.3.1 Polyvinyl Chloride (PVC) Casing

Provide PVC casings that conform to ASTM D1784, Class 12454-B with a minimum thickness equal to the greater of 1/100 the diameter of the casing or 60 mils.

2.2.3.2 Polyethylene (PE) Casing

Provide polyethylene casings conforming to ASTM D3350, Type III, Class C, Category 3 or 4, Grade P 34 with thickness as follows:

Casing Diameter (inches)	Minimum Thickness (mils)
10 and smaller	125
10 to 18	150
18 through 24	200
over 24	225

2.2.3.3 Reinforced Thermosetting Resin Pipe (RTRP) Casing

Provide RTRP casing of the same material as the pipe, with casing thickness as follows:

Casing Diameter (inches)	Minimum Thickness (mils)
8 and smaller	70
10	80
12	105
14	115
16 to 18	120
20	125
24	155

2.3 PIPING CONNECTIONS

2.3.1 Steel Pipe

For pipe smaller than 0.75 inch, provide Schedule 80 steel pipe with threaded end connections conforming to ASME B1.20.1. Weld all steel pipe 0.75 inch and larger. Provide steel welding fittings conforming to the requirements of ASTM A105/A105M or ASTM A234/A234M. Provide welding fittings conforming to ASME B16.9 for buttweld fittings and ASME B16.11

for socket-weld fittings. Use long radius buttwelding elbows conforming to ASME B16.9 whenever space permits.

2.4 END SEALS

Provide pre-insulated sections of pipe with complete sealing of the insulation to provide a permanent water and vapor seal at each end of the pre-insulated section of piping. Provide field modified pre-insulated sections of piping with an end seal which is equivalent to the end seals furnished with the pre-insulated section of piping. Test and certify end seals in accordance with paragraph Casing and End Seal Testing and Certification.

2.4.1 Types

Provide end seals of one of the following types:

a. Carrying the outer casing over tapered pipe insulation ends and extending it to the carrier pipe. Provide sufficient surface bonding area between the casing and the carrier pipe.

b. Using specially designed molded caps made of polyethylene or rubber of standard manufactured thickness. Provide a minimum of 1.5 inch surface bonding area between the cap and both the casing and carrier pipe.

2.4.2 Casing and End Seal Testing and Certification

Demonstrate that testing and certification procedures by an independent testing laboratory, for casings and end seals, are capable of resisting penetration of water into the casing and insulation. Perform the test on each type of prefabricated system to be furnished. Provide hot and cold cycle testing followed by immersion in a water filled chamber with a head pressure, consisting of 14 days of temperature cycling. Circulate a fluid with a temperature of 40 degrees F through the carrier pipe alternating every 24-hours with a fluid with a temperature of 200 degrees F circulating through the carrier pipe for a low temperature hot water or dual temperature service or 75 degrees F for a chilled water service. While the hot and cold cycle test is being performed, the test sample is either buried or encased in dry bedding sand with a minimum of 12 inches of sand all around the test sample. Restrain the 3 inches diameter carrier pipe of the test sample during the test period. Provide an insulation thickness not to exceed the maximum thickness provided for the piping in the project. Do not exceed transition times for temperature cycle testing of 15 minutes in going from cold to hot and 30 minutes in going from hot to cold. The fluid in the carrier pipe may be water, oil or heat transfer fluid. Immerse the test sample in a water filled chamber following the hot and cold cycling test. Provide a pressure of not less than 20 feet of water head pressure at the highest point over the entire length of the 8 foot test sample for a minimum of the 48 hour test period. Provide water containing a dye penetrant to check for end seal leakage. Upon completion of the pressure test, cut the test sample open using a light that will readily show the presence of the dye that was in the water, inspect the test sample. Evidence of the dye inside the test sample indicates that the end seal is not acceptable and cannot be certified.

2.5 INSULATION

2.5.1 Factory Applied Insulation

Provide factory insulated pre-fabricated pipe and fittings with polyurethane (polyisocyanurate) foam meeting the requirements of ASTM C591 having a density not less than 2 pounds per cubic foot (pcf). Provide the polyurethane (polyisocyanurate) foam completely filling the annular space between the carrier pipe and the casing with an insulation thickness of a minimum of 1 inch. Provide an insulation thermal conductivity factor not exceeding the numerical value of 0.15 Btu-inch/square foot-degree F-hour at 75 degrees F, when tested in accordance with ASTM C518. Provide a manufacturer's certification that the insulated pipe is free of insulation voids.

2.5.2 Field Applied Insulation

Provide polyurethane (polyisocyanurate) field applied insulation for fittings, and field casing closures and other piping system accessories, as required, with thickness matching adjacent piping insulation thickness. For buried fittings and accessories, provide field applied polyurethane (polyisocyanurate) insulation to match adjacent piping with a protective covering matching the pipe casing. Provide shrink sleeves with a minimum thickness of 50 mils over casing connection joints.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the project, verify all dimensions in the field and advise the Contracting Officer of any discrepancy before performing the project.

3.2 INSTALLATION

For all pre-insulated, prefabricated systems, obtain the services of a trained representative of the pipe system manufacturer to instruct the Contractor's work forces in the installation procedures to ensure that the system is installed in accordance with the manufacturer's published instructions and the plans and specifications. Provide a manufacturer's representative who regularly performs such duties for the manufacturer. Furnish the Contracting Officer a list of names of personnel trained and certified by the pipe system manufacturer in the installation of this system. Only personnel whose names appear on a less than one year old list will be allowed to install the system.

3.3 PIPING SYSTEMS

3.3.1 Buried Insulated Systems

Provide carrier pipe, insulation, casing, end seals, fittings and accessories for buried insulated systems.

3.4 THRUST BLOCKS

Install thrust blocks at the locations shown or recommended by the pipe system manufacturer. Provide thrust blocks in accordance with manufacturer's recommendations. For systems requiring thrust blocks, at a minimum, provide thrust blocks at all changes in direction, changes in

size, valves and terminal ends, such as plugs, caps and tees with concrete having a compressive strength of not less than 2000 psi after 28 days in accordance with Section 03 30 00.00 10 CAST-IN-PLACE CONCRETE. Place thrust blocks between solid ground and the fitting to be anchored. Unless otherwise indicated or directed, pour the base and the thrust bearing sides of the thrust blocks directly against undisturbed earth. The sides of the thrust blocks not subject to thrust may be poured against forms. Locate thrust blocks so that the joints for all fittings will be accessible for repair wherever possible. Do not embed joints in concrete unless the assembly has previously been hydrostatically tested. Provide thrust blocks resisted by piles or tie rods to solid foundations in muck or peat, or replace peat or muck with ballast of sufficient stability to resist the thrust blocks.

3.5 INSTALLATION OF PIPING SYSTEMS

Prepare pipe ends to match factory coated ends and install the piping system in accordance with the manufacturer's instructions without springing or forcing other than what has been calculated for cold spring allowing free expansion and contraction without damage to joints or hangers. Do not install copper tubing in a trench with ferrous piping materials. Maintain a minimum vertical separation of12 inches between pipes when nonferrous metallic pipe (e.g., copper tubing) crosses any ferrous piping material. Provide transition fittings approved by the manufacturer of the piping system for connections between different types of pipe and system components.

3.5.1 Pitching of Horizontal Piping

Pitch horizontal pipe at a grade of not less than1 inch in 20 feet toward the drain points unless otherwise indicated.

3.5.2 Open Ends

Provide an approved cap or plug for open ends of pipelines and equipment during installation.

3.5.3 Cutting Prefabricated Piping Sections

Provide new end seals similar to factory applied end seal for field cut prefabricated pipe sections in accordance with the manufacturer's instructions.

3.5.4 Joints

3.5.4.1 Welded Joints

Provide welded joints between sections of pipe and between pipe and fittings where specified or indicated.

3.5.4.2 Threaded Joints

No threaded joints are allowed to be used belowground. Make joints tight with polytetrafluoroethylene tape applied to the male threads only with no more than 3 threads showing after the joint is made up.

3.5.4.3 Grooved Mechanical Joints

Provide grooved fittings, couplings, and grooving tools with products of

the same manufacturer. Prepare grooves complying with the tolerances specified by the coupling manufacturer in accordance with the coupling manufacturer's instructions. Measure field made groove diameters using a "go/no-go" gauge, vernier or dial caliper, narrow-land micrometer, or other method specifically approved by the coupling manufacturer for the intended application. Measure and record each groove width and dimension from end of pipe for each change in grooving tool setup to verify compliance with coupling manufacturer's tolerances. Grooved joints are not allowed in concealed locations.

3.5.5 Underground Warning Tape

Provide underground 0.004 inch thick, 6 inches wide, printed with repetitive caution warnings along its length, polyethylene tape warning tape buried above the piping during the trench backfilling approximately12 inchesdeep. Provide tapes, yellow in color with black letters; color and lettering must not be affected by moisture or other substances contained in the backfill material.

3.5.6 Markers for Underground Piping

Submit catalog cuts, brochures, circulars, specifications and product data, and printed information in sufficient detail and scope to verify compliance with the requirements of the contract documents. Place markers for underground piping approximately 2 feet to the right of the distribution system in reference to the fluid flow direction.

Provide concrete markers 6 inch square or round section 2 feet long with the top edge of the marker chamfered at a minimum of.5 inch all around. Impress of cast letters on the top of the marker with letters CHW to indicate the type of system that is being identified. Form each letter with a V-shaped groove with a width of stroke at least .25 inch at the top and depth of .25 inch. Provide elevation of markers no more than 1 inches above finished grade.

3.6 EARTHWORK

Perform earthwork in accordance with Section 31 00 00 EARTHWORK.

3.7 TESTING

Conduct tests before, during, and after installation of the system. Provide all instruments, equipment, facilities, and labor required to properly conduct the tests. Provide test pressure gauges for a specific test with dials indicating not less than 1.5 times nor more than 2 times the test pressure.

3.7.1 Metallic Pipe Welds

Perform radiographic testing in accordance with ASME B31.1. Perform radiographic examination of field welds by an approved independent testing firm or firms regularly engaged in radiographic testing, and interpreted by a Certified Level III Radiographer employed by the testing firm. Review and interpretation of all radiographs must be by a Certified Level III Radiographer employed by the testing firm. Remove, reweld and radiographically examine any welds found to be unacceptable in accordance with the above criteria.

3.7.2 Carrier Pipe Cleaning and Testing

Test distribution piping as required before backfilling, with all joints exposed. The area between joints may be backfilled as necessary to prevent pipe movement.

3.7.2.1 Cleaning Carrier Pipe

Prior to testing, clean the interior of the carrier pipe of foreign materials by thorough flushing with clean water with a circulating water velocity between 2 and 3 m/s (7 and 10 feet per second) for a minimum of 4 hours. Provide temporary and/or supplementary pumps if required to ensure that required velocity is achieved. Clean system strainers after the flushing operation is complete. Temporary strainers must be installed as required. Leave water in the system after flushing for testing of the system to ensure the pipe will maintain pressure and is not leaking.

3.7.2.2 Hydrostatic Pressure Cycling and Tests

Hydrostatic pressure tests consist of 4 cycles; .each cycle consisting of a 10 minute period with the first cycle at 150 psig followed by a 5 minute period at a pressure less than 50 psig. Begin the next cycle immediately following the completion of the previous cycle with the pressure rise and drop no more than 100 psi per minute. Locate the pressure gauge and take the pressure measurement at the opposite end of the system from where the pressure is applied. After completion of the hydrostatic pressure cycling, perform the first hydrostatic pressure test proving the system tight at a pressure of 1.5 times the working pressure up to 150 psig and held for a minimum of 1 hour. Disconnect the pressurizing apparatus from the system before starting the 1 hour pressure holding period. Correct any test failures and repeat the hydrostatic pressure cycling and first hydrostatic pressure test until the system can hold the required pressure for at least 1 hour. After successful completion of the first hydrostatic pressure test, drain piping system and fill the piping system as defined in paragraph TREATED WATER for the remaining tests and for permanent operation of the system. Repeat the hydrostatic pressure cycling and tests for the system after the system has been filled with treated water, using the same test conditions and criteria.

3.7.2.3 Operational Test

Perform operational test on the complete system or testable portions thereof and conduct with full design flows and operating temperatures in all runs of piping as if in service, to demonstrate satisfactory function and operating effectiveness. The operational test will have two cycles. Each cycle must consist of a 6-hour period with treated water in the system at the maximum operating temperature of 70 degrees F and maximum flow rate, and a period of at least 6-hours with no flow. Supply temporary pumps, piping connections, boilers, chillers and the gauges required to circulate the water at the desired temperatures and flow rates. Re-circulate water through supply lines and return through the return piping to demonstrate that the pressure drop is compatible with the flow rate and size of pipe and to show that obstructions do not exist in the piping system. Any unusual indicated pressure drop will be investigated and any obstructions removed. Repair any leaks found. After any obstructions have been removed and any leaks repaired, repeat the operational test until successfully passed.

3.7.2.4 Final Hydrostatic Test

After successful completion of the operational test, pressurize system to 1.5 times the working pressure up to 150 psig and hold for a minimum of 4 hours. Disconnect pressurizing apparatus prior to the start of the 4-hour pressure holding period. Upon test failure, determine the cause of the failure, correct and repeat all of the hydrostatic pressure cycling and pressure tests.

3.8 MAINTENANCE

Submit 6 hard and optic disk copies of operation and 6 copies of maintenance manuals for the equipment furnished, 1 complete set prior to performance testing and the remainder upon acceptance. Provide details in the operation manuals showing the step-by-step procedures required for equipment startup, operation, and shutdown. Include in the operation manuals the manufacturer's name, model number, parts list, and brief description of all equipment and their basic operating features. List in the maintenance manuals routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. Include in the maintenance manuals piping and equipment layout and simplified wiring and control diagrams of the equipment system as installed. Provide approved manuals prior to the field performance testing.

-- End of Section --

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02/15

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SECTION 33 71 02

UNDERGROUND ELECTRICAL DISTRIBUTION
02/15

PART 1 GENERAL

1.1 REFERENCES

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

ASTM INTERNATIONAL (ASTM)

ASTM B1	(2013) Standard Specification for Hard-Drawn Copper Wire
ASTM B3	(2013) Standard Specification for Soft or Annealed Copper Wire
ASTM B8	(2011; R 2017) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2017; Errata 2017) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C119.1	(2016) Electric Connectors - Sealed Insulated Underground Connector Systems Rated 600 Volts
NEMA RN 1	(2005; R 2013) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA TC 2	(2013) Standard for Electrical Polyvinyl Chloride (PVC) Conduit

NEMA TC 9	(2004) Standard for Fittings for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installation

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2017; ERTA 1-2 2017; TIA 17-1; TIA 17-2; TIA 17-3; TIA 17-4; TIA 17-5; TIA 17-6; TIA 17-7; TIA 17-8; TIA 17-9; TIA 17-10; TIA 17-11; TIA 17-12; TIA 17-13; TIA 17-14; TIA 17-15; TIA 17-16; TIA 17-17) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-758	(2012b) Customer-Owned Outside Plant Telecommunications Infrastructure Standard

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS Bull 1751F-644	(2002) Underground Plant Construction

UNDERWRITERS LABORATORIES (UL)

UL 6	(2007; Reprint Nov 2014) Electrical Rigid Metal Conduit-Steel
UL 44	(2018) UL Standard for Safety Thermoset-Insulated Wires and Cables
UL 83	(2017) UL Standard for Safety Thermoplastic-Insulated Wires and Cables
UL 94	(2013; Reprint Sep 2017) UL Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL 467	(2013; Reprint Jun 2017) UL Standard for Safety Grounding and Bonding Equipment
UL 486A-486B	(2018) UL Standard for Safety Wire Connectors
UL 510	(2017) 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 Nov 2014) Conduit, Tubing and Cable Fittings
UL 651	(2011; Reprint Nov 2018) UL Standard for Safety Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings
UL 854	(2004; Reprint Nov 2014) Standard for

	Service-Entrance Cables
UL 1242	(2006; Reprint Mar 2014) Standard for Electrical Intermediate Metal Conduit -- Steel

1.2 SYSTEM DESCRIPTION

Items provided under this section must be specifically suitable for the following service conditions.

a. Fungus Control N/A

b. Altitude 294 feet.

c. Ambient Temperature 90 degrees F.

d. Frequency 60 Hz

e. Ventilation N/A

f. Seismic Parameters N/A

g. Humidity Control 88 percent

h. Corrosive Areas N/A

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.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance with Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Protective Devices and Coordination Study; G

The study must be submitted with protective device equipment submittals. No time extension or similar contract modifications will be granted for work arising out of the requirements for this study. Approval of protective devices proposed must be based on recommendations of this study. The Government must not be held

responsible for any changes to equipment, device ratings, settings, or additional labor for installation of equipment or devices ordered or procured prior to approval of the study.

SD-06 Test Reports

Field Acceptance Checks and Tests; G

1.5 QUALITY ASSURANCE

1.5.1 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.

1.5.2 Standard Products

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

1.5.2.1 Alternative Qualifications

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

1.5.2.2 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-40 or EPC-80 as indicated.

2.1.4 Plastic Duct for Concrete Encasement

Provide Type EPC-40 per UL 651 and NEMA TC 2, as indicated.

2.1.5 Innerduct

Provide corrugated or solid wall polyethylene (PE) or PVC innerducts, or fabric-mesh innerducts, with pullwire. Size as indicated.

2.1.6 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.

2.1.7 Fittings

2.1.7.1 Metal Fittings

UL 514B.

2.1.7.2 PVC Conduit Fittings

UL 514B, UL 651.

2.1.7.3 PVC Duct Fittings

NEMA TC 9.

2.1.7.4 Outlet Boxes for Steel Conduit

Outlet boxes for use with rigid or flexible steel conduit must be cast-metal cadmium or zinc-coated if of ferrous metal with gasketed closures and must conform to UL 514A.

2.2 LOW VOLTAGE INSULATED CONDUCTORS AND CABLES

Insulated conductors must be rated 600 volts and conform to the requirements of NFPA 70, including listing requirements. Wires and cables

manufactured more than 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 THHN/THWN unless otherwise noted. Conductors No. 10 AWG and smaller must be solid. Conductors No. 8 AWG and larger must be stranded. All conductors must be copper.

2.2.2 Conductor Material

Unless specified or indicated otherwise or required by NFPA 70, wires in conduit, other than service entrance, must be 600-volt, Type THWN/THHN conforming to UL 83 or Type XHHW or RHW conforming to UL 44. Copper conductors must be annealed copper complying with ASTM B3 and ASTM B8.

2.2.3 Direct Buried

Single-conductor cables must be of a type identified for direct burial.

2.2.4 In Duct

Cables must be single-conductor cable.

2.2.5 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, or approved equal, 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.

Conductors must be color coded. 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. Control circuit terminations must be properly identified. 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 must be white with a different colored (not green) stripe for each. Color of ungrounded conductors in different voltage systems must be 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

Must provide a uniform compression over the entire conductor contact surface. Use solderless terminal lugs on stranded conductors.

For use with copper conductors: UL 486A-486B.

2.4 LOW VOLTAGE SPLICES

Provide splices in conductors with a compression connector on the conductor and by insulating and waterproofing using one of the following methods which are suitable for continuous submersion in water and comply with ANSI C119.1.

2.4.1 Heat Shrinkable Splice

Provide heat shrinkable splice insulation by means of a thermoplastic adhesive sealant material applied in accordance with the manufacturer's written instructions.

2.4.2 Cold Shrink Rubber Splice

Provide a cold-shrink rubber splice which consists of EPDM rubber tube which has been factory stretched onto a spiraled core which is removed during splice installation. The installation must not require heat or flame, or any additional materials such as covering or adhesive. It must be designed for use with inline compression type connectors, or indoor, outdoor, direct-burial or submerged locations.

2.5 TELECOMMUNICATIONS CABLING

Provide telecommunications cabling in accordance with Section 33 82 00 TELECOMMUNICATIONS OUTSIDE PLANT (OSP).

2.6 TAPE

2.6.1 Insulating Tape

UL 510, plastic insulating tape, capable of performing in a continuous temperature environment of 80 degrees C.

2.6.2 Buried Warning and Identification Tape

Provide detectable tape in accordance with Section 31 00 00 EARTHWORK.

2.7 PULL ROPE

Plastic or flat pull line (bull line) having a minimum tensile strength of 200 pounds.

2.8 GROUNDING AND BONDING

2.8.1 Driven Ground Rods

Provide copper-clad steel ground rods conforming to UL 467 not less than 3/4 inch in diameter by 10 feet in length. Sectional type rods may be used for rods 20 feet or longer.

2.8.2 Grounding Conductors

Stranded-bare copper conductors must conform to ASTM B8, Class B, soft-drawn unless otherwise indicated. Solid-bare copper conductors must conform to ASTM B1 for sizes No. 8 and smaller. Insulated conductors must be of the same material as phase conductors and green color-coded, except that conductors must be rated no more than 600 volts. Aluminum is not acceptable.

2.9 CAST-IN-PLACE CONCRETE

Provide concrete in accordance with Section 03 30 00.00 10 CAST-IN-PLACE CONCRETE. In addition, provide concrete for encasement of underground ducts with 3000 psi minimum 28-day compressive strength. Concrete associated with electrical work for other than encasement of underground ducts must be 4000 psi minimum 28-day compressive strength unless specified otherwise.

2.10 CABLE TAGS IN MANHOLES

Provide tags for each power cable located in manholes. The tags must be polyethylene. Do not provide handwritten letters. The first position on the power cable tag must denote the voltage. The second through sixth positions on the tag must identify the circuit. The next to last position must denote the phase of the circuit and include the Greek "phi" symbol. The last position must denote 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.

2.10.1 Polyethylene Cable Tags

Provide tags of polyethylene that have an average tensile strength of 3250 pounds per square inch; and that are 0.08 inch thick (minimum), non-corrosive non-conductive; resistive to acids, alkalis, organic solvents, and salt water; and distortion resistant to 170 degrees F. Provide 0.05 inch (minimum) thick black polyethylene tag holder. Provide a one-piece nylon, self-locking tie at each end of the cable tag. Ties must have a minimum loop tensile strength of 175 pounds. The cable tags must have black block letters, numbers, and symbols one inch high on a yellow background. Letters, numbers, and symbols must not fall off or change positions regardless of the cable tags' orientation.

2.11 PROTECTIVE DEVICES AND COORDINATION

Provide protective devices and coordination as specified in Section 26 28 01.00 10 COORDINATED POWER SYSTEM PROTECTION.

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 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 RGS 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.

3.4 UNDERGROUND CONDUIT AND DUCT SYSTEMS

3.4.1 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 grouding 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 3 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. Provide ducts with end bells whenever duct lines terminate in structures.

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: 30 degrees.

3.4.2 Treatment

Ducts must be kept clean of concrete, dirt, or foreign substances during construction. Field cuts requiring tapers must be made with proper tools and match factory tapers. A coupling recommended by the duct manufacturer must be used whenever an existing duct is connected to a duct of different material or shape. Ducts must be stored to avoid warping and deterioration with ends sufficiently plugged to prevent entry of any water or solid substances. Ducts must be thoroughly cleaned before being laid. Plastic ducts must be stored on a flat surface and protected from the direct rays of the sun.

3.4.3 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.

3.4.4 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, rigid steel conduit must be installed 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.

3.4.5 Galvanized Conduit Concrete Penetrations

Galvanized conduits which penetrate concrete (slabs, pavement, and walls) in wet locations must be PVC coated and must extend from at least 2 inches within the concrete to the first coupling or fitting outside the concrete (minimum of 6 inches from penetration).

3.4.6 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.

3.4.7 Conduit Plugs and Pull Rope

New conduit indicated as being unused or empty must be provided 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.

3.4.8 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.

3.4.8.1 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. Concrete encasement must extend 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.

3.4.8.2 Directional Boring

HDPE conduits must be installed below the frostline and as specified herein.

For branch circuit wiring less than 600 volts, depths to the top of the conduit must not be less than 24 inches in pavement- or non-pavement-covered areas.

3.4.9 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 must 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 to prevent the assemblies from floating during concrete pouring. Anchoring must be done 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

3.4.9.1 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.

3.4.9.2 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.

3.4.9.3 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.

3.4.10 Duct Sealing

Seal all electrical penetrations for radon mitigation, maintaining integrity of the vapor barrier, and to prevent infiltration of air, insects, and vermin.

3.5 CABLE PULLING

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 or wire 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.

3.5.1 Cable Lubricants

Use lubricants that are specifically recommended by the cable manufacturer for assisting in pulling jacketed cables.

3.6 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.

3.6.1 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.

3.7 CONDUCTORS INSTALLED IN PARALLEL

Conductors must be grouped such that each conduit of a parallel run contains 1 Phase A conductor, 1 Phase B conductor, 1 Phase C conductor, and 1 neutral conductor.

3.8 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.

3.9 GROUNDING SYSTEMS

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

3.9.1 Grounding Electrodes

Provide cone pointed driven ground rods driven full depth plus 6 inches, installed to provide an earth ground of the appropriate value for the particular equipment being grounded.
If the specified ground resistance is not met, an additional ground rod must be provided 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.

3.9.2 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.

3.9.3 Grounding Conductors

Provide bare grounding conductors, except where installed in conduit with associated phase conductors. Ground cable sheaths, cable shields, conduit, and equipment with No. 6 AWG. Ground other noncurrent-carrying metal parts and equipment frames of metal-enclosed equipment. Ground metallic frames and covers of handholes and pull boxes with a braided, copper ground strap with equivalent ampacity of No. 6 AWG.

3.9.4 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.

3.9.5 Manhole Grounding

Loop a 4/0 AWG grounding conductor around the interior perimeter, approximately 12 inches above finished floor. Secure the conductor to the manhole walls at intervals not exceeding 36 inches. Connect the conductor to the manhole grounding electrode with 4/0 AWG conductor. Connect all incoming 4/0 grounding conductors to the ground loop adjacent to the point of entry into the manhole. Bond the ground loop to all cable shields, metal cable racks, and other metal equipment with a minimum 6 AWG conductor.

3.10 CAST-IN-PLACE CONCRETE

Provide concrete in accordance with Section 03 30 00.00 10 CAST-IN-PLACE CONCRETE.

3.10.1 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. Slab must be placed 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.

3.10.2 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.

3.11 FIELD QUALITY CONTROL

3.11.1 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.

3.11.1.1 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.

3.11.1.2 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.

3.11.2 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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SECTION 33 82 00

TELECOMMUNICATIONS OUTSIDE PLANT (OSP)
04/06

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 B1	(2013) Standard Specification for Hard-Drawn Copper Wire
ASTM B8	(2011; R 2017) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

ICEA S-87-640	(2016) Optical Fiber Outside Plant Communications Cable; 4th Edition
ICEA S-98-688	(2012) Broadband Twisted Pair Telecommunication Cable, Aircore, Polyolefin Insulated, Copper Conductors Technical Requirements
ICEA S-99-689	(2012) Broadband Twisted Pair Telecommunication Cable Filled, Polyolefin Insulated, Copper Conductors Technical Requirements

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2017; ERTA 1-2 2017; TIA 17-1; TIA 17-2; TIA 17-3; TIA 17-4; TIA 17-5; TIA 17-6; TIA 17-7; TIA 17-8; TIA 17-9; TIA 17-10; TIA 17-11; TIA 17-12; TIA 17-13; TIA 17-14) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-455-107	(1999a) FOTP-107 Determination of Component Reflectance or Link/System Return Loss using a Loss Test Set
TIA-455-78-B	(2002) FOTP-78 Optical Fibres - Part 1-40: Measurement Methods and Test Procedures - Attenuation
TIA-472D000	(2007b) Fiber Optic Communications Cable for Outside Plant Use
TIA-492CAAA	(1998; R 2002) Detail Specification for Class IVa Dispersion-Unshifted Single-Mode Optical Fibers
TIA-526-14	(2015c) OFSTP-14A Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant
TIA-526-7	(2015a) OFSTP-7 Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant
TIA-568-D.1	(2015) Commercial Building Telecommunications Cabling Standard
TIA-568-D.2	(2015) Balanced Twisted-Pair Telecommunications Cabling and Components Standards
TIA-568-D.3	(2015) Optical Fiber Cabling Components Standard
TIA-569	(2015d) Commercial Building Standard for Telecommunications Pathways and Spaces
TIA-590	(1997a) Standard for Physical Location and Protection of Below Ground Fiber Optic Cable Plant
TIA-606	(2017c) Administration Standard for the Telecommunications Infrastructure
TIA-607-C	(2016) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises
TIA-758	(2012b) Customer-Owned Outside Plant Telecommunications Infrastructure Standard
TIA/EIA-455	(1998b) Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components
TIA/EIA-455-204	(2000) Standard for Measurement of Bandwidth on Multimode Fiber

TIA/EIA-598	(2014D; Add 2 2018) Optical Fiber Cable Color Coding

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS 1755	Telecommunications Standards and Specifications for Materials, Equipment and Construction
RUS Bull 1751F-630	(1996) Design of Aerial Plant
RUS Bull 1751F-640	(1995) Design of Buried Plant, Physical Considerations
RUS Bull 1751F-643	(2002) Underground Plant Design
RUS Bull 1751F-815	(1979) Electrical Protection of Outside Plant
RUS Bull 1753F-201	(1997) Acceptance Tests of Telecommunications Plant (PC-4)
RUS Bull 1753F-401	(1995) Splicing Copper and Fiber Optic Cables (PC-2)
RUS Bull 345-65	(1985) Shield Bonding Connectors (PE-65)
RUS Bull 345-72	(1985) Filled Splice Closures (PE-74)

UNDERWRITERS LABORATORIES (UL)

UL 510	(2017) UL Standard for Safety Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 83	(2017) UL Standard for Safety Thermoplastic-Insulated Wires and Cables

U.S. Army Information Systems Engineering Command

I3A	(2010) Technical Criteria for the Installation Information Infrastructure Architecture

U.S. Army Signal Network Enterprise Center

Ft. Bragg NEC IDC	(2017) Installation Design Criteria for Fort Bragg Specific Communications Infrastructure Require0ments

1.2 RELATED REQUIREMENTS

Section 27 10 00, BUILDING TELECOMMUNICATIONS CABLING SYSTEM andSection 33 71 02, UNDERGROUND ELECTRICAL DISTRIBUTION apply to this section with additions and modifications specified herein.

1.3 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in this specification shall be as defined in TIA-568-D.1, TIA-568-D.2, TIA-568-D.3, TIA-569, TIA-606, and IEEE 100 and herein.

1.3.1 Campus Distributor (CD)

A distributor from which the campus backbone cabling emanates. (International expression for main cross-connect - (MC).)

1.3.2 Entrance Facility (EF) (Telecommunications)

An entrance to the building for both private and public network service cables (including antennae) including the entrance point at the building wall and continuing to the entrance room or space.

1.3.3 Entrance Room (ER) (Telecommunications)

A centralized space for telecommunications equipment that serves the occupants of a building. Equipment housed therein is considered distinct from a telecommunications room because of the nature of its complexity.

1.3.4 Building Distributor (BD)

A distributor in which the building backbone cables terminate and at which connections to the campus backbone cables may be made. (International expression for intermediate cross-connect - (IC).)

1.3.5 Pathway

A physical infrastructure utilized for the placement and routing of telecommunications cable.

1.4 SYSTEM DESCRIPTION

The telecommunications outside plant consists of cable, conduit, manholes, poles, etc. required to provide signal paths from the closest point of presence to the new facility, including free standing frames or backboards, interconnecting hardware, terminating cables, lightning and surge protection modules at the entrance facility. The work consists of providing, testing and making operational cabling, interconnecting hardware and lightning and surge protection necessary to form a complete outside plant telecommunications system for continuous use.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.00 37 SUSTAINABILITY. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Telecommunications Outside Plant; G, AE

Telecommunications Entrance Facility 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

Wire and cable

Cable splices, and connectors

Closures

Building protector assemblies

Spare Parts

Submittals shall include the manufacturer's name, trade name, place of manufacture, and catalog model or number. Submittals shall also include applicable federal, military, industry, and technical society publication references. Should manufacturer's data require supplemental information for clarification, the supplemental information shall be submitted as specified in paragraph REGULATORY REQUIREMENTS and as required for certificates in Section 01 33 00 SUBMITTAL PROCEDURES.

SD-06 Test Reports

Pre-installation tests

Acceptance tests

Outside Plant Test Plan

SD-07 Certificates

Telecommunications Contractor Qualifications

Key Personnel Qualifications

Minimum Manufacturer's Qualifications

SD-08 Manufacturer's Instructions

Building protector assembly installation

Cable tensions

Fiber Optic Splices

Submit instructions prior to installation.

SD-09 Manufacturer's Field Reports

Factory Reel Test Data

SD-10 Operation and Maintenance Data

Telecommunications outside plant (OSP), Data Package 5

Commercial off-the-shelf manuals shall be provided for operation, installation, configuration, and maintenance of products provided as a part of the telecommunications outside plant (OSP). 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 OUTSIDE PLANT SHOP DRAWINGS and TELECOMMUNICATIONS ENTRANCE FACILITY DRAWINGS.

SD-11 Closeout Submittals

Record Documentation

In addition to other requirements, provide in accordance with paragraph RECORD DOCUMENTATION.

1.6 QUALITY ASSURANCE

1.6.1 Shop Drawings

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams 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 Outside Plant Shop Drawings

Provide Outside Plant Design in accordance with TIA-758, RUS Bull 1751F-630 for aerial system design, and RUS Bull 1751F-643 for underground system design. Provide T0 shop drawings that show the physical and logical connections from the perspective of an entire campus, such as actual building locations, exterior pathways and campus backbone cabling on plan view drawings, major system nodes, and related connections on the logical system drawings in accordance with TIA-606. Drawings shall include wiring and schematic diagrams for fiber optic and copper cabling and splices, copper conductor gauge and pair count, fiber pair count and type, pathway duct and innerduct arrangement, associated construction materials, and any details required to demonstrate that cable system has been coordinated and will properly support the switching and transmission system identified in specification and drawings. The telecommunications outside plant (OSP) shop drawings shall be included in the operation and maintenance manuals.

1.6.1.2 Telecommunications Entrance Facility Drawings

Provide T3 drawings for EF Telecommunications as specified in the paragraph TELECOMMUNICATIONS SPACE DRAWINGS of Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEMS. The telecommunications entrance facility shop drawings shall be included in the operation and maintenance manuals.

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, the supervisor (if different from the installer), and the cable splicing and terminating personnel. A minimum of 30 days prior to installation, submit documentation of the experience of the telecommunications contractor and of the key personnel.

1.6.2.1 Telecommunications Contractor Qualifications

The telecommunications contractor 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 that include outside plant and broadband cabling within the past 3 years. Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for the telecommunications contractor. Each of the key personnel shall demonstrate experience in providing successful telecommunications systems in accordance with TIA-758 within the past 3 years.

1.6.2.2 Key Personnel Qualifications

Provide key personnel who are regularly and professionally engaged in the business of the application, installation and testing of the specified telecommunications systems and equipment. There may be one key person or more key persons proposed for this solicitation depending upon how many of the key roles each has successfully provided. Each of the key personnel shall demonstrate experience in providing successful telecommunications systems within the past 3 years.

Cable splicing and terminating personnel assigned to the installation of this system or any of its components shall have training in the proper techniques and have a minimum of 3 years experience in splicing and terminating the specified cables. Modular splices shall be performed by factory certified personnel or under direct supervision of factory trained personnel for products used.

All supervisors assigned to the installation of this system or any of its components shall have a minimum Technician certification from BICSI and installers assigned to the installation of the system or any of its components shall have a minimum Level 1 installer certification from BICSI. All supervisors and installers shall also have factory certification from each equipment manufacturer that they are qualified to install and test.

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 outside plant systems, including broadband cabling, 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's 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-D.1, TIA-568-D.2 and TIA-568-D.3. In addition, cabling manufacturers shall have a minimum of 3 years experience in the manufacturing and factory testing of cabling which comply with ICEA S-87-640, ICEA S-98-688, and ICEA S-99-689.

1.6.3 Outside Plant Test Plan

Prepare and provide a complete and detailed test plan for field tests of the outside plant including a complete list of test equipment for the copper conductor and optical fiber cables, components, and accessories for approval by the Contracting Officer. Include a cut-over plan with procedures and schedules for relocation of facility station numbers without interrupting service to any active location. Submit the plan at least 30 days prior to tests for Contracting Officer approval. Provide outside plant testing and performance measurement criteria in accordance with TIA-568-D.1 and RUS Bull 1753F-201. Include procedures for certification, validation, and testing that includes fiber optic link performance criteria.

1.6.4 Standard Products

Provide materials and equipment that are standard products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship and shall be the manufacturer's latest standard design that has been in satisfactory commercial or industrial use for at least 1 year prior to bid opening. The 1-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 1-year period. Products supplied shall

be specifically designed and manufactured for use with outside plant telecommunications systems. Where two or more items of the same class of equipment are required, these items 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.

1.6.4.1 Alternative Qualifications

Products having less than a 1-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 3000 hours, exclusive of the manufacturers' factory or laboratory tests, is provided.

1.6.4.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.6.5 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "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.

1.6.5.1 Independent Testing Organization Certificate

In lieu of the label or listing, submit a certificate from an independent testing organization, competent to perform testing, and approved by the Contracting Officer. The certificate 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.

1.7 DELIVERY, STORAGE, AND HANDLING

Ship cable on reels in 500 or 1000 feet length with a minimum overage of 10 percent. Radius of the reel drum shall not be smaller than the minimum bend radius of the cable. Wind cable on the reel so that unwinding can be done without kinking the cable. Two meters of cable at both ends of the cable shall be accessible for testing. Attach permanent label on each reel showing length, cable identification number, cable size, cable type, and date of manufacture. Provide water resistant label and the indelible writing on the labels. Apply end seals to each end of the cables to prevent moisture from entering the cable. Reels with cable shall be suitable for outside storage conditions when temperature ranges from minus 40 degrees C to plus 65 degrees C, with relative humidity from 0 to 100 percent. Equipment, other than cable, delivered and placed in storage shall be stored with protection from weather, humidity and temperature variation, dirt and dust, or other contaminants in accordance with manufacturer's requirements.

1.8 MAINTENANCE

1.8.1 Record Documentation

Provide the activity responsible for telecommunications system maintenance and administration a single complete and accurate set of record documentation for the entire telecommunications system with respect to this project.

Provide record documentation as specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

1.8.2 Spare Parts

In addition to the requirements of Section 01 78 23 OPERATION AND MAINTENANCE DATA, provide a complete list of parts and supplies, with current unit prices and source of supply, and a list of spare parts recommended for stocking. Spare parts shall be provided no later than the start of field testing.

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.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Products supplied shall be specifically designed and manufactured for use with outside plant telecommunications systems.

2.2 TELECOMMUNICATIONS ENTRANCE FACILITY

2.2.1 Building Protector Assemblies

Provide self-contained 5 pin or screw type unit supplied with a field cable stub factory connected to protector socket blocks to terminate and accept protector modules for outside cable. Building protector assembly shall have interconnecting hardware for connection to interior cabling at full capacity. Provide manufacturers instructions for building protector assembly installation. Provide copper cable interconnecting hardware as specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

2.2.2 Fiber Optic Terminations

Provide fiber optic cable terminations as specified in 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

2.3 CLOSURES

2.3.1 Copper Conductor Closures

2.3.1.1 Underground Cable Closures

In vault or manhole: Provide underground closure suitable to house a straight, butt, and branch splice in a protective housing. Closure shall

be of suitable stainless steel material supplying structural strength necessary to pass the mechanical and electrical requirements in a vault or manhole environment. Provide filled splice cases in accordance with RUS Bull 345-72. For copper cable sizes 600 pair or greater, splice location shall be at every MH.

2.3.2 Fiber Optic Closures

2.3.2.1 In Vault or Manhole

Provide a 25-pair, filled 710 cable splicing module. Ft. Bragg shall conduct a visual inspection of the interior of all splice cases prior to the closing of the slice case after splicing is completed. The Ft. Bragg NEC will also be present to observe the flash testing of splice cases after splicing is completed. Schrader/ Air valves shall be left with the newly installed cases once flash testing is complete. New cable installed in the Ft. Bragg MH and ducting infrastructure shall be spliced utilizing a stainless steel splice enclosure inside MHs and in accordance with the following guidelines: For copper cable sizes 001-400 pair, splice location shall be at ever other MH.

2.4 CABLE SPLICES, AND CONNECTORS

2.4.1 Copper Cable Splices

Provide multipair, foldback splices of a moisture resistant, three-wire insulation displacement connector held rigidly in place to assure maximum continuity in accordance with RUS Bull 1753F-401. Cables greater than 25 pairs shall be spliced using multipair splicing connectors, which accommodate 25 pairs of conductors at a time. Provide correct connector size to accommodate the cable gauge of the supplied cable.

2.4.2 Copper Cable Splice Connector

Provide splice connectors with a polycarbonate body and cap and a tin-plated brass contact element. Connector shall accommodate 22 to 26 AWG solid wire with a maximum insulation diameter of 0.065 inch. Fill connector with sealant grease to make a moisture resistant connection, in accordance with RUS Bull 1753F-401.

2.4.3 Fiber Optic Cable Splices

Provide fiber optic cable splices and splicing materials for fusion methods at locations shown on the construction drawings. The splice insertion loss shall be 0.05 dB maximum when measured in accordance with TIA-455-78-B using an Optical Time Domain Reflectometer (OTDR). Splices shall be designed for a return loss of 55.0 db min for single mode fiber when tested in accordance with TIA-455-107. Physically protect each fiber optic splice by a splice kit specially designed for the splice.

2.4.4 Fiber Optic Splice Organizer

Provide splice organizer suitable for housing fiber optic splices in a neat and orderly fashion where needed. Splice organizer shall allow for a minimum of 3 feet of fiber for each fiber within the cable to be neatly stored without kinks or twists. Splice organizer shall accommodate individual strain relief for each splice and allow for future maintenance or modification, without damage to the cable or splices. Provide splice organizer hardware, such as splice trays, protective glass shelves, and

shield bond connectors in a splice organizer kit. The Ft. Bragg NEC shall conduct a visual inspection of the interior of all splice cases prior to the closing of the splice case after splicing is completed. The Ft. Bragg NEC will also be present to observe the flash testing of splice cases after splicing is completed. Schrader\Air valves shall be left with the newly installed cases once flash testing is complete. New cable installed in the Ft. Bragg MH and ducting infrastructure shall be spliced utilizing a stainless steel splice enclosure inside MHs and in accordance with Ft. Bragg NEC IDC and I3A.

2.4.5 Shield Connectors

Provide connectors with a stable, low-impedance electrical connection between the cable shield and the bonding conductor in accordance with RUS Bull 345-65.

2.5 CONDUIT

Provide conduit as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.6 PLASTIC INSULATING TAPE

UL 510.

2.7 WIRE AND CABLE

2.7.1 Copper Conductor Cable

Solid copper conductors, covered with an extruded solid insulating compound. Insulated conductors shall be twisted into pairs which are then stranded or oscillated to form a cylindrical core. For special high frequency applications, the cable core shall be separated into compartments. Cable shall be completed by the application of a suitable core wrapping material, a corrugated copper or plastic coated aluminum shield, and an overall extruded jacket. Telecommunications contractor shall verify distances between splice points prior to ordering cable in specific cut lengths. Gauge of conductor shall determine the range of numbers of pairs specified; 19 gauge (6 to 400 pairs), 22 gauge (6 to 1200 pairs), 24 gauge (6 to 2100 pairs), and 26 gauge (6 to 3000 pairs). Copper conductor shall conform to the following:

2.7.2 Fiber Optic Cable

Provide single-mode, 8/125-um, 0.10 aperture 1310 nm fiber optic cable in accordance with TIA-492CAAA, TIA-472D000, and ICEA S-87-640 including any special requirements made necessary by a specialized design. Provide optical fibers as indicated. Fiber optic cable shall be specifically designed for outside use with loose buffer construction. Provide fiber optic color code in accordance with TIA/EIA-598

2.7.2.1 Strength Members

Provide central or non-central, non-metallic or metallic strength members with sufficient tensile strength for installation and residual rated loads to meet the applicable performance requirements in accordance with ICEA S-87-640. The strength member is included to serve as a cable core foundation to reduce strain on the fibers, and shall not serve as a pulling strength member.

2.7.2.2 Performance Requirements

Provide fiber optic cable with optical and mechanical performance requirements in accordance with ICEA S-87-640.

2.7.3 Grounding and Bonding Conductors

Provide grounding and bonding conductors in accordance with RUS 1755.200, TIA-607-C, IEEE C2, and NFPA 70. Solid bare copper wire meeting the requirements of ASTM B1 for sizes No. 8 AWG and smaller and stranded bare copper wire meeting the requirements of ASTM B8, for sizes No. 6 AWG and larger. Insulated conductors shall have 600-volt, Type TW insulation meeting the requirements of UL 83.

2.8 CABLE TAGS IN MANHOLES, HANDHOLES, AND VAULTS

Provide tags for each telecommunications cable or wire located in manholes, handholes, and vaults. Cable tags shall be polyethylene and labeled in accordance with TIA-606. Handwritten labeling is unacceptable.

2.8.1 Polyethylene Cable Tags

Provide tags of polyethylene that have an average tensile strength of 3250 pounds per square inch; and that are 0.08 inch thick (minimum), non-corrosive non-conductive; resistive to acids, alkalis, organic solvents, and salt water; and distortion resistant to 170 degrees F. Provide 0.05 inch (minimum) thick black polyethylene tag holder. Provide a one-piece nylon, self-locking tie at each end of the cable tag. Ties shall have a minimum loop tensile strength of 175 pounds. The cable tags shall have black block letters, numbers, and symbols one inch high on a yellow background. Letters, numbers, and symbols shall not fall off or change positions regardless of the cable tags' orientation.

2.9 BURIED WARNING AND IDENTIFICATION TAPE

Provide fiber optic media marking and protection in accordance with TIA-590. Provide color, type and depth of tape as specified in paragraph BURIED WARNING AND IDENTIFICATION TAPE in Section 31 00 00, EARTHWORK.

2.10 GROUNDING BRAID

Provide grounding braid that provides low electrical impedance connections for dependable shield bonding in accordance with RUS 1755.200. Braid shall be made from flat tin-plated copper.

2.11 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.

2.12 FIELD FABRICATED NAMEPLATES

Provide laminated plastic nameplates in accordance with ASTM D709 for each patch panel, protector assembly, rack, cabinet and other equipment or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine

plastic, 0.125 inch 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 inch high normal block style.

2.13 TESTS, INSPECTIONS, AND VERIFICATIONS

2.13.1 Factory Reel Test Data

Test 100 percent OTDR test of FO media at the factory in accordance with TIA-568-D.1 and TIA-568-D.3. Use TIA-526-7 for single mode fiber and TIA-526-14 Method B for multi mode fiber measurements. Calibrate OTDR to show anomalies of 0.2 dB minimum. Enhanced performance filled OSP copper cables, referred to as Broadband Outside Plant (BBOSP), shall meet the requirements of ICEA S-99-689. Enhanced performance air core OSP copper cables shall meet the requirements of ICEA S-98-688. Submit test reports, including manufacture date for each cable reel and receive approval before delivery of cable to the project site.

PART 3 EXECUTION

3.1 INSTALLATION

Install all system components and appurtenances in accordance with manufacturer's instructions IEEE C2, NFPA 70, and as indicated. Provide all necessary interconnections, services, and adjustments required for a complete and operable telecommunications system.

3.1.1 Contractor Damage

Promptly repair indicated utility lines or systems damaged during site preparation and construction. Damages to lines or systems not indicated, which are caused by Contractor operations, shall be treated as "Changes" under the terms of the Contract Clauses. When Contractor is advised in writing of the location of a nonindicated line or system, such notice shall provide that portion of the line or system with "indicated" status in determining liability for damages. In every event, immediately notify the Contracting Officer of damage.

3.1.2 Cable Inspection and Repair

Handle cable and wire provided in the construction of this project with care. Inspect cable reels for cuts, nicks or other damage. Damaged cable shall be replaced or repaired to the satisfaction of the Contracting Officer. Reel wraps shall remain intact on the reel until the cable is ready for placement.

3.1.3 Direct Burial System

Installation shall be in accordance with RUS Bull 1751F-640. Under railroad tracks, paved areas, and roadways install cable in conduit encased in concrete. Slope ducts to drain. Excavate trenches by hand or mechanical trenching equipment. Provide a minimum cable cover of 24 inches below finished grade. Trenches shall be not less than 6 inches wide and in straight lines between cable markers. Do not use cable plows. Bends in trenches shall have a radius of not less than 36 inches. Where two or more cables are laid parallel in the same trench, space laterally at least 3 inches apart. When rock is encountered, remove it to a depth of at least 3 inches below the cable and fill the space with sand or clean earth free

from particles larger than 1/4 inch. Do not unreel and pull cables into the trench from one end. Cable may be unreeled on grade and lifted into position. Provide color, type and depth of warning tape as specified in paragraph BURIED WARNING AND IDENTIFICATION TAPE in Section 31 00 00 EARTHWORK.

3.1.3.1 Cable Placement

a. Separate cables crossing other cables or metal piping from the other cables or pipe by not less than 3 inches of well tamped earth. Do not install circuits for communications under or above traffic signal loops.

b. Cables shall be in one piece without splices between connections except where the distance exceeds the lengths in which the cable is furnished.

c. Avoid bends in cables of small radii and twists that might cause damage. Do not bend cable and wire in a radius less than 10 times the outside diameter of the cable or wire.

d. Leave a horizontal slack of approximately 3 feet in the ground on each end of cable runs, on each side of connection boxes, and at points where connections are brought aboveground. Where cable is brought aboveground, leave additional slack to make necessary connections.

3.1.3.2 Identification Slabs

Provide a marker at each change of direction of the cable, over the ends of ducts or conduits which are installed under paved areas and roadways and over each splice. Identification markers shall be of concrete, approximately 20 inches square by 6 inches thick.

3.1.3.3 Backfill for Rocky Soil

When placing cable in a trench in rocky soil, the cable shall be cushioned by a fill of sand or selected soil at least 2 inches thick on the floor of the trench before placing the cable or wire. The backfill for at least 4 inches above the wire or cable shall be free from stones, rocks, or other hard or sharp materials which might damage the cable or wire. If the buried cable is placed less than 24 inches in depth, a protective cover of metal or concrete shall be used.

3.1.4 Cable Protection

Provide direct burial cable protection in accordance with NFPA 70 and as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Galvanized conduits which penetrate concrete (slabs, pavement, and walls) shall be PVC coated and shall extend from the first coupling or fitting outside either side of the concrete minimum of 6 inches per 12 inches burial depth beyond the edge of the surface where cable protection is required; all conduits shall be sealed on each end. Where additional protection is required, cable may be placed in galvanized iron pipe (GIP) sized on a maximum fill of 40 percent of cross-sectional area, or in concrete encased 4 inches PVC pipe. Conduit may be installed by jacking or trenching. Trenches shall be backfilled with earth and mechanically tamped at 6 inches lift so that the earth is restored to the same density, grade and vegetation as adjacent undisturbed material.

3.1.4.1 Cable End Caps

Cable ends shall be sealed at all times with coated heat shrinkable end caps. Cables ends shall be sealed when the cable is delivered to the job site, while the cable is stored and during installation of the cable. The caps shall 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.

3.1.5 Underground Duct

Provide underground duct and connections to existing manholes, handholes, and existing ducts as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION with any additional requirements as specified herein.

3.1.6 Reconditioning of Surfaces

Provide reconditioning of surfaces as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.1.7 Penetrations

Caulk and seal cable access penetrations in walls, ceilings and other parts of the building. Seal openings around electrical penetrations through fire resistance-rated wall, partitions, floors, or ceilings in accordance with Section 07 84 00 FIRESTOPPING.

3.1.8 Cable Pulling

Test duct lines with a mandrel and swab out to remove foreign material before the pulling of cables. Avoid damage to cables in setting up pulling apparatus or in placing tools or hardware. Do not step on cables when entering or leaving the manhole. Do not place cables in ducts other than those shown without prior written approval of the Contracting Officer. Roll cable reels in the direction indicated by the arrows painted on the reel flanges. Set up cable reels on the same side of the manhole as the conduit section in which the cable is to be placed. Level the reel and bring into proper alignment with the conduit section so that the cable pays off from the top of the reel in a long smooth bend into the duct without twisting. Under no circumstances shall the cable be paid off from the bottom of a reel. Check the equipment set up prior to beginning the cable pulling to avoid an interruption once pulling has started. Use a cable feeder guide of suitable dimensions between cable reel and face of duct to protect cable and guide cable into the duct as it is paid off the reel. As cable is paid off the reel, lubricate and inspect cable for sheath defects. When defects are noticed, stop pulling operations and notify the Contracting Officer to determine required corrective action. Cable pulling shall also be stopped when reel binds or does not pay off freely. Rectify cause of binding before resuming pulling operations. Provide cable lubricants recommended by the cable manufacturer. Avoid bends in cables of small radii and twists that might cause damage. Do not bend cable and wire in a radius less than 10 times the outside diameter of the cable or wire.

3.1.8.1 Cable Tensions

Obtain from the cable manufacturer and provide to the Contracting Officer, the maximum allowable pulling tension. This tension shall not be exceeded.

3.1.8.2 Pulling Eyes

Equip cables 1.25 inches in diameter and larger with cable manufacturer's factory installed pulling-in eyes. Provide cables with diameter smaller than 1.25 inches with heat shrinkable type end caps or seals on cable ends when using cable pulling grips. Rings to prevent grip from slipping shall not be beaten into the cable sheath. Use a swivel of 3/4 inch links between pulling-in eyes or grips and pulling strand.

3.1.8.3 Installation of Cables in Manholes, Handholes, and Vaults

Do not install cables utilizing the shortest route, but route along those walls providing the longest route and the maximum spare cable lengths. Form cables to closely parallel walls, not to interfere with duct entrances, and support cables on brackets and cable insulators at a maximum of 4 feet. In existing manholes, handholes, and vaults where new ducts are to be terminated, or where new cables are to be installed, modify the existing installation of cables, cable supports, and grounding as required with cables arranged and supported as specified for new cables. Identify each cable with corrosion-resistant embossed metal tags.
Fiber optic cables shall be engineered with a 20-foot (6-m) service loop installed in each pull-through maintenance hole or a 50-foot (15-m) splice loop installed on each side of a splice case. The service and splice slack shall be coiled and lightly secured in loops that do not violate the bending radius. The slack shall be placed in the maintenance hole in such a manner that the cables are out of the way and not wrapped around other cables or lying on the floor.

3.1.9 Cable Splicing

3.1.9.1 Copper Conductor Splices

Perform splicing in accordance with requirements of RUS Bull 1753F-401 except that direct buried splices and twisted and soldered splices are not allowed. Exception does not apply for pairs assigned for carrier application.

3.1.9.2 Fiber Optic Splices

Fiber optic splicing shall be in accordance with manufacturer's recommendation and shall exhibit an insertion loss not greater than 0.05 dB for fusion splices.

3.1.10 Surge Protection

All cables and conductors, except fiber optic cable, which serve as communication lines through off-premise lines, shall have surge protection installed at each end which meet the requirements of RUS Bull 1751F-815.

3.1.11 Grounding

Provide grounding and bonding in accordance with RUS 1755.200, TIA-607-C, IEEE C2, and NFPA 70. Ground exposed noncurrent carrying metallic parts of telephone equipment, cable sheaths, cable splices, and terminals.

3.1.11.1 Telecommunications Main Ground Bar (TMGB)

The TMGB is the hub of the basic telecommunications grounding system

providing a common point of connection for ground from outside cable, CD, and equipment. Establish a TMGB for connection point for cable stub shields to connector blocks and CD protector assemblies as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.1.11.2 Incoming Cable Shields

Shields shall not be bonded across the splice to the cable stubs. Ground shields of incoming cables in the EF Telecommunications to the TMGB.

3.1.11.3 Campus Distributor Grounding

a. Protection assemblies: Mount CD protector assemblies directly on the telecommunications backboard. Connect assemblies mounted on each vertical frame with No. 6 AWG copper conductor to provide a low resistance path to TMGB.

b. TMGB connection: Connect TMGB to TGB with copper conductor with a total resistance of less than 0.01 ohms.

3.1.12 Cut-Over

All necessary transfers and cut-overs, shall be accomplished by the telecommunications contractor.

3.2 LABELING

3.2.1 Labels

Provide labeling for new cabling and termination hardware located within the facility in accordance with TIA-606. Handwritten labeling is unacceptable. Stenciled lettering for cable and termination hardware shall be provided using thermal ink transfer process or laser printer.

3.2.2 Cable Tag Installation

Install cable tags for each telecommunications cable or wire located in manholes, handholes, and vaults including each splice. Tag only new wire and cable provided by this contract. The labeling of telecommunications cable tag identifiers shall be in accordance with TIA-606. Do not provide handwritten letters. Install cable tags so that they are clearly visible without disturbing any cabling or wiring in the manholes, handholes, and vaults. Telecommunications Busbars shall have the following statement imprinted on a placard and mounted on or in close proximity to each Busbar in every TR: "WARNING - IF ANY OF THESE CONNECTORS OR CABLES ARE LOOSE OR MUST BE REMOVED, PLEASE CONTACT THE ARMY ENTERPRISE SERVICE DESK AT 1-866-335-2769".

3.2.3 Termination Hardware

Label patch panels, distribution panels, connector blocks and protection modules using color coded labels with identifiers in accordance with TIA-606.

3.3 FIELD APPLIED PAINTING

Provide ferrous metallic enclosure finishes as specified in Section 09 90 00 PAINTS AND COATINGS.

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 FIELD QUALITY CONTROL

Provide the Contracting Officer 10 working days notice prior to each test. Provide labor, equipment, and incidentals required for testing. Correct defective material and workmanship disclosed as the results of the tests. Furnish a signed copy of the test results to the Contracting Officer within 3 working days after the tests for each segment of construction are completed. Perform testing as construction progresses and do not wait until all construction is complete before starting field tests.

3.5.1 Pre-Installation Tests

Perform the following tests on cable at the job site before it is removed from the cable reel. For cables with factory installed pulling eyes, these tests shall be performed at the factory and certified test results shall accompany the cable.

3.5.1.1 Cable Capacitance

Perform capacitance tests on at least 10 percent of the pairs within a cable to determine if cable capacitance is within the limits specified.

3.5.1.2 Loop Resistance

Perform DC-loop resistance on at least 10 percent of the pairs within a cable to determine if DC-loop resistance is within the manufacturer's calculated resistance.

3.5.1.3 Pre-Installation Test Results

Provide results of pre-installation tests to the Contracting Officer at least 5 working days before installation is to start. Results shall indicate reel number of the cable, manufacturer, size of cable, pairs tested, and recorded readings. When pre-installation tests indicate that cable does not meet specifications, remove cable from the job site.

Contractor shall pretest the existing copper and fiber cabling that will be spliced into the new cabling. The tests shall check for cable faults (grounds, shorts, crosses, opens), splicer's errors (splits, reverses, transpositions), shield continuity, and insulation resistance (insulation resistance on existing cables is accomplished on spare pairs only). The contractor shall not be responsible for correcting existing cable faults (e.g., splicer's errors, open shield continuity, low insulation resistance), however, the NEC PM must be notified of such conditions immediately upon identification approximately 2 weeks prior to splicing and before any splicing takes place. Any existing cable cable-faults or splicer's errors not documented and reported to the NEC shall be cleared by the contractor.

3.5.2 Acceptance Tests

Perform acceptance testing in accordance with RUS Bull 1753F-201 and as

further specified in this section. Provide personnel, equipment, instrumentation, and supplies necessary to perform required testing. Notification of any planned testing shall be given to the Contracting Officer at least 14 days prior to any test unless specified otherwise. Testing shall not proceed until after the Contractor has received written Contracting Officer's approval of the test plans as specified. Test plans shall define the tests required to ensure that the system meets technical, operational, and performance specifications. The test plans shall define milestones for the tests, equipment, personnel, facilities, and supplies required. The test plans shall identify the capabilities and functions to be tested. Provide test reports in booklet form showing all field tests performed, upon completion and testing of the installed system. Measurements shall be tabulated on a pair by pair or strand by strand basis.

3.5.2.1 Copper Conductor Cable

Perform the following acceptance tests in accordance with TIA-758:

a. Wire map (pin to pin continuity)

b. Continuity to remote end

c. Crossed pairs

d. Reversed pairs

e. Split pairs

f. Shorts between two or more conductors

3.5.2.2 Fiber Optic Cable

Test fiber optic cable in accordance with TIA/EIA-455 and as further specified in this section. Two optical tests shall be performed on all optical fibers: Optical Time Domain Reflectometry (OTDR) Test, and Attenuation Test. In addition, a Bandwidth Test shall be performed on all multimode optical fibers. These tests shall be performed on the completed end-to-end spans which include the near-end pre-connectorized single fiber cable assembly, outside plant as specified, and the far-end pre-connectorized single fiber cable assembly.

a. OTDR Test: The OTDR test shall be used to determine the adequacy of the cable installations by showing any irregularities, such as discontinuities, micro-bendings or improper splices for the cable span under test. Hard copy fiber signature records shall be obtained from the OTDR for each fiber in each span and shall be included in the test results. The OTDR test shall be measured in both directions. A reference length of fiber, 66 feet minimum, used as the delay line shall be placed before the new end connector and after the far end patch panel connectors for inspection of connector signature. Conduct OTDR test and provide calculation or interpretation of results in accordance with TIA-526-7 for single-mode fiber and TIA-526-14 for multimode fiber. Splicing of fiber optic cable shall be accomplished using splicing to weld the two fibers together. Fusion splices shall have insertion loss values of less than 0.05 dB.

b. Attenuation Test: End-to-end attenuation measurements shall be made on

all fibers, in both directions, using the appropriate nanometer light source at one end and the optical power meter on the other end to verify that the cable system attenuation requirements are met in accordance with TIA-526-7 for single-mode fiber optic cables. The measurement method shall be in accordance with TIA-455-78-B. Attenuation losses shall not exceed 0.5 db/km at 1310 nm and 1550 nm for single-mode fiber. Attenuation losses shall not exceed 5.0 db/km at 850 nm and 1.5 db/km at 1300 nm for multimode fiber.

c. Bandwidth Test: The end-to-end bandwidth of all multimode fiber span links shall be measured by the frequency domain method. The bandwidth shall be measured in both directions on all fibers. The bandwidth measurements shall be in accordance with TIA/EIA-455-204.

3.5.3 Soil Density Tests

Determine soil-density relationships as specified for soil tests in Section 31 00 00 EARTHWORK.

-- End of Section --